THE REPUBLIC OF MOLDOVA TERRITORY'S VULNERABILITY (EXPOSURE) TO THE MANIFESTATION OF SOME CLIMATE RISKS

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Abstract. Current frequent alternation of dry and wet periods is a justification for the elaboration of new climate indices that would take into account rainfall precarious aspect in the Republic of Moldova. In dry periods assessment is proposed Dry Periods Izu Index which illustrates the desertification degree in the Central and Southern part of the country, and Rainfall Excesses Ip Index, that expresses the degree of abundant rainfall in terms of floods risk. Using Geographical Information Systems, Izu and Ip cartographic models were developed, which illustrate the territories vulnerable to the desertification process and flooding risks.

Introduction

According to the IVth Report on Climate change, this vision is based on the well-known IPCC (2007a) definition: "Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is *exposed*, its *sensitivity*, and its *adaptive capacity*". Thus, vulnerability is a function of three components reflecting: adaptability, sensitivity and territory's exposure to climate change.

Adaptive capacity largely depends on the country's stability, the performance in education and income diversity. Sensitivity in its turn depends on the disaster's intensity, health indicators and food insecurity.

The Exposure is influenced by high frequency of extreme temperatures, a wide range of inter-monthly temperature fluctuations, and frequency of natural

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disasters. We consider that by proper highlight of exposure degree also depends on the vulnerability calculation higher veracity. In this context, in our opinion it is necessary to specify the formula underlying exposure calculation, based on climatic parameters intensity and frequency, and also hazards that occur at the regional level.

1. Research materials and methods

According to [1], the exposure calculation has follow aspect:

$$E = ((sdT1 + ... + sdT12)/12 + (sdP1 + .. sdP12)/12 + (rT1 + .. rT12)/12 + (N\,hot + Ncold)/2 + N\,dry + Ndisaster)/6,$$

where,

sdTi - standard deviation of average temperature in month i.

sdPi - standard deviation of total precipitation in month i.

R Ti - range between maximum and minimum average temperature in month i. N hot - frequency of extremely hot months, when average temperature was higher than 30°C. N cold - frequency of extremely cold months, when average temperature was lower than - 10°C N dry - frequency of extremely dry months in the spring (less than 5 ml total precipitation) and summer (0 ml total precipitation)

N disaster - frequency of weather related disasters between 2000 and 2009.

Based on specific regional particularities, on frequency and intensity of climate anomalies, in our opinion, it is important to establish the climate variability limits that are in the abovementioned variables.

Thus, we consider that in calculating the frequency of months with „extreme heat” (N”hot”) - to be included high temperature above 22°C, and in the calculating the frequency of months with „extreme cold” (N ,”cold”) to include lower temperature than -5°C.

So, at the regional level, exposure is determined by the frequency of extreme temperatures, by the wide range of fluctuations in rainfall deficit and the natural disasters frequency (tab.1).

Table 1. The exposure calculation (E) on the Republic of Moldova territory

Meteorological Station	σT	ΔT	σP	Nhot-Ncold/2	N „dry"	N „disaster"	$\overline{x}$
Cahul	0,40	0,42	0,40	0,55	0,46	0,40	0,44
Leova	0,40	0,42	0,43	0,50	0,49	0,40	0,44
Balţata	0,30	0,40	0,46	0,45	0,47	0,40	0,41
Bălţi	0,33	0,36	0,35	0,45	0,41	0,40	0,38
Chişinău	0,35	0,40	0,47	0,10	0,42	0,51	0,37
Soroca	0,32	0,28	0,35	0,40	0,38	0,40	0,35
Făleşti	0,39	0,44	0,35	0,46	0,38	0,70	0,44
Tiraspol	0,33	0,37	0,43	0,54	0,44	0,35	0,43
Bravicea	0,36	0,33	0,36	0,33	0,46	0,30	0,36
Dubăsari	0,33	0,37	0,45	0,53	0,35	0,60	0,40
Corneşti	0,37	0,44	0,35	0,37	0,36	0,40	0,38
Comrat	0,41	0,40	0,33	0,55	0,42	0,40	0,42
Camenca	0,33	0,34	0,37	0,45	0,33	0,30	0,36
Briceni	0,34	0,34	0,28	0,38	0,38	0,40	0,35

Spatial interpolation of obtained data allows concluding that the most vulnerable area to climate change and risks is the South and South-Eastern part of the country.

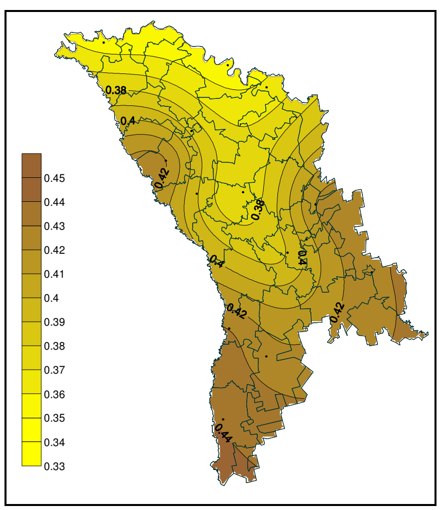

Fig.1 Cartographical modelling of the exposure calculation (E) on the Republic of Moldova territory

The overlapping of results obtained by modelling with administrative districts map allows emphasizing the territory's exposure at the district level-necessary data for the vulnerability index calculation (Fig.1).

Thus, the exposure components and variables express the variability of hydrothermal regime, represented by monthly sigma index, and thermal amplitude, the frequency of cold and hot extremes, extremes of rainfall deficit. But, dense alternation in the last period of dry to wet periods, contribute to the manifestation of both severe droughts and floods onset. According to the Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain (UCL), Belgium -CRED, for a period of more than a century, a significant share of damages across the country caused by climate risks is attributed to droughts and floods (Fig.2).

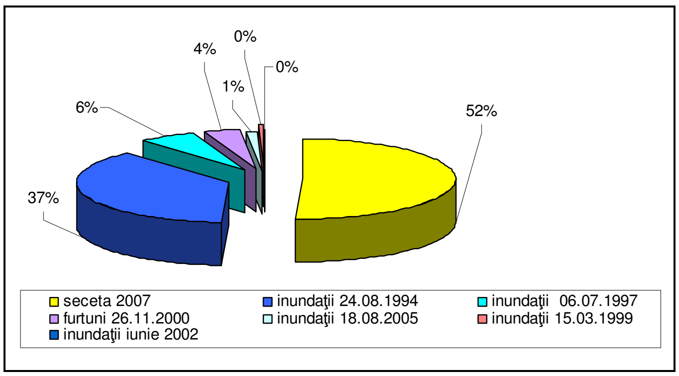

Fig.2 Share of climatic factors in material losses (1900-2011 period) on the Republic of Moldova territory. Source: CRED CRUNCH

Therefore, current alternation of dry and wet periods contribute to the new climatic indexes elaboration, climatic indices which would take into account such manifestations as rainfall deficit as well as moisture excess throughout the Moldova's territory.

Such an index is [2] Dry Periods Index (I_{zu}), which represents the ratio between the numbers of dry days recorded during May-August, in some concrete years reported to their multiannual average, expressed by:

$$Izu = \frac{\sum zu_{(V-VIII)}}{\overline{\overline{X}} zu_{(V-VIII)}}, \quad (1)$$

where $\Sigma zu_{(V\text{-}VIII)}$– amount of dry days during the period May-August, when there is an intensive growth and development of crops, $\overline{X}\, zu_{\,(V\text{-}VIII)}$ – annual average of dry days (May-August).

I_{zu} ratings allow to highlight the dry days periods' aridity degree. Thus, in I_{zu}= 2,1 the number of dry days exceed twice their annual average, by setting up as a significant dry period (tab.2).

As „dry days" are considered the days when air temperature is above 25^{0}C and relative humidity is lower than 30%.

Table 2 Dry Periods Index Ratings (Izu)

Izu Values	***Izu Qualifiers***
0,1-1,0	**Regular period**
1,1-2,0	**Moderate dry period**
2,1-3,0	**Significantly dry period**
3,1-4,0	**Dangerously dry period**
>4,1	**Exceptionally dry period**

Izu cartographic modelling shows that in May-August 2007, except the north-western part of the country, dry and dangerous conditions were established for crop growth and development, confirmed by a recorded low productivity (Fig.3).

At the same time, frequent flood manifestations contributed to the index elaboration that could express the rainfall excesses' danger degree that may result in the flooding onset.

In this context, we propose a new index, which will be taken into account in the final calculation of exposure, and that will be the excess rainfall index:

$$Ip = \frac{\sum P\max - Pmed}{\sum P\max} * 100\% \text{ ....} \qquad (2)$$

where $\Sigma Pmax$ - represents the diurnal maximum precipitation, and *Pmed* – is the average monthly rainfall. The index values that range up to 50% denote the pronounced rainfall excess, *Ip* between values 51-89% indicates the severe rainfall excesses, and higher than 90% - the rainfall excesses with devastating character.

A Therefore, the Rainfall Excesses Index (Ip) serves as a danger degree indicator during a heavy rainfall event. *Ip* cartographic modelling of June 2011 shows that the Index ranged within 65-85%, which indicates the severe rainfall excesses character (Fig.4) of the Republic of Moldova.

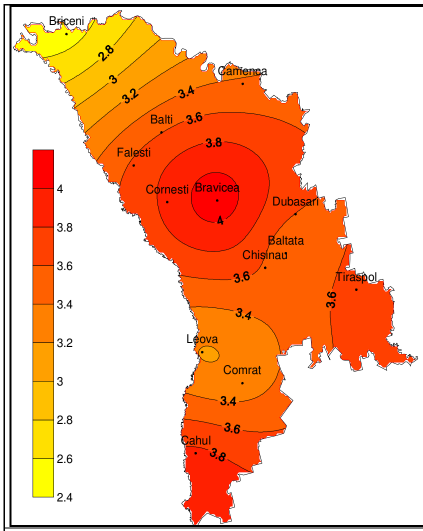

Fig.3. Spatial Modelling of Dry Days Index (Izu) for Republic of Moldova's territory, year-2007

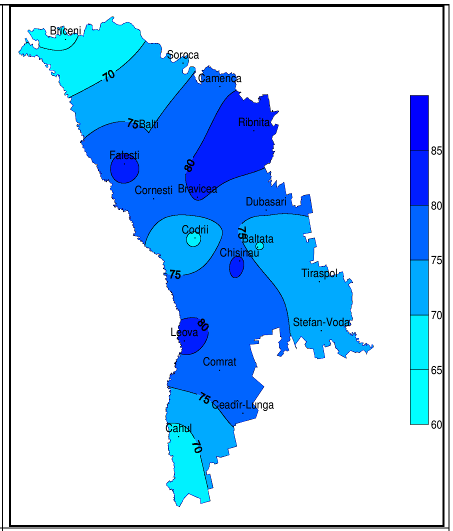

Fig.4. Cartographic modelling of Rainfall Excesses Index (Ip) for the Republic of Moldova's territory, June 2011

Close to the excesses devastating rainfall character was the north-eastern part of the country and Tigheci's Hills, where this value was 80%. At the same time, we mentioned that multiannual analysis data demonstrate that if the level of 89% and more is reached, there is a risk of flood event. In such a case, since the hazard limit of extremes diurnal rainfall was not exceeded, a flood risk was not registered in the Republic.

Conclusion

In conclusion, we notice that the unstable character intervened in the regional climate system requires exposure estimation particularly and vulnerability in general to the climate change risks. The results can help taking adaptation measures to the new climate conditions.

References:

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