DE GRUYTER OPEN

DOI 10.1515/pesd-2015-0007 PESD, VOL. 9, no. 1, 2015

ELEMENTS OF CLIMATE EVOLUTION IN THE AREA BETWEEN PRUT AND DNIESTER RIVERS. LANDSCAPE AND PEDOGENETIC IMPLICATIONS

Gheorghe Jigău [1], Liviu Apostol[2], Ana Barsan[1], Elena Tofan[1]

Keywords: pedogenetic, climate evolution, Prut and Dniester rivers.

Abstract. Component part of the Carpathian-Danubian-Pontic space, the interfluve area between Prut and Dniester is subject to the regional process of climate evolution and change. In what regards the concept of human-influenced pedogenesis, the role of the biological factor is significantly reduced. As a consequence the direction and intensity of the elementary landscape and pedogenetic processes are determined by the relations between climate and the geomorphological factor. In the conditions of a relative stability of the geomorphological factor, the determining role is held by climate. To this is added soil vulnerability to the implications of climate changes, determined by the degree of soil physical degradation but also by a series of intrinsic and external (drainage) factors. This implies the idea of the control and management of the landscape and pedogenetic implications of climate changes by improving soil physical characteristics.

Introduction

In diverse forms and with different intensity, climate changes are felt by all world countries. Their impact represents combinations of slow changes (temperature or ecosystem changes) and sudden manifestations (extreme rainfall quantities, floods).

In the socio-economical area, climate changes are manifested in the intensification of the stress states, cataclysms and the considerable increase of expenses to cover material losses and repairing infrastructure.

In the Carpathian-Danubian-Pontic area climate changes imply: changes in the temperature regime (extreme temperatures in the warm period); changes in the

[1]State University of Moldova
[2] Prof. PhD. “Alexandru Ioan Cuza” University of Iaşi, Romania

precipitation regime (increases of the extreme quantities); an increase in the frequency and intensity of drought periods; intensification of desertification effect.

In what follows we present a first evaluation of the implications of climate changes on the direction and intensity of elementary landscape and pedogenetic processes.

Problem evaluation

The comparative analysis of the dynamics of climate indices in the years 1887-1980 and 1981-2010 has shown that their evolution is significantly diverse (Table 1).

Table 1. Linear tendencies in the evolution of air temperature (°C/year) and rainfall (mm/year) (Chişinău meteorological station) (V. Cazac)

Season	Mean air temperatures (°C)		Mean rainfall (mm)	
	1887-1980	1981-2010	1887-1980	1981-2010
Winter	0.010	0.039	0.472	1.0284
Spring	0.005	0.061	-0.059	0.187
Summer	0.002	0.097	0.619	-1.406
Autumn	0.003	0.048	0.412	1.291
Year	0.005	0.063	1.448	1.301

According to the data in table 1, the 90s are the beginning moment of climate warming. In this respect, during 1887-1980 at each 10 years air temperature has increased by 0.005 °C and in 100 years by 0.5°C. During 1981-2010 the increase in ten years has been of 0.63°C, and for 100 years of 6.3°C. The increase of annual temperatures during 1981-2010 is mainly due to the increases in spring, summer and autumn.

At the same time can be witnessed a stable tendency of increase in the rainfall quantities (Table 2), which allows for the conclusion that beginning with the 80s and 90s a climate warming is emerging.

Table 2. Evolution of mean seasonal and annual temperature and rainfall quantities (Chişinău station)

Season	Mean air temperature (°C)		Mean rainfall quantities (mm)	
	1887-1980	1981-2010	1887-1980	1981-2010
Winter	-2.2	-1.1	100.6	105.6
Spring	9.4	10.2	121.5	123.8
Summer	20.5	21.3	185.9	186.1
Autumn	10.1	10.3	113.1	132.2
Year	9.5	10.2	520.1	547.6

Based on own analyses, Nedealcov (2012) reached the conclusion that at regional level climate changes are unpredictable (Table 3). The cited author considers that a clear tendency of air temperature increase in the last 20 years can be seen (Table 4) (Nedealcov, 2012), and that the evolution of climate indices bears the mark of a natural – anthropic character. In this sense the author point out that in the first 10 years of the 21st century is witnessed a higher rhythm in the increase in maximum temperatures compared to the minimum values, and that in this way the air temperature variation also increases (Table 4).

Table 3. Evolution of the mean air temperatures in conditions of climate change (Nedealcov, 2012)

Statistic parameters	**Time period**					
	1887-2010	**1887-1959**	**1961-1990**	**1980-1999**	**1989-1999**	**2000-2010**
X	9.6	9.3	9.6	9.7	10.2	10.7
σ	0.8	0.7	0.8	1.0	0.8	0.7
Xmin	7.2	7.2	8.0	8.0	9.1	9.8
X max	12.1	10.7	11.3	11.3	11.3	12.1

Table 4. Top teen warmest and coldest years for the analyzed period (mean annual temperatures), (Nedealcov, 2012)

Cold years		**Warm years**	
Year	**t°C**	**Year**	**t°C**
1933	7.2	2007	12.1
1929	7.9	2009	11.4
1934	8.0	1990	11.3
1985	8.0	1994	11.3
1912	8.1	2008	11.3
1940	8.1	2000	11.2
1987	8.1	1999	11.0
1988	8.3	1966	10.9
1976	8.3	1989	10.9
1980	8.3	2002	10.8

The precipitation regime is characterized by a significant and inconsistent variation (Tables 5 and 6).

A specific feature of the region's climate is the humidity deficit and the disorderly distribution of rainfall, which make it a sub-humid – sub-arid area. Droughts are inherent for these conditions. According to calculations, the probability of drought occurrence during the vegetation season with catastrophic consequences is of 11-41%.

Table 5. Evolution of the annual rainfall regime in conditions of climate change (Nedealcov, 2012)

Statistical indices	Time periods					
	1887-2010	1887-1959	1961-1990	1980-1999	1989-1999	2000-2010
X	526.2	503.8	548.2	555.9	548.3	544.2
σ	122.2	133.1	100.6	118.9	128.7	107.9
Xmin	271.8	271.8	361.0	361.0	361.0	407.0
X max	915.0	915.0	774.0	712.0	711.0	735.0

Table 6. Top ten driest and wettest years in the analyzed period (Nedealcov, 2012)

Dry years		Wet years	
Year	Rainfall, mm	Year	Rainfall, mm
1903	271.8	1912	915.0
1896	301.0	1914	903.0
1938	320.0	1933	777.0
1945	329.0	1966	774.0
1951	345.0	2010	735.0
1924	357.0	1948	734.0
1990	361.0	1922	729.0
1902	368.0	1955	721.0
1953	373.0	1980	712.0
1898	374.0	1996	711.0

According to meteorologists, during the last 20-30 years droughts are more frequent and more intense. During 1990-2012 in the region have been registered 11 years (1990, 1992, 2003, 2012) when droughts have continued during the entire vegetation period. At the same time, data in table 7 show that droughts during the last 20 years are manifested on the background of higher rainfall quantities and a higher hydro-thermal coefficient than in the precedent periods. This draws the conclusion that as droughts are strongest, their effects are more pronounced.

In our opinion this situation is due to the fact that soils are degraded more strongly and are more vulnerable to drought. In this direction we can mention that agriculture intensification from the beginning of the 60s has led to the occurrence in soils of a stable tendency of reduction in organic matter reserves. This is due first of all to the accelerated reduction of the arable layer which has caused an intensification in the humus mineralization process. According to this, the annual losses of humus make up 0.5-1.6 t/ha.

The annual loss in the crop biomass has provoked a significant reduction in the quantities of fresh organic matter entering human-influenced pedogenesis. In rare cases, it makes up 3-4 t/ha. As a consequence, the quantity of formed fresh humus compensates only partially the quantities of mineralized organic matter. In this way, in the agricultural soils occurs a stable tendency of humification which is characteristic for all the soils in the region.

Table 7. Rainfall quantities and the productions for the main crops during dry years in the Republic of Moldova (V. Cazac)

Year	Rainfall, mm			Productions		Hydro-thermal coefficient
	Total, year	November-Marche	April-October	Autumn wheat, q/ha	Corn, q/ha	
1946	365	130	224	4.8	6.4	0.5
1953	344	144	197	13.8	9.5	0.5
1957	410	105	316	18.0	16.5	0.8
1983	419	67	352	27.5	37.4	0.8
1986	370	136	234	33.1	31.5	0.6
1990	385	103	133	31.1	34.8	0.5
1992	405	111	249	34.8	24.5	0.6
2000	458	130	289	21.0	24.0	0.8
2003	459	179	330	6.8	27.8	0.8
2007	479	122	306	15.2	8.5	0.7
2011	400			31.0	37.0	

To the de-humification phenomenon is associated the reduction in the structuring capacity, in the thermal absorption and the specific heat of soils. These changes lead to a faster and stronger warming of soils, which increases air and soil temperatures and contributes to an extension of the areas affected by drought (Table 8).

The data presented shows that during the last 70 years the effects of droughts and the associated temperatures have intensified, confirming the previous conclusions. In this context we mention that compared to previous events, the drought of 1994 has affected 87% of the country territory and was accompanied by temperatures which significantly exceeded the annual means for the spring season. The dynamics of the hydro-thermal conditions for the summer season has contributed to a reduction of the affected surface by 40%. In the autumn months, the drought intensified and extended on about 70% of the republic's territory. The hydro-thermal coefficient varied in some areas between 0.3-0.5, with temperatures up to 30°C.

The drought of 2007 practically begun in the autumn of 2006. During 01.09.2006-06.08.2007 the sum of rainfall in the region has made up for only 50-70% of the multi-annual mean. The length of the period with an air humidity of ≤ 30 % summed up 55-78 days, which is 3-4 times more than the multi-annual mean. During May-July 2007 the mean air temperature exceeded the annual mean for this period by 3-4°C. The number of days with temperatures ≥ 30 °C was of 35-46, three times more than the multi-annual mean of the period. The number of days

Table 8. Evaluation of areas affected by drought in the Republic of Moldova (V. Cazac)

Year	Spring		Summer		Autumn	
	Surface affected by drought, %	**Drought type**	**Surface affected by drought, %**	**Drought type**	**Surface affected by drought, %**	**Drought type**
1945	-	-	60	Catastrophic	40	Extremely strong
1946	100	Catastrophic	33	Extremely strong	-	-
1947	39	Extremely strong	-	-	60	Catastrophic
1948	-	-	-	-	60	Catastrophic
1949	60	Catastrophic	-	-	20	Strong
1950	33	Strong	-	-	20	Strong
1951	60	Catastrophic	40	Strong	-	-
1953	-	-	40	Strong	60	Catastrophic
1954	-	-	73	Catastrophic	23	Very strong
1960	-	-	53	Catastrophic	13	Strong
1963	40	Strong	7	Local	60	Catastrophic
1965	-	-	47	Strong	93	Catastrophic
1966	17	Strong	7	Local	60	Catastrophic
1967	60	Catastrophic	40	Strong	93	Catastrophic
1968	93	Catastrophic	7	Local	87	Catastrophic
1969	7	Local	47	Strong	73	Catastrophic
1970	-	-	-	-	83	Catastrophic
1973	-	-	7	Local	87	Catastrophic
1975	-	-	7	Local	87	Catastrophic
1981	7	Local	53	Catastrophic	-	
1982	60	Catastrophic	-	-	93	Catastrophic
1983	20	Strong	13	Strong	93	Catastrophic
1985	27	Very strong	-	-	73	Catastrophic
1986	100	Catastrophic	13	Strong	100	Catastrophic
1990	7	Local	67	Catastrophic	60	Catastrophic
1992	27	Very strong	60	Catastrophic	70	Catastrophic
1994	87	Catastrophic	40	Strong	44	Strong
2000	75	Catastrophic	55	Catastrophic	49	Strong
2003	86	Catastrophic	61	Catastrophic	26	Very strong
2004	-	-		Strong		Very strong
2005	-	-		Strong		Very strong
2006	-	Local		Strong		Very strong
2007	78	Catastrophic	77	Catastrophic	-	-
2011	-	-	-	-	80	Catastrophic
2012	80	Catastrophic	100	Catastrophic	80	Catastrophic

with temperatures ≥ 35 °C summed up to 10-12, the deviations from the mean being 10-12 times larger. On 21 July 2007 the meteorological station of Camenca recorded the absolute maximum of 41.5°C.

Identical parameters have characterized the drought of 2012, which practically begun in the autumn of 2011.

The data in table 8 clearly point out the fact that beginning with the year of 1946 in the study region manifested cycles of 5 years, with a cumulative effect of drought determined by the accumulation of the remnant effects of soil drought. The cumulative effect of the drought implies a lack of compensation of the productive water reserves in soils, affecting soil functioning in the eco(agro)system.

Table 9. Reserves of productive water in the 0-100 cm layer in the dry year of 2007 (sunflower crop) (V. Cazac)

Meteorological station	**Previous crops**	**Soil depth, cm**				**Mean annual reserves in the 0-100 cm layer**
		0-10	**0-20**	**0-50**	**0-100**	
Edineţ	Autumn	5	13	31	63	81
Camenca	Spring	1	4	8	26	108
Glodeni	Grain leguminous	0	0	1	4	96
Râbniţa	Spring	0	0	1	4	108
Şoldăneşti	Weeding	0	0	3	39	108
Rezina	Autumn	0	2	18	38	108
Făleşti	Autumn	0	0	0	0	96
Corneşti	Autumn	0	0	0	5	96
Dubăsari	Autumn	0	0	5	16	104
Anenii-Noi	Autumn	0	0	0	3	115
Tiraspol	Weeding	1	6	16	41	55
Ştefan-Vodă	Weeding	0	0	0	13	96
Ceadâr-Lunga	Weeding	0	0	0	3	112
Cahul	Autumn	0	0	12	26	112
Vulcăneşti	Weeding	0	1	15	28	112

In the case of such productive water reserves, the biological and biogeochemical processes in soils are reduced to zero. Capillary ascension of carbonates and other soluble takes place, increasing the concentration of soil solution. The mentioned processes are accompanied by a reduction in the percentage of calcium in the adsorbtive complex and an increase of the share of magnesium and calcium. As a consequence, in the dry periods the proportion of magnesium and calcium in the soil adsorbtive complex partially increases.

This is manifested in increases of the soil pH values up to 8.6 – 8.7. The later wetting of the soil leads to the dispersion and disaggregation of the soil material. At the same time during the long dry periods, in soils take place intense processes of mechanical destruction of structural aggregates as a consequence of exaggerated drying. Other intensive processes taking place are the disaggregation ones following humus mineralization. The organic materials present in soil are also subject to mineralization, and thus their decomposition and transformation is accompanied by the formation of small quantities of humic substances capable of ensuring soil aggregation.

Table 10. Physical state of the arable layer of the levigated, typical moderate and weakly humiferous Chernozems with different degrees of physical degradation

Parameters	**Real values**	**Non-degraded soil**	**Degradation degree**		
			Weak	**Moderate**	**Strong**
Content in > 10 mm aggregates, %	8-65	< 30	30-40	40-50	>50
Content in 0.25-10 mm aggregates, %	20-85	>70	60-70	50-60	<50
Porosity of 5-7 mm aggregates, %	29-44	<42	40-42	36-42	<36
Bulk density	0.84-1.55	<1.20	1.20-1.30	1.30-1.35	<1.35
Water permeability mm/min	0.02-2.5	>1.0	1.0-0.7	0.7-0.5	<0.5

In this way, the aridization of the soil cover is accompanied by a reduction in the soil structuring capacity, and a stable tendency of soil destructuring occurs. This is followed by a reduction in the percentage of valuable aggregates and the aggregate stability, and an intensification of the crusting and compaction capacity of soils. These processes are strongly related to the phenomena of porous space degradation and to the soil-water relations. In this context we mention the reduction in water permeability, hydraulic conductivity, total water capacity, capillary capacity, field capacity and available water capacity (Tables 10, 11 and 12). At the same time occurs an increase in water evaporation from the soil surface and takes place a slow aridization of Chernozems.

Table 11. Elements of change in the porous space of the typical Chernozem following compaction

Soil layer	Parameters	Bulk density	
		Un-plowed	**Plowed**
		1.03	1.22
0-30 cm	Total porosity. %	59.4	44.6
	7-5 mm aggregate density. g/cm^3	1.44	1.53
	7-5 mm aggregate porosity. %	42.8	39.1
	3-5 mm aggregate density. g/cm^3	1.48	1.69
	3-5 mm aggregate porosity. %	38.3	32.3
		Un-plowed	**Plowed**
		1.12	1.49
30-40 cm	Total porosity. %	55.2	41.6
	7-5 mm aggregate density. g/cm^3	1.48	1.74
	7-5 mm aggregate porosity. %	41.1	31.8
	3-5 mm aggregate density. g/cm^3	1.50	1.92
	3-5 mm aggregate porosity. %	41.0	24.1

Table 12. Evolution of differentiated porosity and physical parameters of Chernozems under the influence of compaction

Bulk density, g/cm^3	Total porosity, %	Differentiated porosity					Hydro-physical indicators, %		
		<0.2µ	**0.2-1.0µ**	**1.0-10.0µ**	**10-300 µ**	**>300 µ**	**CO**	**CC**	**DAU**
1.00-1.25	54.7	7.3	8.8	24.0	7.9	6.7	10.3	28.8	18.5
1.26-1.40	48.5	10.8	9.2	19.6	5.9	2.8	11.4	27.6	15.2
1.41-1.45	46.7	11.3	9.4	20.0	4.3	1.7	12.0	26.9	14.9
1.46-1.50	43.7	13.2	10.4	18.2	1.9	0	12.6	26.3	13.7
1.51-1.55	42.0	16.9	10.5	12.9	1.7	0	13.3	26.4	12.8
1.56-1.60	39.7	16.9	10.3	11.2	1.3	0	14.8	25.5	10.7

Table 13 presents the criteria for the diagnostic and evaluation of the process of Chernozem aridization as consequence of climate changes

Together with these takes place a significant change of a series of bio-geo-cenotic functions of the Chernozems, materialized in a series of functional and genetic effects (Tables 14 and 15) which modify soil functions in its quality of ecosystem layer.

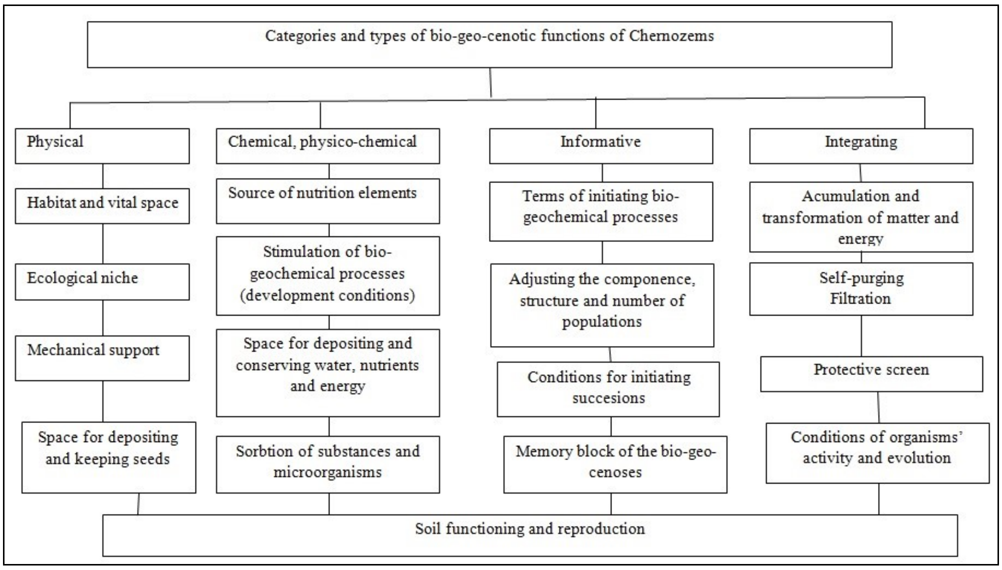
Table 13. Criteria for the diagnostic and evaluation of the impact of climate changes on the Chernozems from the region between Prut and Dniester

Nr.	Processes and features subjected to aridization	Criteria for diagnosing aridization	Anthropic factors that favor Chernozem aridization
1.	Destructuring and crusting.	Increased content of the <0.25 mm fraction. High percentage of the <1 mm aggregates. Low content of 5-1 mm aggregates. Small hydro-stability of the >3 mm aggregates.	Use of heavy machinery. Conducting works in optimum conditions. Not respecting crop rotation and technologies. The use of mineral fertilizers. Irrigation with low-quality water.
2.	Soil compaction.	Compaction of the arable layer (bulk density values > 1.3 g/cm^3). Compaction / hardpan in the sub-arable layer (bulk density > 1.45 g/cm^3). Values of compaction degree of > 11 %.	Not respecting terms and conditions for agricultural works. Dehumification and reduction in the humus reserves. Not respecting crop rotation and other technologies. Practicing technologies which degrade the soil resources.
3.	Degradation of the porous space.	Reduction of the total pore volume under 45%. Air porosity under 12%. Compaction and reduction in 7-1 mm aggregate porosity.	Soil destructuring and disaggregation. Agrogene compaction. Not respecting crop rotation. High percentage of weeding crops in the crop structure.
4.	Hydrophisical degradation.	Increase in the values of wilting coefficient and of the humidity of breaking point of capillary continuity. Reduction in water permeability, hydraulic conductivity, total water capacity, capillary capacity, field capacity. Reduction in water mobility and accessibility.	Soil destructuring and disaggregation. Compaction, discontinuous porous space. Reduction in the porous space continuity and stability. Not respecting crop rotation. Practicing technologies which degrade the soil resources.
5.	Dehumification and reduction of humus reserves. Disturbance of the humification process and reduction in the fresh humus quantities.	Reduction in the humus content in the arable layer under functional, equilibrium values. Attenuation of the differences between Chernozem subtypes coming from the humus content in the arable layer.	Increasing and alternating aeration degree of soils through agricultural works. Reduction in the quantity of fresh organic matter entering pedogenesis. Not respecting crop rotation and practicing short crop rotations.
6.	Dez-argilization of the arable layer.	Reduction of the physical clay (<0.01 mm) and fine clay (<0.001 mm) contents in the arable layer as a consequence of wind erosion.	Plowing with furrowing. Structure fragmentation under the influence of vehicles and aggregates. Agricultural terrains remain for long time uncovered and unprotected.
7.	Alkalization of soil solution and changes in the composition of the adsorbtive complex.	Increase in the pH values and in the percentage of Mg and Na cations in the soil adsorbtive complex.	Physical (destructuring, compaction) and hydrophisical degradation (reduction of productive water reserves). Degradation of the porous space.

Table 14. Functional-genetic effects provoked by Chernozem compaction

Criteria	Process content and direction	Effects
Humification – mineralization	Accumulation of incompletely decomposed and pseudo-humic organic matter in the aggregate pores	Reduction in the intensity of typogenetic processes (humus formation and accumulation, structuring)
Biological and microbiological activity	Reduction and degradation of biodiversity and of the soil biological activity	Partial (mosaicked) abiotization of the sub-arable layer
Modifications in the solid-liquid phases relations	Increase in the physically bound (thermodynamic) water content	Conservation of substances in aggregates, reduction of their capacity of vertical migration
Transformation of substances in the large and small elements circuits	Reduction of the intensity and speed of transformation of the substances participating to the large and small circuits of elements	Reduction in the intensity of the Chernozemic soil formation process
Formation of surface liquid and solid discharge	Spatial differentiation of substances in the landscape	Intensification of erosion
Pollution of landscape elements	Migration of pollutants	Accumulation of pollutants and reduction in biological processes

Table 15. Changes in the bio-geo-cenotic functions of Chernozems as a consequence of anthropic compaction



Evolution tendencies of the climate in the area between Prut and Dniester. Landscape and pedogenetic implications

The landscape and pedogenetic implications of climatic changes will be examined in relation to other pedogenetic factors, especially the biologic and geomorphologic ones. In this context, our research have shown that in the present stage of natural-anthropic evolution of the landscape between Prut and Dniester rivers, the role of the biological factors decreased considerably, increasing the role of the relations between the climatic and geomorphologic ones (Jigău, 2009). In the same order of ideas will be examined the eventual (prognosticated) climatic changes (Tables 16 and 17).

Table 16. Prognosis of air temperature changes in the area between Prut and Dniester for the 2021-2050 period

Indicators	Upper segment			Medium segment			Lower segment		
	Temperatures over:								
	0°C	5°C	10°C	0°C	5°C	10°C	0°C	5°C	10°C
Rainfall duration, days	15.2	9.5	12.4	16.7	9.3	13.1	17.7	8.9	13.0
Sum of temperatures, °C	192	309	321	208	323	344	251	365	384

Table 17. Prognosis of precipitations in the area between Prut and Dniester for the 2021-2050 period

Indicators	Upper segment		Medium segment		Lower segment	
	Precipitations in 24 hours over:					
	20 mm	30 mm	20 mm	30 mm	20 mm	30 mm
Changes, days	4.8	-3.1	10.5	9.2	14.1	9.6
Number of possible days	109	39	90	38	72	30

Following such an evolution of the climatic agents, a series of exodynamic processes can suffer significant changes: soil erosion, landslides and the covering of soil with a frequently humiferous pedolith.

According to some more recent calculations, water erosion affects more than 25% of the republic’s territory, being favored by a series of natural and anthropic factors (Eroziunea solurilor, 2003). Sheet erosion has a higher frequency, and thus weakly eroded soils.

During the last 2-3 decades, soil erosion has intensified (the surface affected annually by erosion has increased from 7000 to 8400 hectares). This has led to an increase in the surface occupied by moderate and intensely eroded soils. In the conditions of a stability of the geomorphologic factor, erosion intensification is caused by the instability of the climatic conditions and by a significant reduction of the soil anti-erosional stability as a consequence of compaction and the favoring of superficial discharge.

The discontinuity of the porous space leads to the reduction in hydraulic conductivity of the sub-arable layer, and further to an over-damping of the arable layer and the weakening of soil structure with the reduction up to minimum of the anti-erosional stability. In what regards the erosion processes, climatic changes will be analyzed in connection to soil degradation degree.

Previous studies approach erosion in relation to pedogenesis only as a destructive factor which leads to soil degradation and economic losses. Erosion consequences are undisputable, yet at the same time Jigău (2009), based on evaluating energy fluxes in pedogenesis, has shown that soil erosion has a series of functions which determine ecosystem functionality (Jigău, 2009):

1. Through the loss of humic material from the upper part of the soil profiles for tens and hundreds of millions of years in the planetary ocean, erosion directs the carbon and nitrogen contents in the ecosystems (biosphere).
2. Erosion determined a permanent energetic disequilibrium between the soil and the environmental factors, in this way ensuring the continuity of the pedogenesis process and the functionality of ecosystems (biosphere).
3. Erosion leads to a rejuvenation of the pedogenetic substratum, ensuring the chemical elements needed for the reproduction of the pedogenesis process.

Table 18. Norms for appreciating physical parameters of loamy-clayey and clayey-loamy levigated, typical moderate and weakly humiferous Chernozems with agricultural utilization

Parameters	Optimal	Admissible	Criteria
Bulk density, g/cm^3	1.10-1.25	1.25-1.35	>1.35
Total porosity, %	50-60	50-45	< 45
Air porosity (W=CC), %	15-25	15-7	< 7
Content of 0.25-10.0 mm aggregates, %	65-75	50-65	< 50
Content of > 10 mm aggregates, %	< 30	30-40	> 40
Aggregate stability, %	40-45	40-36	< 36
5-7 mm aggregates porosity, %	40-42	42-36	< 36
Water permeability, mm/min	>1.0	0.7-0.5	<0.5
Field capacity, %, g/g	34-38	30-34	<30(28)
Penetration resistance, kg/cm^2	<30	30-40	>40

At the same time, erosion is affecting a series of soil (pedosphere) functions (energetic functions, gas exchanges with the atmosphere, filter, self-cleansing, protection etc.) and thus may provoke ecological disequilibrium (Eroziunea solurilor, 2007).

This implies the need for erosion control, especially in the process of climatic evolution, through the management and optimization of soil physical properties, by practicing management and conservation systems adapted to the concrete landscape conditions. The optimum model is presented in table 18.

In such models the accent will be placed on optimizing aggregate composition and stability, while the applied measures will be selected taking into account the degree of soil structure degradation (Tab. 19) (Jigău, 2015; Jigău, 2015 b.).

In the case of the terrains unaffected by physical degradation processes, the accent will be placed on respecting the practiced technologies adapted to the landscape conditions, practicing a crop rotation with minimum 5 crops, in whose composition priority will be given to the soil protective crops which ensure the conservation and reproduction of soil physical properties (Codul de bune practici agricole, 2007). The management of the organic residues implies their incorporation in the first 10-14 cm and keeping at least 35% of this soil surface. For sustaining soil biochemical processes, intermediary crops will be introduced.

Terrains with a low degradation degree need beside the measures mentioned above a reduction of the mechanical pressures and systematic measures for increasing the reserves of fresh organic matter in soils, and for ensuring the biological nitrogen needed for their decomposition with a formation of fresh humic substances. These are the only residues that take part in the formation of soil structure.

Table 19. Evolution tendencies of soils with coarse texture (loamy sands and sandy loams)

Soils	Elementary pedologic processes					
	Fallowing	Humus accumulation	Sodization	Carbonatation	Salinization	Levigation
	Increasing the general humidity degree, of the humus content and of the A+AB horizons depth.	Intensifying the process of formation and increasing the content of humus in the A+AB horizons.	Due to the fact that sodium is practically absent from the adsorbtive complex, the development of the sodization process is less possible.	Decrease of the carbonate effervescence line and of the level of maximum carbonate accumulation.	Due to the absence of easily soluble salts and the high level of groundwater, reduced capillary ascension, the probability of salinization is low.	Deeper percolation of the soil profile and intensification of the levigation process.
Taxonomic level of potential evolution changes						
Carbonatic Chernozem → weakly humiferous levigated Chernozem → Illuvial, clay-illuvial Chernozem → molic gray soil. All Chernozems.		At the subtype level. At the subtype level. At the subtype level. At the gender level.		At the subtype level. At the subtype level. At the subtype level. At the gender level		At the subtype level. At the subtype level. At the subtype level. May occur profiles with eluvial-illuvial features.

Terrains with a moderate degree of erosion imply a minimization of works by practicing the crop rotation no-till agricultural system and intensifying processes of structure formation by practicing a covered field. In the crop structure will dominate plants with a fasciculated radicular system, which favor the protection of the arable layer and the recovery of the structure in the tilled layer. Ensuring an organic mulch layer at the soil surface and the periodic deep loosening without furrowing are also indicated.

Terrains with a high degree of soil erosion need special measures oriented on the recovery of the structural integration and organization of the soil substance in some ameliorative crop rotation systems.

Table 20. Evolution tendencies of soils with medium and medium-fine texture and good natural drainage in conditions of climate change

Soils	Elementary pedogenetic processes					
	Fallowing	Humus accumulation	Sodization	Carbonatation	Salinization	Levigation
	Increase of the general humidity degree, of the humus content and the depth of the A+AB horizons. Diversification of carbonate neo-formations; more efflorescences. Occurrence of gleyzation and gleyic features in the lower part of the profile.	Increase of the humus content in the A+AB horizons; intensification of organo-mineral reactions in the B layer. Extension of the humus formation and accumulation processes on the profile.	In the cases where the original soil was not sodic, sodization will not occur.	Levigation of the upper segment with partial de-carbonatation. Increase of the Ca:Mg ratio in the lower horizons. Ascending and descending carbonate migration .	Dilution of the soil solution in the upper part of the profile and increase of its concentration in the lower part.	Partial dez-argilization of the upper part of the profile.
	Taxonomic level of eventual evolution changes					
Clay-illuvial, levigated, typical moderate and weakly humiferous, carbonatic Chernozems	At the gender level	At the gender level	Absent	At the gender level	At the gender level	At the gender level

Table 21. Evolution tendencies of Chernozems with medium fine texture and defective natural drainage and of those with fine texture, in conditions of climate change

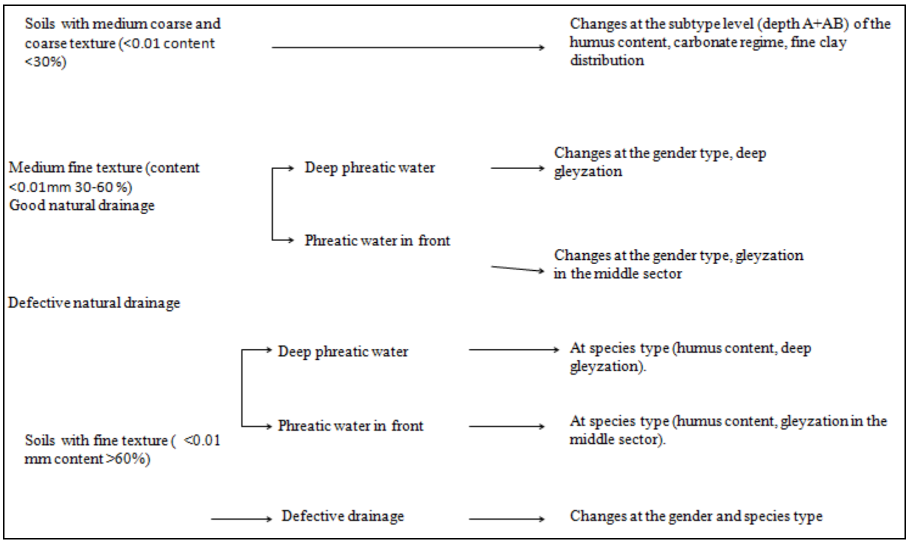
Soils	Elementary pedogenetic processes					
	Fallowing	Humus accumulation	Sodization	Carbonatation	Salinization	Levigation
	Increase in the humidity degree. Occurrence of deficient air-hydric regime. Stagnogleyic processes. Gleyic features in the deep layers with constant hydric regime.	Increase of the humus content in the A+AB horizons.	Increase of the Ca:Mg ratio. Intensification of the sodization process in the AB and B horizons.	No significant changes.	Insignificant increase of the salt content in the lower horizons.	No significant changes.
Clay-illuvial, levigated, typical moderate and weakly humiferous, carbonatic Chernozems	At the gender type	At the species type	No changes	No changes	No changes	No changes
Vertic Chernozems	At the gender type	At the species type	At the species type	No significant changes	No changes	No changes

Another elementary landscape process related to climate warming is the extension of the terrains with water excess in the warm periods and in the years with precipitation quantities that significantly exceed the annual mean. The causes and mechanisms of this phenomenon make a separate field of study. We would only like to mention that during the last 40-50 years the surface of terrains with humidity excess has grown from 30,000 ha (1975) to more than 100,000 ha in the

Table 22. Eventual changes in the intensity of elementary pedogenetic processes and the structure of the soil cover in the area between Put and Dniester (etalon the present silvo-steppe, pasture steppe and proper steppe) only in the case of fine textures

Nr.	Indicators	Landscape type		
		Autonomous	Transition	Subordinated
North area of the Republic of Moldova				
1	Processes which will intensify	Fallowing, levigation, deep gleyzation, surface gleyzation	Levigation, deep and surface gleyzation, sodization	Salinization Sodization, Gleyzation
2	Processes which reduce their share in soil evolution	Carbonate migration, Argilization	Erosion, Argilization	-
3	Changes in the structure of the soil cover	The percentage of clay-illuvial and levigated Chernozems and chernoziomoid soils will increase. The percentage of typical Chernozems will decrease.	The percentage of levigates Chernozems, humid chernoziomic soils and chernoziomoid soils will increase. The zonal pedogenetic process will intensify in the eroded areas and the proportion of eroded soils will be reduced.	The percentage of saline soils will increase; will occur gleyic soils of the (A-AB-G-CG) type.
4	Changes in the degree of soil cover complexity	Increase	Increase	Increase
Central area of the Republic of Moldova				
1	Processes which will intensify	Levigation, humification, fallowing, gleyzation and surface gleyzation	Levigation, humification, fallowing, gleyzation and surface gleyzation, sodization.	Saliniztion Sodization, Gleyzation
2	Processes which reduce their share in soil evolution	Carbonate migration Argilization	Erosion, carbonate migration and argilization	-
3	Changes in the structure of the soil cover	Will increase the surface of levigated and typical moderate humiferous soils. The surface of weakly humiferous Chernozems will be reduced. Will increase the percentage of humid Chernozems and chernoziomoid soils.	Will increase the percentage of levigated and typical moderate humiferous Chernozems, will decrease the surface of typical weakly humiferous Chernozems. Start of processes of recovery of eroded soils. Will increase the surface of humid chernoziomic and chernoziomoid soils.	Will increase the percentage of saline soils and degree of salinity-sodicity of soils.
4	Changes in the degree of soil cover complexity	Will increase.	Will increase.	-
South area of the Republic of Moldova				
1	Processes which will intensify	Humification, Levigation, Fallowing, Deep gleyzation	Humification, Levigation, Fallowing, Deep gleyzation, Sodization	Salinization, Sodization, Gleyzation
2	Processes which reduce their share in soil evolution	Carbonate migration Argilization	Carbonate migration Argilization	Argilization
3	Changes in the structure of the soil cover	Will increase the surface of typical weakly and moderate humiferous Chernozems, of humid chernoziomic soils and chernoziomoid soils.	Will increase the surface of typical weakly humiferous Chernozems, of humid chernoziomic soils and chernoziomoid soils. Eroded soils start to recover.	Will increase the degree of salinization-sodization and the percentage of saline and sodic soils.
4	Changes in the degree of soil cover complexity	Will increase.	Will increase.	-

Table 23. Evolution mechanisms of Chernozems in conditions of over-damping from meteoric water



first decade of the 21st century. The surface of these terrains has grown significantly in 2013, 2014 and mainly 2015, years not taken into account for the previous figures.

Over-humectation reflects mainly on the hydric, air and hydro-thermal regimes of soils, leading to changes in the direction and intensity of elementary landscape processes, at the same time implying a series of elementary processes characteristic to the process itself (Tab. 20, 21, 22, 23).

Conclusions

1. Landscape and pedogenetic implications of climatic changes are examined through the relations with other pedogenetic factors in the factors ← soil system.
2. In the human-influenced pedogenesis from the area between Prut and Dniester the role of the biological factor is significantly reduced. As a consequence the direction and intensity of the landscape and pedogenetic elementary processes are determined by the relations between climate and the geomorphologic factor. In the conditions of a relative stability of the geomorphologic factor, the dominant role is held by climate, to which is added soil vulnerability to climate instability.
3. Soil vulnerability to the implications of climate changes is determined by the degree of soil physical degradation, but also by a series of intrinsic and landscape factors, such as the drainage degree. This implies the idea of the control and management of climate changes by optimizing soil physical properties.

References

Gh. Jigău, 2009, Geneza şi fizica solurilor, CEP USM, Chişinău, p. 144

Gh. Jigau, 2015, Nekotorye itogi primenenija konservativnogo zemledelija v RM, No. 1-2 (51-52), p. 32-36

Gh. Jigau, 2015, Analiz sovremennogo sostojanie i tendencii èvoljucij klimata v RM, No. 4 (54)

M. Nedealcov, 2012, Schimbarea climei în Republica Moldova în perioada observaţiilor instrumentale, Akademos, Nr. 4 (27), p. 88-94

*** Cod de bune practici agricole, Chişinău, 2007, p. 187

*** Eroziunea solurilor, Chişinău, 2004, Ed. Pontos, p. 421