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# CLIMATE CHANGES AND THEIR EFFECTS ON OLTENIA PLAIN – CARACAL MICROREGION

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***Abstract***

*In our country, the territory with increased risk from droughts, with a tendency to aridity and desertification even includes large areas of southern Oltenia region; we may consider this to be the most exposed to desertification in Romania. In this context, we analyzed the evolution of agriculture in micro area Caracal (in the towns belonging to that micro-area) in the past decade, drawing out the dependence of production on climatic phenomenon. For conditions in Caracal micro area, the Seleaninov indices were calculated and these were correlated with the economic and financial information for the micro region. Our results have revealed that the maize crop is exposed to losses, and the least exposed is the sunflower. Wheat performed relatively better than maize, as demonstrated by the reduction in the period of maize acreage and a slight increase in areas planted with winter wheat. The main conclusion drawn from research undertaken in Caracal micro region is that agriculture is increasingly volatile to climate change variations from one production year to another, with direct implications on the financial results of farmers.*

***Key words*: *climate changes, production, Seleaninov indexes***

## INTRODUCTION

In Romania, the effects of climate change have had and will have a significant impact on the development of natural conditions, agriculture and biodiversity are the most vulnerable areas to climate change, given the dependence on climatic conditions and the negative ecological, economic and social changes affecting the sustainable development of a region.

The weather can have both a direct influence, reflected in agriculture losses, and year indirect impact on the economic growth noticed in case of high dependency on the farming sector [5].

Our country has a growing vulnerability in intensity and frequency of climate extremes (drought, floods, heat, frost, pests and diseases, etc.), producing significant losses in all sectors, especially in agriculture. Thus, it is considered of the approximately 14.7 million ha of agricultural land (of which 9.4 million hectares of arable land) soils affected by long periods of drought and consecutive years are spread over an area of approx. 7 million ha of agricultural land (48%) and those subject to excess moisture in wet years (about 4 million ha). Drought becomes the limiting factor affecting crops on the largest areas, extent and intensity of this type of risk demising annual fluid reduction of agricultural production of at least 30-50% [8].

Territories with increased risk from droughts, with a tendency to aridity and desertification even include large areas of southern Oltenia considering that this region is most exposed to these phenomena in Romania. Of thermal risks affecting agricultural crops in Oltenia Plain, those with serious effects on production are the maximum temperatures above the critical threshold of 32°C. The amount of days of heat, the deficit widened from the air and ground water, causes major production losses and calamity for spring crops, which in July and August, when the frequency is high risk of these phenomena lies in the critical vegetation phase of flowering. In Oltenia Plain, heat has a high frequency (over 30% of the year), the highest in the whole country with Teleorman Plain and Danube Valley towards Giurgiu.

Climate change effects on agricultural crops in the southern part of Romania depend on local conditions of each site and the severity of changes in climate [4]. So that the climate characteristics can be used effectively to determine the productive capacity of the land, it must be "true" for the location to which it relates. To meet this goal it is necessary to determine not only the climate as a whole, but also the microclimate (Caracal) each portion of territory in the region (Oltenia) [10].

In this context, we believe that the study area (micro area of Caracal), increased tendency scorching heat and aridity of the climate are phenomena that need to be considered and efforts and financial investments should be intensified in order to create a favorable fitoclimat, a competitive agriculture and a sustainable development [9].

For this, present research consider annual turnover of climatic factors that determine crop yields significant variations from year to year and aims to knowing the impact of climatic variability on yield.

## MATERIALS AND METHODS

In the agro meteorological research, impact studies in agriculture are based on weather data / climate and agro meteorological stations with agro meteorological software and climatology archive ( archive NIMH ), as well as specialized measurements, phenology, and biometric production, made on standard platforms both in the agro-meteorological weather stations and software, as well as production fields located near the weather station.

Fluctuation analysis of agro climatic resources through dynamic evolution of agro meteorological/agro climatic factors constitutes the basic criterion to quantify agricultural drought impact on the vegetation, crop productivity [3]. This method of characterization and evaluation of the influence of climate variability on the species/varieties grown include monitoring of meteorological / climatic factors through the accumulation of plant evolution (duration and completion of phonological phases) in conjunction with agricultural practice, i.e. cultivation technology applied differently depending on the specific agropedoclimatic conditions.

During the growing season, field crops requirement have differentiated climatic conditions, with highs in the critical phases of crop-specific consumption.

Agrometeorological parameters evolving optimum necessary to carry out properly the physiological processes of plant growth and development are considered risk/stress factors with adverse effects on crop growth status and ultimately on agricultural productions.

Agropedoclimatic risk types defined using agro meteorological and agro climatic indices show that the heat or fluid risk / stress can be classified according to the basic criteria used in the analysis and evaluation of effects on each agricultural species [6] [7]. The decline of the species cultivated productive potential is directly proportional to the intensity, frequency, sequence and duration of action of disturbances – agro meteorological factors.

**Winter wheat** has a growing season that fall generally between 230 and 250 days, it depends on the variety grown, but especially the growing climatic conditions. Status of vegetation varies throughout the agricultural south, and from one year to another, due to the different agropedoclimatic conditions. In May-June winter wheat goes through the period of maximum sensitivity - "critical period" to environmental conditions - temperature and precipitation, positive or negative deviations from the optimal values are more harmful to plants as they vary in one direction or the other (positive or negative) to the optimum (Table 1).

Table 1. Requirements for air temperature (degrees Celsius) for wheat in the critical period

| Month | Air temperature | | | |
|---|---|---|---|---|
| | Lethal | Minimum | Optimal | Maximum |
| May | > 35 | 8-10 | 16-20 | 30-35 |
| June | > 35 | 8-10 | 16-22 | 30-35 |

Source: Berbecel and colab.

In this critical period, the drought associated with low atmospheric humidity and high maximum temperatures (heat days) causes severe reduction in yields of wheat [1].
Humidity is the second major important factor to winter wheat. Organic range favorable for wheat, from the point of view of precipitation recorded, is between 370 and 875 mm. Latest experimental results from our country considers as optimal for the entire growing season of wheat, the amount of about 600 mm rainfall [10] (Table 2).

Table 2.The optimum of precipitation (l /sq m) in winter wheat / reference thresholds

| IX | X | XI-III | IV | V | VI | VII | VIII | IX-VIII |
|---|---|---|---|---|---|---|---|---|
| 40,0 | 60,0 | 200,0 | 50,0 | 80,0 | 80,0 | 50,0 | 40,0 | 600 |

Source: Teaci

**Maize** Regarding maize crop requests to temperature, it is assumed that maize is a plant with high requirements to temperature. Temperature requirements of maize in the "critical period" that corresponds to the months of July are illustrated in the following table [1] (Table 3).

Table 3. Requirements for air temperature (degrees Celsius) for maize in the critical period

| Month | Air temperature | | | |
|---|---|---|---|---|
| | Lethal | Lethal | Lethal | Lethal |
| July | 0 | 10 | Ave. daily temp. < 23 | 32-33 |
| August | 0 | 16 | Ave. daily temp.21 | < 30 |

As for humidity, the conditions in our country, Bîlteanu [2] established maize production per hectare if the average rainfall totals exceed amounts greater than 40 mm in May, 60 mm in June and July respectively in 80 mm in August. The same author considers optimal distribution of rainfall following: May 60-80 mm, June, 100-120 mm, 100-120 mm in July, August, 60-80 mm. For the three test cultures taken in the thermal limits of survival and that ensures the best results are presented in the following table [10] (Table 4).
Temperature and humidity data above are compared in agro climatic database tests. Many, however, the agro-climatic indicators are correlated with each other directly, in which case it is not necessary to use only some of them.

Table 4. Thermal limits for wheat, maize and sunflower

| Crop | Thermal limits (degrees) | | | |
|---|---|---|---|---|
| | Minimum annual average | | Absolute min. for survival | Optimal annual average |
| | For fructification and harvesting the beans | For green mass | | |
| Winter wheat | -6 | 6 | -10 -20 by variety | 11 |
| Maize | -7 | 6 | 0 | 12 |
| Sunflower | 8 | 6 | -2 | 10 |

Source: Teaci

Of these we selected Seleaninov index that measures variations of phenomena in different periods of the year, taking into account the phenomena normally seasonal fluctuations (temperature and precipitation):

$$SHR = \frac{\sum \text{precipitation}}{0.1x\sum \text{average temperature}}$$

Average index was calculated as the average of individual indices shows the same characteristics in different groups variation units. They were determined for the three major crops for micro area analyzed namely wheat, maize and sunflower.
Agro climatic indices of the type Seleaninov were used to calculate regression functions, which describe the dependence of a analytical characteristic result and a characteristic factor. With its synthetic nature and direction they have expressed the relationship between phenomena.
The regression function mirrored the way the scope changed of change characteristic feature resultant factor, apart from the influence of other features considered random, and therefore not included in the analysis.
In our analysis, regression function was a linear feature evenly resultant, changing under the influence of changing factorial feature, the linear function that we used with the formula:

$$y = a + b\,x,$$

where y values resulting features depend only on x factor values. All other factors are considered constant.
Geometric regression coefficient b is the slope of the straight line. Coefficient was calculated using the method of smallest squares. From the linear regression coefficient b and the correlation coefficient r there was manifested relation:

$$b = \frac{\sigma y}{\sigma x} r,$$

where $\sigma y$ *şi* $\sigma x$ are standard medium deviations of r y, and x characteristics, $\sigma y$ *şi* $\sigma x$ concrete indicators, expressed by a certain unit of measure.
Their report showed that the linear regression coefficient shows how many units of the variable y per one unit of the variable x. In our case the coefficient has a negative correlation. The correlation coefficient, used to determine the intensity correlation, was calculated using the formula:

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{n\sigma x \sigma y}$$

where:
x – values of factorial features;
y - values of resulting features;
σ x – standard medium deviation of the feature x;
σ y – standard medium deviation of the feature y;
n – number of pairs of values observed attributes of features x and y
or

$$r = \frac{\overline{xy} - \bar{x} - \bar{y}}{\sigma_x \sigma_y}$$

where:
$\overline{xy}$ - average of products xy ($\overline{xy} = \frac{\sum xy}{n}$)
$\bar{x}$ and $\bar{y}$ - average of features x and y.

For the calculation of the correlation coefficient there was used the formula:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{[n\sum x^2 - (\sum x^2)][n\sum g^2 - (\sum g)^2]}}$$

We then determined curve adjustment operation that was useful, and had to be done; taking into account the data that must be adjusted. For this there was used a continuous, depending on the adjustment of a number of three parameters: temperature, rain, production.
Regarding interpretation of Seleaninov index, it is measured by SHR value for a given day, or the weather sizes given by Caracal station. Impact (on production) is given by compliance with certain values:

$$I(SHR) = \begin{cases} \min\{M, (1-SHR)*\theta\} & SHR \in [0,1.0) \\ 0 & SHR \in [1,1.4) \\ \min\{M, (1-SHR)*\theta\} & SHR \in [1.4,2) \end{cases}$$

where M is the average production, and θ is the analytical adjustment value.
The conditions necessary to obtain the best yields are when the SHR ε (1.0-1.4). When it exceeds 1.4, the output will decrease due to excessive moisture, and when it drops below 1.0, due to the drought. In general, a related SHRI isolinear equal to 0,5-0.6 coincides with semi-desert climate conditions.

## RESULTS AND DISCUSSIONS

**The Caracal Micro area** has in its components, beside city of Caracal, another 8 localities (Brastavăţu, Bucinişu, Deveselu, Obârşia, Redea, Rotunda, Traian and Vlădila). Agriculture in this micro area is well represented, the following data is very eloquent.
In the year 2012 compared to the Olt county, whose total area was of 549 828 ha, the micro-region was approximately 47 696 i.e. 9%. A similar percentage still holds in terms of agricultural area, the micro area Caracal holding 9.5% of the agricultural area of Olt County. As arable land, the micro area of Caracal had, in the year 2012 at the County level, accounted for over 10% of the total arable area.
In 2012, wheat was cultivated on an area of 19539 hectares, representing 18.1% of the total area cultivated with wheat in the County of Olt and wheat production was of 36905 tones (13.8% of the county's wheat production). Maize was grown in 2012, at the micro area level, on an area of 7015 ha (5.15% of the area cultivated with maize in Olt County) and maize production in the same year totaled 15,550 tons (8.68% of the

County). Sunflower was grown in 2012 on an area of about 9840 ha (19% of the county area planted with sunflower) products obtained being 8135 tones (13.53% of the County).

In the period 2004-2012, the area under wheat increased by 3.8%, the area under maize decreased by 46.8% and the area under sunflower has increased by 80%. During the same period wheat production fluctuated between a minimum of 59 198 tones in 2005 and a peak of 80,000 tons in 2011, the maize from a minimum of 3166 tones in 2007 and a maximum of 9429 tones in 2008, and the sunflower between a minimum of 15 549 tones in 2007 and a peak of 37,000 tons in 2004.

As shown in table 5, fluctuations in production are very high, as a direct consequence of changes in cultivated areas, especially the yields per hectare.

Table 5: The average production of wheat, maize and sunflower in areas of Caracal micro area, during 2004 - 2012 (tons/hectare)

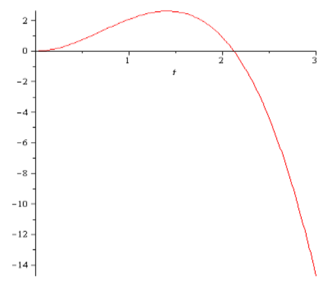
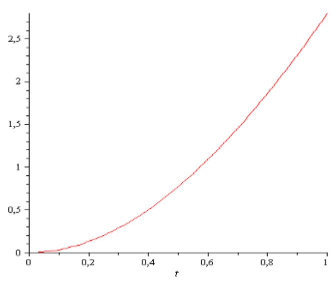
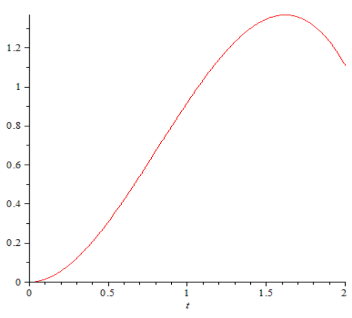
| Locality | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|
| Wheat | | | | | | | | | |
| Brastavăţu | 3.3 | 2.5 | 0.9 | 2.9 | 7.1 | 2.9 | 2.9 | 2.6 | 3.0 |
| Bucinişu | 3.3 | 2.2 | 2.3 | 1.0 | 3.2 | 2.8 | 2.8 | 2.8 | 0.9 |
| Caracal | 2.1 | 2.7 | 1.7 | 0.8 | 2.6 | 2.4 | 2.4 | - | 2.4 |
| Deveselu | 3.3 | 3.0 | 0.2 | 0.8 | 3.1 | 3.1 | 3.1 | - | 2.6 |
| Obârşia | 3.3 | 5.3 | 1.0 | 0.7 | 2.6 | 2.6 | 2.6 | 2.2 | 1.9 |
| Redea | 3.3 | 2.8 | 12.9 | 1.4 | 4.2 | 3.8 | 3.8 | 3.5 | 1.7 |
| Rotunda | 3.3 | 2.8 | 1.8 | 0.9 | 2.8 | 3.1 | 3.1 | 3.1 | 2.4 |
| Traian | 3.3 | 3.0 | 1.6 | 0.5 | 2.7 | 2.8 | 2.8 | 3.5 | 1.4 |
| Vlădila | 3.3 | 2.5 | 1.9 | 0.9 | 3.0 | 2.8 | 2.8 | - | 1.3 |
| Total | 3.2 | 3.0 | 3.5 | 1.1 | 3.6 | 3.1 | 3.1 | 1.5 | 1.6 |
| Maize | | | | | | | | | |
| Brastavăţu | 3.6 | 4.8 | 1.0 | 0.3 | 1.5 | 4.0 | 4.0 | 4.9 | 2.4 |
| Bucinişu | 3.6 | 5.0 | 2.0 | 0.5 | 3.0 | 3.3 | 3.3 | 3.1 | 1.6 |
| Caracal | 3.6 | 3.5 | 3.5 | 0.5 | 4.4 | 4.3 | 4.3 | - | 2.4 |
| Deveselu | 3.6 | 4.0 | 2.9 | 0.2 | 1.2 | 5.5 | 5.5 | - | 3.1 |
| Obârşia | 3.6 | 3.8 | 3.5 | - | 1.5 | 5.5 | 5.5 | 2.8 | 1.4 |
| Redea | 3.6 | 7.8 | 3.0 | 0.7 | 2.2 | 3.5 | 3.5 | 2.7 | 2.7 |
| Rotunda | 3.6 | 4.5 | 3.4 | 0.7 | 2.7 | 4.8 | 4.8 | 4.2 | 1.3 |
| Traian | 3.6 | 3.5 | 2.5 | - | 2.0 | 4.0 | 4.0 | 8.3 | 0.5 |
| Vlădila | 3.6 | 2.5 | - | 0.7 | 2.0 | 3.9 | 6.0 | - | 2.6 |
| Total | 3.6 | 4.4 | 2.7 | 0.5 | 2.3 | 4.3 | 4.1 | 4.3 | 2.0 |
| Sunflower | | | | | | | | | |
| Brastavăţu | 1.5 | 2.5 | 0.3 | 0.4 | 1.7 | 1.8 | 1.8 | 1.6 | 1.1 |
| Bucinişu | 1.5 | 2.0 | 1.5 | 0.4 | 1.1 | 1.6 | 1.6 | 2.3 | 1.2 |
| Caracal | 1.5 | 1.3 | 0.8 | 0.4 | 0.7 | 1.4 | 1.4 | 1.84 | 1.7 |
| Deveselu | 1.5 | 1.4 | 1.3 | 0.1 | 1.2 | 2.3 | 2.3 | 2.5 | 1.3 |
| Obârşia | 1.5 | 1.3 | 1.8 | 0.4 | 1.2 | 1.8 | 0.2 | 1.6 | 1.0 |
| Redea | 1.5 | 2.3 | 1.0 | 1.0 | 1.8 | 1.8 | 1.8 | 3.7 | 0.6 |
| Rotunda | 1.5 | 2.8 | 1.9 | 0.5 | 1.3 | 0.2 | 1.8 | 2.0 | 0.6 |
| Traian | 1.5 | 1.7 | 1.56 | 0.3 | 1.4 | 2.2 | 1.0 | 2.2 | 0.6 |
| Vlădila | 1.5 | 1.6 | 0.2 | 0.3 | 1.2 | 1.2 | 1.0 | 1.5 | 1.4 |
| Total | 1.5 | 1.9 | 0.9 | 0.6 | 1.5 | 1.6 | 1.5 | 2.5 | 1.0 |

Source: National Institute of Statistics

In the analyzed period, the strongest influence on productivity was of climatic conditions. To commensurate the climate impact on crops, we applied the index Seleaninov over crops of winter wheat, maize and sunflower, taking into account the growing in features and risks of these three crops in various stages of development (for wheat - April-June, for maize and sunflower - April to August).

Trying to correlate data on the production of wheat, maize and sunflower, with the Seleaninov index (based on temperature and precipitation) there were obtained regression curves like those in the following table (Table 6).

Table 6: Curves adjustment list

| Station | Crop | Seleaninov dependence curve adjustment ->Production Graphic | Indices point Loss production |
|---|---|---|---|
| Caracal | Wheat | $F_{griu}(x) = 3.943x^2 - 1.858x^3$  | 0.01<br>90 kg/indices point |
| | Maize | $F_{porumb}(x) = 3.386x^2 - 0.589x^3$  | 0.01<br>175 kg/ indices point |
| | Sunflower | $F_{floarea\ soarelui}(x) = 4.262x^2 - 2.341x^3$  | 0.01<br>45 kg/ indices point |

Source: own calculations

Following the Seleaninov Index in the last 9 years we find that in four years (2006, 2007, 2008 and 2012) there were droughts, which led to the loss of production from all three crops examined, only five years (2004, 2005, 2009, 2010 and 2011) can be considered normal in terms of temperature and precipitation (Table 7).

Table 7: Seleaninov Index and deviation from normal values – Caracal weather station

| 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| **Wheat** | | | | | | | | |
| Seleaninov Index | | | | | | | | |
| 1,11 | 0,98 | 0,85 | 0,8 | 1,03 | 1,06 | 1,01 | 1,01 | 0,84 |
| *Seleaninov* Index deviation from normal values (percentages) | | | | | | | | |
| - | 2 | 15 | 20 | - | - | - | - | 14 |
| **Maize** | | | | | | | | |
| Seleaninov Index | | | | | | | | |
| 1,32 | 1,15 | 0,83 | 0,78 | 0,82 | 1,1 | 1,08 | 1,02 | 0,81 |
| *Seleaninov* Index deviation from normal values (percentages) | | | | | | | | |
| - | - | 17 | 22 | 18 | - | - | - | 19 |
| **Sunflower** | | | | | | | | |
| Seleaninov Index | | | | | | | | |
| 1,32 | 1,15 | 0,83 | 0,78 | 0,82 | 1,1 | 1,08 | 1,02 | 0,81 |
| *Seleaninov* Index deviation from normal values (percentages) | | | | | | | | |
| - | - | 17 | 22 | 18 | - | - | - | 19 |

Source: own calculations

In these circumstances, we find that farmers in the micro area Caracal lose in terms of significant production in this period, as reflected by the Seleaninov index (Table 8):

Table 8: Production losses reflected by the Seleaninov index to normal values for winter wheat, maize and sunflower (kg / ha)

| 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|
| Winter wheat | | | | | | | | |
| - | - | 1530 | 1980 | 1620 | - | - | - | 1710 |
| Maize | | | | | | | | |
| - | - | 2975 | 3850 | 3150 | - | - | - | 3325 |
| Sunflower | | | | | | | | |
| - | - | 765 | 990 | 810 | - | - | - | 855 |

Source: own calculations

Losses were over 10 percent in all crops and for all years, the most affected being maize, which, for example in the last 7 years, the average losses to more than half (58.4% in 2006 over 75% in 2007, almost 62% in 2008 and 65.2% in 2012).

Sunflower crop was also affected by the drought in most years, with 38.9% in 2006, 50.3% in 2007, 41.2% in 2008 and 43.5% in 2012. Noticeable for this crop is the loss in 2007, when production was achieved in less than half the average annual long-range as specialists say, all crops being compromised.

Wheat has proved to be the best enduring crop to unfavorable evolution of climatic elements. The table shows that it has been less affected by the drought; production losses registered in the micro area of Caracal being 34.3% in 2006, 44.5% in 2007 and 36.3% in 2008, following three years are favorable for wheat, as in 2012 losses to be significant again, standing at almost 40% of the value.

We conclude that all these variations from one production year to another actually show vulnerability which exposed farmers in the study area, the climatic factor being decisive. And when we say this, we mean financial losses that farmers had to bear.

Table 9: Financial losses to the farmers reflected by the Seleaninov index to normal values for winter wheat, maize and sunflower (lei / ha)

| 2006 | 2007 | 2008 | 2012 |
|---|---|---|---|
| Winter wheat (kg/ha) | | | |
| 1530 | 1980 | 1620 | 1710 |
| Winter wheat (lei/ha) | | | |
| 474,3 | 1267,2 | 1134 | 1522,5 |
| Maize (kg/ha) | | | |
| 2975 | 3850 | 3150 | 3325 |
| Maize (lei/ha) | | | |
| 1011,5 | 2502,5 | 2236,5 | 2360,7 |
| Sunflower (kg/ha) | | | |
| 765 | 990 | 810 | 855 |
| Sunflower (lei/ha) | | | |
| 428,4 | 811,8 | 1012,5 | 1492,2 |

Source: own calculations

The following table presents what level stood for a hectare of crop losses in the micro area of Caracal, taking into account the losses of production and the prices of those years. As seen in the years that have losses in production (2006, 2007, 2008, 2012) there were recorded financial losses that varied quite much.

Thus, for the wheat crop, the biggest losses were obtained in 2012 (1522.5 Lei). This was due on the one hand, to large physical loss of that production year and, on the other hand, high wheat prices were recorded that year. Losses were recorded in 2007, severe drought year, when harvests were compromised micro area almost in total.

For maize, losses were even higher, reaching for example in 2007 to 2502.5 Lei to 2236.5 Lei in 2008 and 2360.7 Lei in 2012. Of the three crops analyzed losses were the lowest for sunflower crops (compared to the other two crops), varying between a minimum of 428.4 Lei in 2004, to a maximum of 1492.2 Lei in 2012.

## CONCLUSIONS

Impact of climate variability on growth and development of agricultural crops is quantified by the potentiality of weather parameters to ensure optimum growing conditions or adverse effects.

For Romania, in general, and Oltenia and Caracal micro region, in special, climate change has had and will have a significant impact on the development of natural conditions. Here, agriculture and biodiversity are the area's most vulnerable to the effects of these changes given to the dependence of climatic conditions and to the negative effects of ecological, economic and social conditions.

Actually, a big part of Oltenia area presents an increased risk to droughts and have a tendency to aridity and desertification.

Our research was concentrating to the evaluation of implication of risk involved in agriculture. Calculation of Seleaninov indexes and their correlation with the economic and financial results at Caracal micro region level come to confirm that the agriculture is increasingly volatile to climate change variations. In addition, the yield variations and the financial results have direct implications on income levels and living standard.

Based on the results obtained, we conclude that the maize crop is exposed to losses and the least exposed is the sunflower. Wheat performed relatively better than corn, as demonstrated by the reduction in the period of corn acreage and a slight increase in areas planted with winter wheat. Therefore, we conclude that variations from one production year to another actually show vulnerability of exposed farmers in the study area, the climatic factor being decisive. And when we say this we mean financial losses that farmers had to bear.

In these conditions, to counter the effects of agro-climatic risks involved in production for the Caracal micro region we propose:

- Measures to improve the efficiency of water resources, especially for maize;
- Adaptation measures to climate change:
  - Farming practices to reduce effects such as: a selection of agricultural measures allowing water preserving; assessment and quantification measures; develop immediate and adaptation strategies in the future;
  - An efficient crop management and land use: selection of varieties/genotypes; crop rotation; tillage system;
  - Risk management and climate change impacts on agricultural productivity through the adoption of strategies including: a diagnosis and prognosis of their occurrence; monitoring of such phenomena; environmental protection measures by specific plant technology systems and ways of use adapted to local conditions; the support of agricultural technology and alternative agricultural management practices in order to prevent and mitigate the possible negative effects on the vegetation and agricultural yields in areas most vulnerable to climate risks.
- Measures on the development of an efficient agricultural insurance.

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