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THE ANALYSIS OF THE RELATIONSHIP BETWEEN CLIMATIC WATER DEFICIT AND CORN AGRICULTURAL PRODUCTIVITY IN THE DOBROGEA PLATEAU

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Abstract. This paper attempts to analyze the potential relationship between the climatic water deficit of the vegetation period of corn (April-September) and its agricultural yield, recorded in the Dobrogea plateau between 1990 and 2003. The data included in this study comprise spatialized climatic water deficit values (mm) (computed as the difference between precipitation and potential evapotranspiration), obtained through interpolation methods based on ten regional weather stations and corn crop yield data (t/ha/year) in 99 territorial administrative units, almost entirely overlapping the analyzed geographical region. The study essentially aims to identify the statistical connection between the independent variable (climatic water deficit) and the dependent one (agricultural yield) over 14 years - to this end, a series of detailed statistical correlations were applied to both variables. The results showed a statistically significant relationship especially in the plateau's central-southern region, where agricultural productivity is obviously dependent to a higher extent on climatic conditions, compared to the northern study area where, according to statistical results, there are additional factors significantly influencing crop yields. Regarding the quantification of the statistical relationship in the central-southern area in the analysed period, an average dependence of approx. 40% of corn yields was found in relation to climatic conditions, with regional differences ranging from 23% to 51%. Also, while an 8.3 kg/ha/year average decrease of corn productivity was observed for a 1 mm climatic water deficit increase, in certain areas (south-western sectors) values go as high as 11 kg/ha/year (which is rather high given that, for instance, for a 100 mm humidity deficit increase, agricultural productivity-related losses reach 1.1 t/ha/year).

Keywords: Dobrogea, crop yield, corn, climatic water deficit, statistical correlations.

1. INTRODUCTION

The impact of climate change is now a major concern of the scientific community and policy makers concerned with improving analysis methods and identifying solutions in order to mitigate these imbalances. The effects of climate change are increasingly noticeable on both the natural environment, and the economic and social components of the affected territorial systems (Klein Tank & Können, 2003; Vespremeanu-Stroe & Tătui, 2011; Chamchati & Bahir, 2011; Abbaspour et al., 2012; Chuai et al., 2012; Wadhams, 2012; Meddi et al., 2013; Prăvălie, 2013; Prăvălie et al., 2013a; Rangecroft et al., 2013; Nandintsetseg & Shinoda, 2014; Prăvălie et al., 2014; Scasta & Rector, 2014). These changes were outlined by the Intergovernmental Panel on Climate Change (IPCC, 2007), which suggests the augmentation of climate effects on all components of territorial systems.

Agriculture is one of the most sensitive components of the economic system, which, under the impact of climate change, undergoes major fluctuations, thus resulting a chain of imbalances in other elements of local systems (Bouma et al., 1998; Parry et al., 2004). These imbalances are frequently magnified by other disturbances such as changes in land ownership regime, in the sense of intensified fragmentation, or in central agricultural support policies (Prăvălie et al., 2013b; Peptenatu et al., 2013).

All these changes can generate functional ruptures that can escalate uncontrollably in local agricultural systems, with potentially extremely high associated management costs. However, alongside weather conditions, there are other variables that can influence agricultural systems, such as soil characteristics, land use, infrastructure conditions, or the territorial systems' ability to cope with change (Reilly et al., 1994; Bouma et al., 1998; Reilly & Schimmelpfennig 1999; Olesen et al., 2011; Dawelbait & Morari, 2012).

Therefore, approaching the climate change impact on agriculture is a pragmatic way of identifying coherent strategies to mitigate the resulting imbalances, as part of the spatio-temporal planning of territorial management policies so as to reduce the additional costs their delay might generate. The analysis of climate change impact on agricultural production systems should be a compulsory element of development strategies of local systems – in the absence of such analyses, it is difficult to design models capable of ensuring a functional dynamic balance. The policy makers' strategies can ensure an optimal functional state of territorial systems affected at a certain time by climate change, as well as by other environmental issues (Braghină et al., 2011; Mocanu et al., 2011; Peptenatu et al., 2011; Vanderpost et al., 2011; Nikolova & Boroneanţ, 2011; Arheimer et al., 2012; Peptenatu et al., 2012; Ianoș et al., 2012; Piwowarczyk et al., 2012; Amin et al., 2013; Brown et al., 2014).

The present study examines the impact of climate conditions on local agricultural systems in south-eastern Romania, the study area currently being considered to have the most arid climate conditions in the country (these conditions having intensified over the past few decades against the background of global climate change).

2. DATA AND METHODS

The study area covers approximately 12 000 km², overlapping a total of 99 administrative units (Fig. 1). It mainly corresponds to the Dobrogea Plateau, except for certain small-scale areas in the west and east, where the boundaries of administrative units intersect the Danube floodplain or the Razim Sinoe lagoon complex.

In terms of climate, the study area (including the lagoon complex and the Danube Delta) is considered to be the most arid region (semiarid and dry sub-humid climate) in the country (Păltineanu et al., 2007; Păltineanu et al., 2009; Bandoc & Golumbeanu, 2010; Bandoc, 2012a; Bandoc 2012b; Croitoru et al., 2013), with annual climatic water deficit values generally lower than -200 mm at most weather stations over the past five decades (with a maximum deficit exceeding -400 mm at Sulina station, located in the far east).

In terms of agriculture, corn is the main agricultural crop in the Dobrogea Plateau, alongside wheat and sunflower. Although it is a drought-resistant plant, the high levels of climatic water deficit, typical to this region, are currently showing a significant impact on corn crop yield, especially due to irrigation deficiencies which have become increasingly noticeable after 1990, along with the progressive collapse of irrigation systems in the study area, as well as throughout the entire country (Grumeza & Klepş, 2005).

The paper is based on two data sets, namely climate data and agricultural data.

The climate data (mean temperatures and precipitation) were provided by ten weather stations - Galaţi, Brăila, Tulcea, Hârşova Jurilovca, Medgidia, Adamclisi, Călăraşi, Constanţa and Mangalia (Fig. 1) -, over a relatively short period (1990 - 2003), depending on the availability of agricultural data. The data source was the European platform for climate data ECA&D (European Climate Assesment and Dataset) (Klein Tank et al., 2002) for the Galaţi, Tulcea, Călărași and Constanţa stations, the National Meteorological Administration (NMA, 2012) for the Hârșova, Jurilovca, Medgidia, Adamclisi and Mangalia stations, and Vișinescu et al., (2003) for the Brăila station (for the 1990-2002 period; the data for 2003 were provided by the National Meteorological Administration).

The climatic data were used in order to compute the climatic water deficit (CWD), considered to be a good parameter for quantifying the climate-crop yield relationship, as it integrates two key parameters and expresses a given territory's synthetic climatic water balance. It is computed based on the difference between precipitation (P) and potential evapotranspiration (PET); the latter is obtained based on the temperature parameter, using the Thornthwaite method (Thornthwaite, 1948).

The deficit data were obtained by considering the difference between total rainfall and evapotranspiration recorded during the vegetation period of corn (April-September), based on spatialized values of the two parameters.

Figure 1. Location of the study area in Romania.

The spatial data were therefore obtained by means of interpolation, separately for each year. In order to obtain the climatic water deficit, a first stage consisted in spatializing the rainfall and potential evapotranspiration parameters separately, consequently obtaining the climatic deficit based on their difference in the ArcGIS 9.3 software.

The spatialization of rainfall and potential evapotranspiration was based on data provided by the 10 weather stations. The ordinary kriging, universal kriging and regression - kriging methods were performed, using the Geostatistical Analyst module. Theoretical details regarding these methods, along with application instances, can be found in numerous specialized papers (Dobesch et al., 2007; Li & Heap, 2008; Patriche, 2009).

The predictors used for improving the spatial interpolation models were the numerical terrain model obtained through SRTM, the X and Y coordinates and average rainfall (April-September) between 1950 and 2000 (predictor used in precipitation interpolation), found in the WorldClim global database (Hijmans et al., 2005) (Table 1).

In the case of the numerical terrain model, statistically significant correlations with climate data were only found for potential evapotranspiration values, and solely in two instances (1991 and 1995) (Table 1). With regard to the X and Y coordinates, where rainfall and evapotranspiration values had significant correlations, universal kriging was applied (Table 1), which first determines a general rainfall spatial trend, quantified by polynomial functions (this analysis used only first order functions), and subsequently interpolates, through ordinary kriging, all deviations from this trend (Matheron, 1969; Goovaerts, 1997). Ordinary kriging was used for insignificant correlations. This is a local interpolation method based on the spatial autocorrelation of a variable's values. This spatial dependence is quantified through variograms, which are then used to determine the weighting coefficients for the recorded values (Goovaerts, 1997; Burrough & McDonnell, 1998).

Using WorldClim data as a predictor for precipitation is appropriate, as while the spatial distribution of rainfall has a distinct pattern every year, there is a theoretical general level, a multiannual average distribution, compared to which rainfall distribution values recorded in a given year deviate to a lesser or greater extent, negatively or positively.

Therefore, when significant correlations were found between rainfall and average WorldClim values, linear regression was applied and the residual data were interpolated by ordinary kriging - this hybrid method is called regression-kriging (Hengl et al., 2007). For potential evapotranspiration, most models were of ordinary or universal kriging types, except for the years 1991 and 1995 (Table 1).

Table 1. Linear correlation coefficients between the dependent variables and potential predictors, and types of interpolation methods used for rainfall and potential evapotranspiration between 1990 and 2003.

Dependent variable/years		**Predictors**				**Interpolation methods**
		SRTM	X	Y	Rainfall WorldClim	
Rainfall	1990	0.494	-0.348	0.049	0.484	Ordinary kriging
	1991	0.266	**-0.650**	0.305	**0.722**	Regression- ordinary kriging
	1992	0.444	-0.519	-0.004	**0.630**	Regression- ordinary kriging
	1993	0.334	**-0.623**	-0.110	**0.643**	Regression- ordinary kriging
	1994	0.475	**-0.767**	0.110	**0.827**	Regression- ordinary kriging
	1995	0.587	-0.442	**-0.695**	0.355	Universal kriging – first order global trend
	1996	-0.007	-0.389	0.150	0.468	Ordinary kriging
	1997	0.313	-0.280	-0.031	0.355	Ordinary kriging
	1998	0.571	-0.426	-0.406	0.411	Ordinary kriging
	1999	0.325	**-0.753**	-0.258	**0.760**	Regression- ordinary kriging
	2000	0.111	**-0.705**	0.193	**0.754**	Regression- ordinary kriging
	2001	0.270	**-0.606**	0.077	**0.664**	Regression- ordinary kriging
	2002	0.585	-0.469	-0.595	0.326	Ordinary kriging
	2003	0.459	**-0.821**	-0.421	**0.770**	Universal kriging – first order global trend
Potential evapotranspiration	1990	-0.108	**-0.692**	0.400	-	Kriging universal – first order global trend
	1991	**-0.839**	0.181	0.300	-	SRTM regression – ordinary kriging
	1992	-0.269	-0.428	0.243	-	Ordinary kriging
	1993	0.016	**-0.760**	0.208	-	Universal kriging – first order global trend
	1994	0.021	-0.573	0.344	-	Ordinary kriging
	1995	**-0.650**	-0.267	0.296	-	SRTM regression – ordinary kriging
	1996	-0.061	**-0.669**	0.248	-	Universal kriging – first order global trend
	1997	-0.447	-0.404	0.230	-	Ordinary kriging
	1998	-0.132	-0.531	0.198	-	Ordinary kriging
	1999	-0.519	-0.390	0.297	-	Ordinary kriging
	2000	0.119	**-0.772**	0.228	-	Universal kriging – first order global trend
	2001	-0.032	-0.593	0.077	-	Ordinary kriging
	2002	-0.595	0.197	0.425	-	Ordinary kriging
	2003	0.053	**-0.760**	0.202	-	Universal kriging – first order global trend

Note: in bold, statistically significant correlations for a 0.05 significance level (Fisher-Snedecor test).

The agricultural data consist of corn crop yields (CCY), expressed in t/ha/year, recorded between 1990 and 2003 in 99 territorial administrative units (Fig. 1), provided by the County Department for Statistics Tulcea and Constanța (CDSTC, 2013). Corn crops (*Zea mays* L.) were chosen for this analysis after having considered data availability, the plant's importance in terms of total crop surface, and climate aspects related to the highest values of climatic deficit throughout the year overlapping with the vegetation period of corn in this region of the country (April-September).

The analysis of the climate's impact on corn crop output (yield) was performed using statistical correlations between climatic water deficit values and corn yield data. Climatic water deficit (CWD) values (mm) were computed as the arithmetic mean of spatialized deficit raster pixels, with Thiessen-Voronoi polygons, delineated by GIS techniques in order to identify the weather stations' areas of influence (Fig. 1). The yield values (t/ha/year) were obtained through the arithmetic mean of administrative units overlapping by at least 50% with the area of the ten polygons delineated.

Thus, two data sets, each comprising 140 entries, were available (14 years x 10 Thiessen areas). Before addressing the data processing, it is noteworthy that the data series did not include any mention regarding the contribution of irrigation (or of other factors) to the climatic water deficit supplementation. Basically, in the present study there is no additional information on other humidity factors that could influence the recorded yields, namely in which areas and in which years corn crops were irrigated and to what extent, or if they were influenced by other factors (e.g. groundwater level).

The preliminary analysis using the Shapiro-Wilk's W test (Royston, 1982) showed that none of the indicators had a normal distribution (e.g. Fig. 2), and that they all exhibited apparent asymmetries. For example, in the case of CWD the null hypothesis is that the data set comes from a normal distribution. The test statistic W is 0.8823, while the p-value equals 0. In such a way, the null hypothesis is rejected, and we can presume that our data are not normally distributed. Therefore, further analysis requires that our data must undergo some transformation in order to fit normal distribution.

The simple transformations used to correct asymmetries (logarithms and square root extraction), applied to the entire distribution, did not work. It is therefore necessary to correct the distribution by eliminating extreme values, which are generated by certain exceptional circumstances.

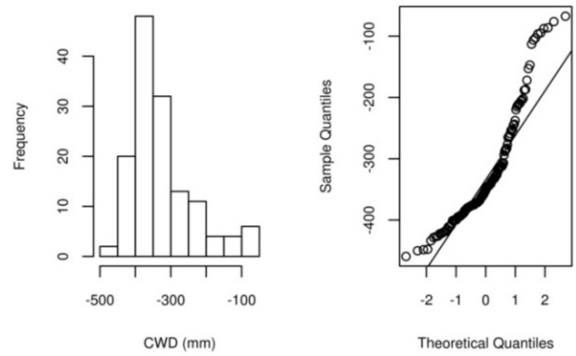

Figure 2. Histogram (left) and normal q-q plot (right) of asymmetric distribution of CWD

The identification of potential candidates for removal was done by the cluster method. The single linkage clustering method (Gordon, 1999), using both indicators, revealed the existence of seven distinct clusters.

Therefore, most of the data (126) were included in the first cluster, while the other six clusters consisted almost exclusively of values recorded in 1991 and 1997 ((Fig. 3 (left)). Considering these six clusters to be extreme cases, further analysis was conducted on the first cluster. While corn yield values in the first cluster represent a normal distribution, the climatic water deficit required a series of transformations: a constant was added to every value, the minimum dataset value plus 1, after which a square root was extracted from the resulting sum. This method solved the problem of negative values, which occurs during conversion, and corrected the distribution's asymmetry (right).

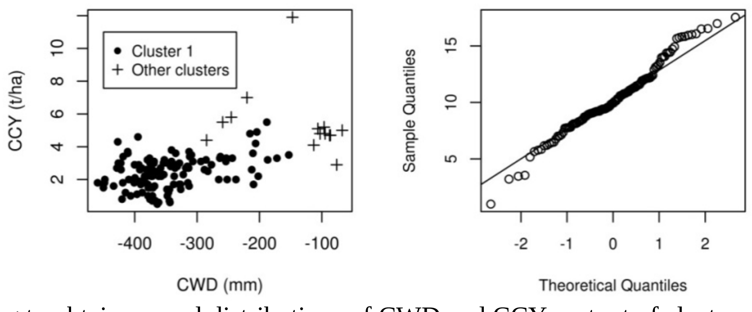

Figure 3. Data processing to obtain normal distributions of CWD and CCY: output of cluster analysis (left), and normal q-q plot of transformed CWD (right).

3. RESULTS AND DISCUSSIONS

3.1 Interannual climatic and agricultural variability between 1990 and 2003

Following the variation of corn crop yield and that of climatic water deficit (data resulting from interpolations) in the study area (Fig. 4, 5), a general similarity can be noticed among the interannual oscillations (1990 - 2003) of the two variables (in the Thiessen polygons), which confirms a link between the independent variable, the climate, and the dependent one – crop yield (Fig. 6).

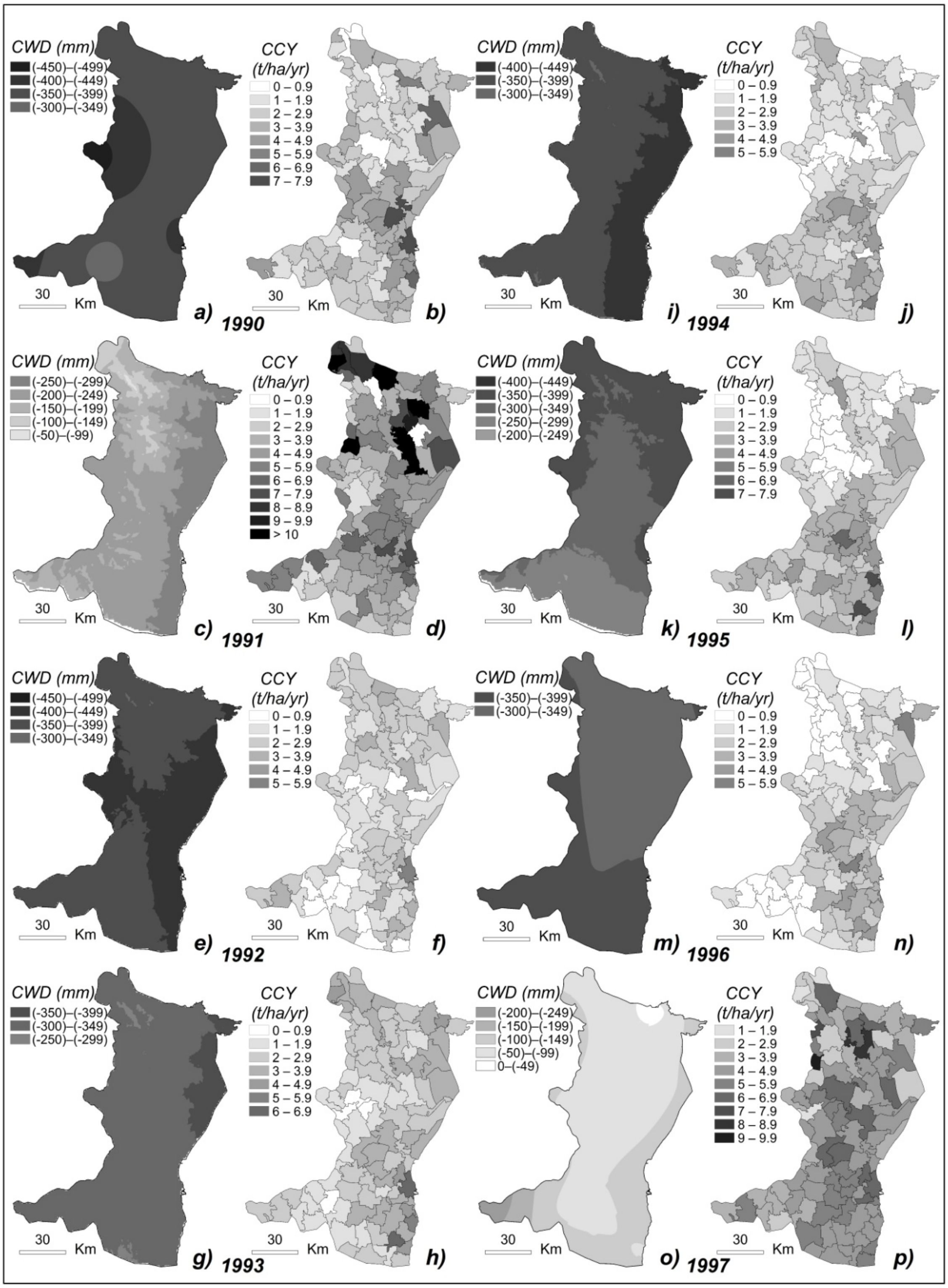

Figure 4. Spatial representation of the CWD between April and September and CCY values in 1990 (a, b), 1991 (c, d), 1992 (e, f), 1993 (g, h), 1994 (i, j), 1995 (k, l), 1996 (m, n) and 1997 (o, p).

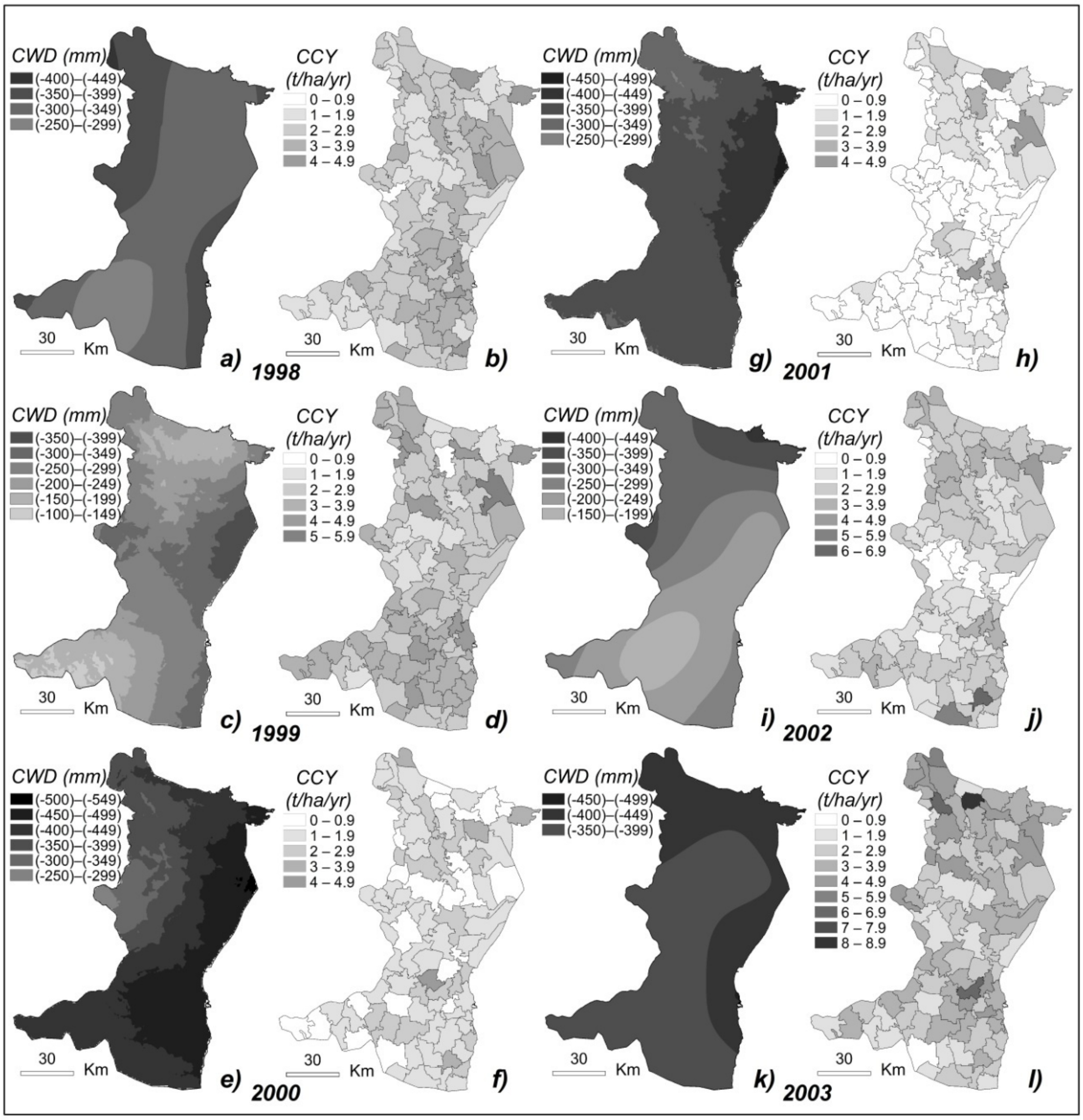

Figure 5. Spatial representation of the CWD between April and September and CCY values in 1998 (a, b), 1999 (c, d), 2000 (e, f), 2001 (g, h), 2002 (i, j) and 2003 (k, l).

For instance, the years 1991, 1997 and 1999 are characterized by lower water deficit and higher yield values, while in the years 1992, 2000 and 2001 lower crop yield values can be noticed, against the background of high climatic deficit values (Fig. 4, 5).

In terms of climate, this is mostly due to the corn ecological requirements on moisture conditions, which presented certain particularities during the reviewed period. Usually, for the conditions recorded in Romania, the minimum amount of rainfall during the corn growing season is of about 250-300 mm, while the optimum amount needed to sustain an above average crop output is of about 300-400 mm (Salontai & Muntean, 1982; Bîlteanu, 2003). Considering the heavily humidity-deficient years, it can be noticed that they were characterized by very low rainfall, generally under 250 mm for the growing season (for most of the weather stations) – this parameter is the main restrictive factor for agricultural output.

Although the high potential evapotranspiration values can cause direct or indirect consequences in lowering agricultural yields (the average value of about 600 mm for most of the weather stations, notably exceeding average rainfall values), the data series analysis showed that, generally, this parameter presented a more constant interannual nature when compared to the pronounced temporal dynamics-characterized rainfall, responsible for the powerful fluctuations in agricultural production.

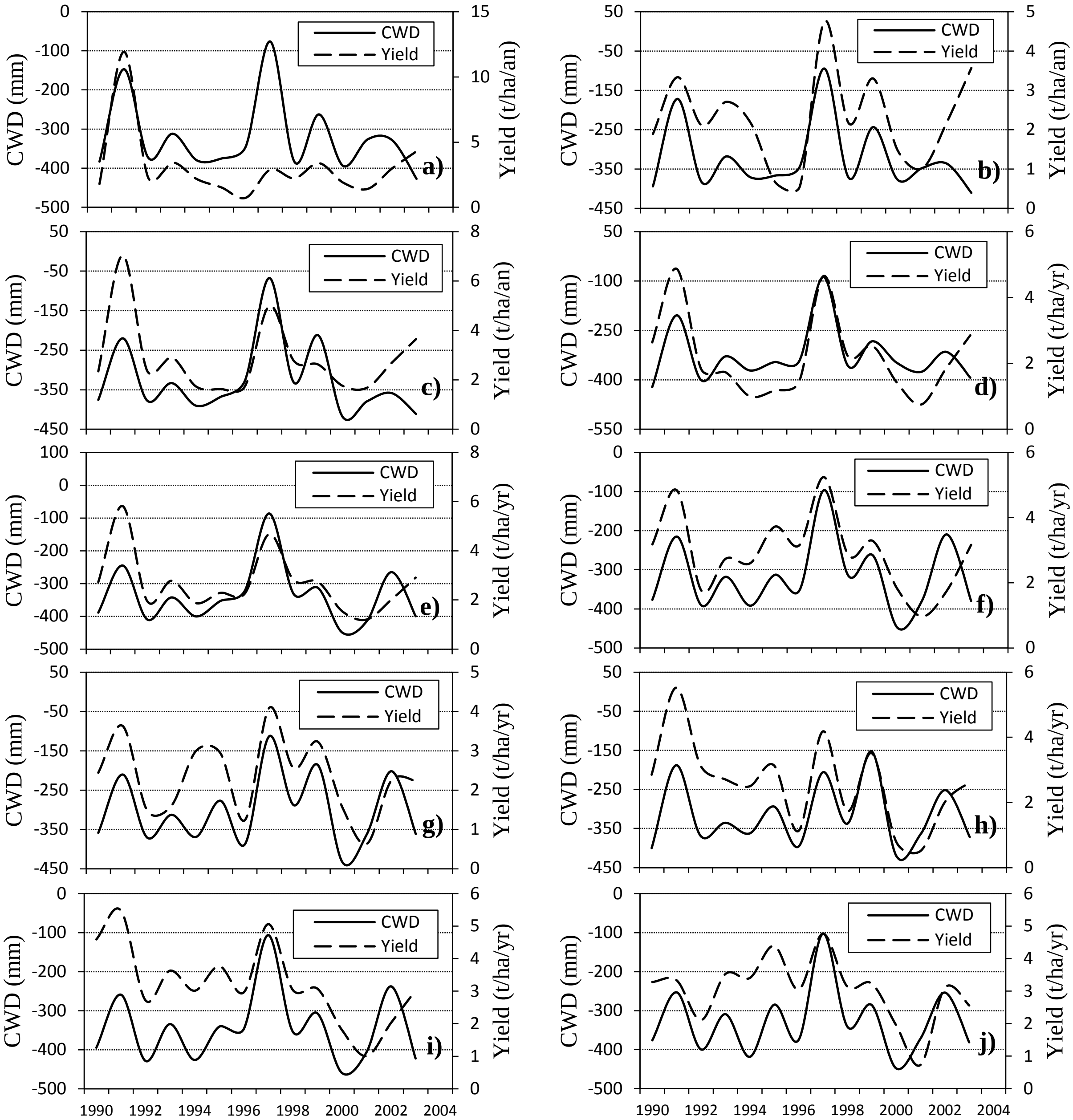

Figure 6. Interannual variation (1990 - 2003) of CWD (obtained through the pixel deficit average in the Thiessen areas) and the corn production yield (the average for the administrative units classified in the Thiessen polygons influence area) for the Galaţi (a), Brăila (b), Tulcea (c), Hârşova (d), Jurilovca (e), Medgidia (f), Adamclisi (g), Călăraşi (h), Constanţa (i) and Mangalia (j) weather stations.

Moreover, the variation coefficient computation confirmed the greater variability of precipitation, with values between 30-40% for the ten weather stations (accurate values recorded at the stations), compared to values of 3-4% for the potential evapotranspiration, an aspect which suggests a precipitation variability ten times higher than that of evapotranspiration.

However, it is noteworthy that the uniform rainfall distribution during the growing period is even more important than the mentioned minimum or optimal quantities, of which the most important are the precipitations in May, June and July (Pandreea, 2012). According to specialized studies, uniform rainfall distribution for obtaining optimum production must cover a quantity of 60-80 mm for May, 100-120 mm for June, 100-120 mm for July and 40-60 mm for August (rainfall for April is less important) (Salontai & Muntean, 1982; Bîlteanu, 2003), heavy rainfall in September is sometimes harmful to production, as it extends the growing period (Pandreea, 2012). A rainfall quantity temporal analysis for the most important months in terms of humidity shows that these thresholds were not met in most cases (Fig. 7a-j). In general, August recorded the most cases (number of years) with optimum rainfall quantities, followed by May, June and July (Fig. 7k, l). This highlights the fact that the biggest rainfall non-uniformity (in terms of corn optimum humidity requirements) was recorded during the hottest month of the year, resulting an even further augmented climatic stress on agricultural yields.

Besides the climatic water balance, another climatic element, temperature, can become an additional conditioning factor of crop output, when

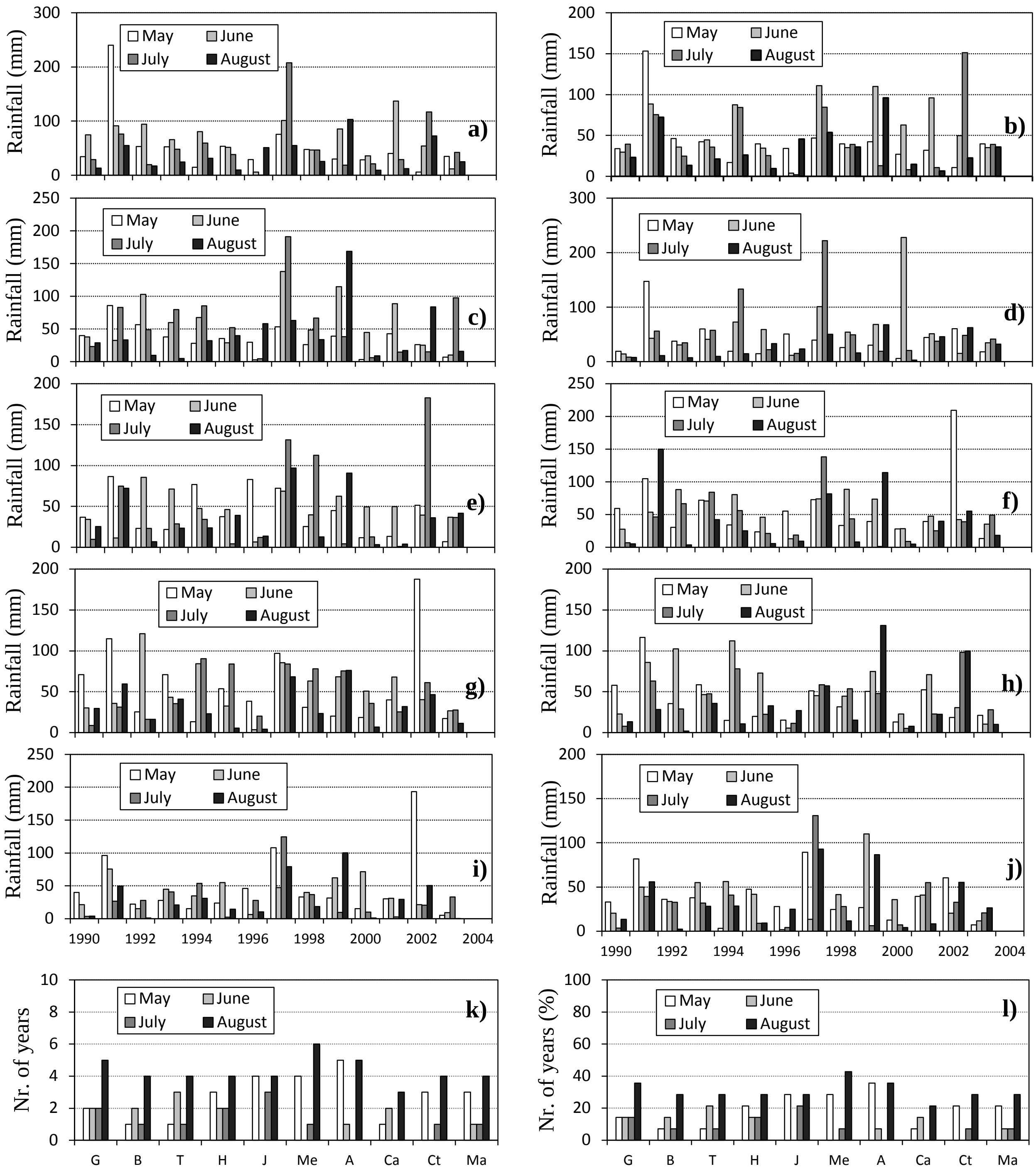

Figure 7. Interannual rainfall quantity variation (mm) for the May-August period, as recorded at the Galati (a), Brăila (b), Tulcea (c), Hârşova (d), Jurilovca (e), Medgidia (f), Adamclisi (g), Călăraşi (h), Constanţa (i) and Mangalia (j) weather stations; distributions of the number of years (k) and the percentage of the total 14 years analyzed (l) with optimal rainfall during 1990-2003, for the May-August period (60 mm minimum in May, 100 mm in July and August and 40 mm minimum in August), for the Galaţi (G), Brăila (B), Tulcea (T), Hârşova (H), Jurilovca (J), Medgidia (Me), Adamclisi (A), Călăraşi (Ca), Constanţa (Ct) and Mangalia (Ma) weather stations.

reaching minimal or maximal values; however, for the study area, the temperature generally addresses most of the optimal thermal requirements of corn, which range from 16°C to 19°C between April and September (Lungu, 2009); this parameter is therefore not a restrictive factor for this particular case. There are monthly differences in thermal requirements in this case as well (for instance, the required minimum average germination temperature for April is of about 8-10°C, followed by a 13°C minimum in May and higher temperatures in the other months), but these conditions are met for both the analyzed plateau area and the entire Dobrogea surface (including the delta and the lagoon complex) (Lungu, 2009). In addition, this issue was confirmed upon the consultation of local climate data.

3.2 The analysis of the statistical relationship between the climatic water deficit and recorded agricultural yields

By presenting all these aspects connected to the empirical assessment of the climate-crop output oscillation relationship, the statistical analysis showed that there was a connection (statistically significant) between the two variables only in certain situations. In conducting the statistical analysis, the correlational analysis was performed in two ways: on the one hand, it sought to identify the links between climatic water deficit and corn productivity for the entire area, using the truncated data sample left after having removed the extreme values, with the converted CWD indicator. Its size consists of 126 entries, which is 90% of the available data. On the other hand, each Thiessen area received a correlational analysis using the entire unprocessed data stock. The analysis was applied to the 10 Thiessen areas, each containing 14 values.

Therefore, there is a weak correlation between variables when considering the entire study area (Fig. 8). Although the relationship is significant, the climatic water deficit would only contribute by 12% to the corn production variation. The contribution of other environmental factors is extremely noticeable in this case.

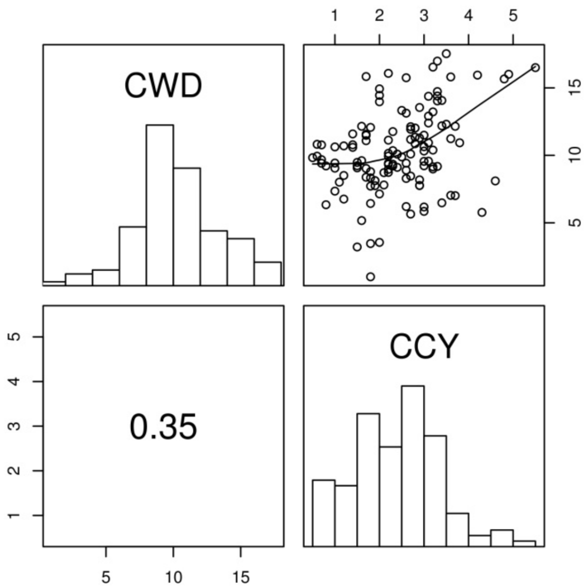

Figure 8. Correlation pair plot between CWD and CCY: histograms (upper-left and lower-right panels), pair plot (upper-right panel) and correlation coefficient (lower-left panel).

The analysis applied separately for each of the Thiessen areas shows a different view (Fig. 9). For five of the areas, transforming the data sets in order to satisfy the normality criterion did not provide satisfactory results. At the same time, the variables recorded in the other five areas (Adamclisi, Călăraşi, Constanţa, Mangalia and Medgidia) satisfy this criterion without any prior transformation.

The results obtained through linear regression modeling show that the water deficit, for the five Thiessen areas (polygons), is responsible for corn productivity to a variable extent, ranging from 23% to 51% (about 40% on average) (Table 2). The positive inclination of the regression line indicates a direct relationship between the parameters (Fig. 9). Therefore, it was found that a 1 mm increase of the climatic water deficit would lead to a 7.1 – 11.0 kg/ha decrease in corn productivity (Table 2).

Grouping the data from these five areas into a single sample (with 70 entries) and constructing a linear regression (Fig. 9), we obtain a valid result by using the transformed values of the water deficit,

Table 2. Parameters of the regression analysis for the five normal distributions Thiessen polygons.

Thiessen areas	Dependent variable	Independent variable	Intercept	Slope	R^2 adjusted	p-value
Adamclisi	Corn crop yield (CCY)	Climatic water deficit (CWD)	4.69	0.0078	0.51	0.002
Călărași			6.07	0.0110	0.45	0.005
Constanța			5.67	0.0071	0.23	0.046
Mangalia			5.49	0.0075	0.39	0.001
Medgidia			5.47	0.0080	0.37	0.013

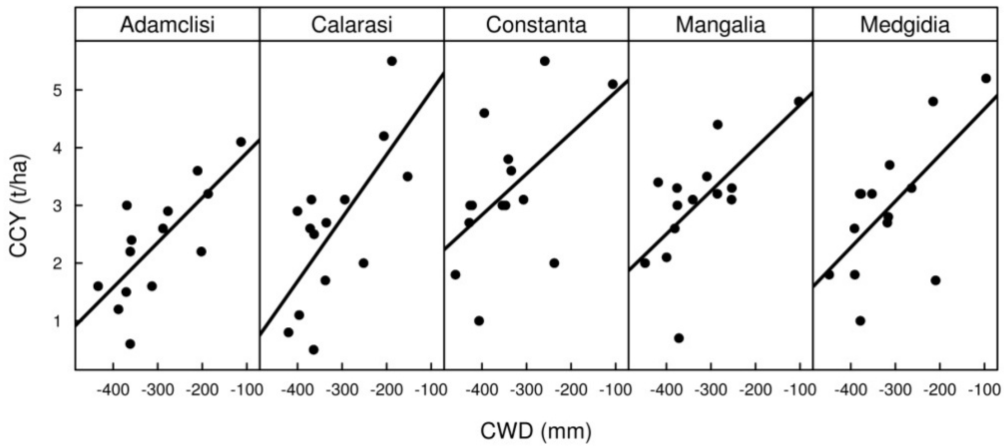

Figure 9. Pair plot of CCY vs. CWD for five Thiessen polygons (regression line shown in black).

instead of the normal values used for each zone separately. This model shows that the relationship between the two parameters is proportional to the square root of the independent variable. The water deficit contribution to corn productivity variation, for this case, would be generally of 29% for Southern Dobrogea.

The fact that the determination coefficient values are not very high for the areas showing satisfactory statistical results (Adamclisi, Călărași, Constanţa, Mangalia and Medgidia) may be justified through certain important variables, other than climatic component, which play an essential role in agricultural yield dynamics, including corn. These variables can be natural (e.g. soil and groundwater characteristics, extreme weather events such as hail, certain diseases and pests) and anthropic, depending on the human management of agricultural systems (e.g. irrigation, agricultural parcel fragmentation, the amount of applied fertilizer, crop farming techniques, maintenance activities); however, no such data was available for the present study in order to complete the climate analysis.

For instance, in terms of environmental requirements for groundwater and soil conditions, corn crops prefer an optimum groundwater level ranging from 1.5 to 3.5 m, as well as friable soils (especially loam and sandy loam soils), with a favorable aero-hydric regime; clay soils that crack during the summer due to high temperatures, breaking the corn root system, are not recommended (Roman et al., 2006). Still, the most important cause of agricultural fluctuations can be linked to faulty anthropic management, as irrigations represent one of the main conditions for obtaining high production. Their countrywide collapse after the political transition of 1990, including the largest irrigation system in Romania (Carasu system in Southern Dobrogea) (Grumeza & Klepș, 2005), represented a major cause in the decrease of agricultural production in the study area, as well as in many other cases across the country.

The high degree of agricultural parcel fragmentation, a process amplified in most agricultural regions of Romania by changes in land ownership regime as a result of the 18/1990 law, may be another important cause for the agricultural production decrease. Other possible causes of the corn production dynamics could be linked to fertilizer quantity, as for a 10 tons/ha/year crop output, which is considered high, the fertilizer quantities needed to cover the entire area may reach 280 kg for N, 140 kg for P_2O_5 and up to 260 kg for K_2O (Pandreea 2012). The crop farming techniques (density, depth of sowing, etc) and the maintenance activities (weed-check-ups, Fusariose-type diseases) may represent important elements influencing the resulting harvests (Roman et al., 2006).

All these issues, connected to the influence potential of other environmental factors on agricultural yield, are valid for the Thiessen areas where statistical results were obtained by correlating data on the two indicators, and especially for the other five areas (Galaţi, Brăila, Tulcea, Hârşova and Jurilovca), where it is very likely that these factors play a larger role in agricultural system dynamics.

4. CONCLUSIONS

After a preliminary evaluation of the oscillations of the two indicators analyzed between 1990 and 2003, a connection can be noticed between climatic and agricultural components. However, detailed quantitative analyses showed that the independent variable (climatic) and the dependent variable (agricultural) present limited statistical relationships, for about half of the study area (central-southern area).

Therefore, in the central-southern region of Dobrogea Plateau, an average dependence of about 40% of corn yields was found with regard to climatic water deficit (the 51% peak corresponds to the Adamclisi climate zone, which means that, in this particular case, more than half of the agricultural yield variability was due to climatic factors). An average, corn productivity sensitivity of 8.3 kg/ha/year was associated to a one unit-climatic deficit variation (this sensitivity reaches a maximum value of 11 kg/ha/year in Calarasi Thiessen area, which means that this agricultural value would be lost in the case of a 1 mm climate deficit increase).

However, given that over the entire study area climatic factors are not the main contributors to corn agricultural yield dynamics changes, other elements must be sought out and entered into models.

Our analysis suggests that the additional factors have a considerable influence, especially in the northern half of Dobrogea, where there is a large climatic and agricultural data heterogeneity which did not allow a normal distribution, despite having applied the appropriate statistical adjustments. The models built for the southern half of the studied area show, above all, that agriculture in this area is much more dependent on water climate characteristics than in the north, as demonstrated by the significantly higher data oscillation similarity, which were statistically correlated even without prior processing.

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