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EVALUATION AND SPECIFICATION OF NATURAL FACTORS OF THE IALOVENI DISTRICT IN THE REPUBLIC OF MOLDOVA

Iurie ROZLOGA, Vladimir FILIPCIUC, Lilia BOAGHE, Olesea COJOCARU

Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo",
100 Ialoveni Street, Chisinau, Republic of Moldova

Corresponding author email: iu_rozloga@yahoo.com

Abstract

The Republic of Moldova is characterized by temperate continental climate, mild and short winter, hot and long summer with a relatively small amount of atmospheric precipitation. The average annual rainfall volume in the North of Moldova is 550-600 mm. In the Center region, rainfall is predominantly low (500-550 mm), and in the South - very low (450-500 mm). The climatic zone determines the frequency of the drought phenomenon. In the North of the country, a severe drought is recorded every 10 years, in the Center area, 2-3 times, and in the South region, 3-4 times. With global climate change, the phenomenon of drought is more frequent. This creates a high moisture deficiency in soil and air, the consequences of which lead to a substantial decrease in crop productivity or even loss of crop. In the territory of Ialoveni district the pedoameliorative situation is very complex. As a result of the work carried out, new data were obtained regarding the current state of the natural factors influencing the eco-natural settlement within the studied territory. In order to appreciate the natural potential of Ialoveni district, protect and increase soil fertility, trace the ways of development of agricultural enterprises, and thus improve the socio-economic level of the rural population, it is necessary to study in detail the natural factors: climate, relief, surface waters and pedophrenatics, silvicultural arrangements, soil cover, and others.

Key words*: Digital Model - SIG, eco-natural settlement, Ialoveni district, natural factors, soil.*

INTRODUCTION

The rational use of soil resources is based on the detailed knowledge of the main natural and anthropogenic factors that influence effective fertility and their quality status. It is established that in recent decades such serious soil degradation has increased, such as water erosion, landslides, dehumidification and nutrient depletion, salinisation and secondary solonization as a result of irrigation, and so on.

In the last decades, the role of the anthropic factor has grown in erosion processes. An example of inappropriate human intervention and with extremely serious consequences on soil cover is agrarian reform carried out without scientific support. Thus, through the implementation of the "Earth" program, spraying (compacting) small-scale compact land, which excludes the possibility of organizing the territory and applying the anti-erosion technologies, occurred.

Concurrent assessment of land quality is necessary to justify a complex system of measures to prevent degradation and conservation of soil production capacity. For the development of complex measures to prevent soil degradation it is necessary to know the spatial spread and the intensity of the manifestation of these processes on a more detailed scale.

Achieving this goal in limited terms is possible with the use of the Geoinformatics System (GIS), which allows an operative and reasoned approach to inventory, analysis, planning and design issues. This system creates prerequisites for the development and implementation of measures to combat soil degradation at a new quality level aimed at maintaining and improving soil fertility.

The need to carry out these research results from the fragmentary and incomplete character of previous research. Concurrent assessment of land quality is necessary to justify a complex system of measures to prevent degradation and conservation of soil production capacity. The results of the works and the practical recommendations will be used for the elaboration of the irrigation, the erosion control, the planting of the fruit plantations, and the protection of the environment by afforestation and erosion of degraded lands (landslides, ravines etc.).

In the territory of Ialoveni district, the pedoameliorative situation is very complex. A special set of methodological procedures has been applied for its proper characterization. At their base are laid the principles of the physico-geophysical method (Gherasimov et al., 1960) and the conjugate analysis of the cartographic materials, the laboratory results and the data of the observations in nature with the application of the genetic methods of the system. As a result of the performed works, new data were obtained regarding the current state of the natural factors influencing the econo- mural situation within the studied territory.

The results of the works and the practical recommendations will be used for the elaboration of the projects for erosion control, irrigation systems development, establishment of fruit plantations, protection of the environment by afforestation and erosion of degraded lands (landslides, ravines, eroded etc.).

MATERIALS AND METHODS

The research methods were office, field, laboratory and office. Initial office work was carried out with the use of the informational geographic system, which allowed for the development of the digital model of the relief and the dimensioning of the land infrastructure. Fieldwork or focusing on updating land-based limestones and sampling of surface water samples. Determination of water quality properties and indices has been made by laboratory analysis with the application of classical methods and existing standards. The study objects were carried out within the Ialoveni district (25 communes) on an area of over 78 thousand ha.

The purpose of the works included in the stage - the evaluation of the geomorphological, infrastructure and hydrochemical factors for assessing the volume of the irrigation fund at the administrative level II. The evaluation of natural and anthropic parameters and the delimitation of boundaries between taxonomically subordinate soil units - is the most complex and important stage of research.

The mapping method used the comparative-geographic method of V.V. Dokuchaev. It helps to establish the natural relationships between soils and soil formation factors (Kashanskii, 1987). The most complete numerical form of factors determining soil properties at a certain point is reflected in the SCORPAN model (McBratney et al., 2003):

$$S = f * (S, C, O, R, P, A, N) \qquad (1)$$

where:

S - soil; C - climate; O - organisme; R - relief; P - parental rocks; A - age and N - territorial neighborhood.

It is assumed that the same combination of soil-forming factors (predictors) corresponds to one and the same soil.

In order to evaluate the changes in the natural and anthropic parameters obtained over the years the thematic materials elaborated previously were used. Therefore, they do not fully reflect (for objective reasons) the complexity of the situation on the ground at the moment.

This finding refers in particular to the forms of use (agricultural, non-agricultural, infrastructure), to the landscapes of the basins, where the pedogenic factors (parental rocks, hydrology, lithology, hydrogeology and vegetation) interact in various ways lead to the emergence of forms of extremely complex degradation (Rozloga, 2013; 2015).

Over the last years, the informational-geographic system has been used in the Republic of Moldova. High-resolution satellite imagery and photogrammetry sets appeared.

The use of the geographic information system (GIS) and the modern equipment in the mapping works took place within the territory of Ialoveni rayon. The research was carried out in 2015-2016 by the collaborators of the Pedological Geological Information System and Precision Agriculture Laboratory and the Soil Improvement and Protection Laboratory of the Institute of Pedology, Agrochemistry and Soil Protection “Nicolae Dimo”.

The following materials were used in the study:
- the maps of the organization of the territory of the Ialoveni rayons at 1: 10000 scale;
- the pedological maps from the Ialoveni rayons at 1: 10000 scale;
- topographical plan sheets at 1: 50000 scale;
- topographical plan sheets at 1: 10000 scale;

- digital map of the land cover of the Republic of Moldova at 1: 50000 scale developed in 2011;
- "Orto-Foto" spatial remote sensing materials at ARFC scale 1: 5000;
- Materials "Land Digital Model (DTM)" of the Land and Cadastre Agency.

These materials have been linked to the national reference system MoldRef-99. Subsequently, the thematic layers ("Hidro", "Roads", "Localities", "Forests", "Forest Strips", etc.) were formed. Also, the structure of the database parameters for the elaborated layers was formed. It was then proceeded to vector the contours of the land according to the categories and subcategories of use, updating them using the Orto-Foto materials, elaborating the digital model of the relief at the scale 1: 1000 and introducing the attribution information for each area. Field research has been carried out to update and correct infrastructure contour boundaries, land degradation forms digitally sized in the office from geospatial remote sensing materials. The work has been done in MapInfo (2D) and ArcGIS (3D).

The research was carried out in accordance with the "Guidelines for Land Surveys for Lands and State Grants" approved in 1991 (Filipciuc, 2007), "Regulation on the content of the land registry documentation" approved by the Government Decision of the Republic of Moldova No. 24 of 11 January 1995 (Arinushkina, 1963).

RESULTS AND DISCUSSIONS

In order to appreciate the natural potential of Ialoveni district, the protection and increase of soil fertility, the development of agricultural enterprises, and therefore the improvement of the socio-economic level of the rural population, it is necessary to study in detail the natural factors: climate, relief, surface waters and pedophrenatics, silvicultural arrangements, soil cover, etc.

Weather conditions. The Republic of Moldova is characterized by temperate continental climate, mild and short winter, hot and long summer with a relatively small amount of atmospheric precipitation. The average annual rainfall in the northern area of Moldova is 550-600 mm (Figure 1, Table 1). In the Center region, rainfall is predominantly low (500-550 mm), and in the South - very low (450-500 mm). The climatic zone determines the frequency of the drought phenomenon. In the North of the country, a severe drought is recorded every 10 years, in the Center area - 2-3 times and in the South region 3-4 times. With global climate change, the phenomenon of drought is more frequent.

This creates a high moisture deficiency in soil and air, the consequences of which lead to a substantial decrease in crop productivity or even crop loss.

The geographic location of the surveyed territory includes area II (72030 ha) and sub-area IIa (6239 ha) pedoclimateric with insufficient humidity (Ursu, 2011).

According to statistical data, the average annual air temperature for zone II is 9.0-9.5ºC and 8.5-9.0ºC for sub-area IIa; the sum of temperatures above 10ºC is 3000-3200ºC and 2900-3000ºC, correspondingly; the duration of the vegetation period with temperatures above 10°C extends over a period of 177-182 days. The cold period (with temperatures below 0°C) averages 174-188 days. Sun days have a duration of 290-320 per year (Table 1, Figure 1).

For the territory of the rayon the materials of the monthly climatic indices were processed during the period 1950-2016 (Agrometeorological Bulletin, 2011). The lowest average mean temperature was set in 1954, which was minus 11.9°C, and the maximum was found in 1992, this being 25.1°C (Figure 2). The average annual temperature is 9.79ºC.

All field and office materials have undergone a conjugate analysis and were studied in the system (Gherasimov et al., 1960). Subsequently, these were used to develop updated cartographic information.

The result of the geoinformation works was finalized with the elaboration of the set of digital thematic maps from the territory of the Ialoveni district. In Figure 3 shows the average monthly temperature over the years with climatic data. The diagram shows that the minimum average temperature during the years corresponds to January, minus 3.46° C, and the maximum - in the months of August to August, reaching the value of 20.4°C. For the normal development of metabolism processes between plants and soil, an optimal water regime is required. In the Republic of Moldova the level of water supply is quite variable over the years; from normal to critical crop development.

Table 1. Characterization of the main agro-climatic indices

Indices	Zone, subzone				
	I	Ia	II	IIa	III
Surface, ha	769912.40	224822.73	1359714.01	124398.72	901282.61
Altitude, m	100-300	200-300	50-200	200-400	10-200
Solar days	290-300	280-290	310-320	290-300	310-320
Hours of sunshine	2050-2100	2000-2050	2100-2200	2100-2150	2200-2300
T° annual average	8.0-8.5	7.0-8.0	9.0-9.5	8.5-9.0	9.5-10.0
$\sum$ T° > 10°	2750-3000	2750-2800	3000-3200	2900-3000	3200-3450
$\sum$ annual rainfall, mm	550-600	550-630	500-550	550-600	450-550
K, h	0.65-0.8	0.7-0.8	0.6-0.65	0.7-0.8	0.5-0.6
No. of drought in 10 years	1-2	1	2-3	1-2	3-4
Vegetation period, days	167-176	166-167	177-182	178-182	179-187
The period of the angels, days	163-179	163-179	174-189	175-188	175-196

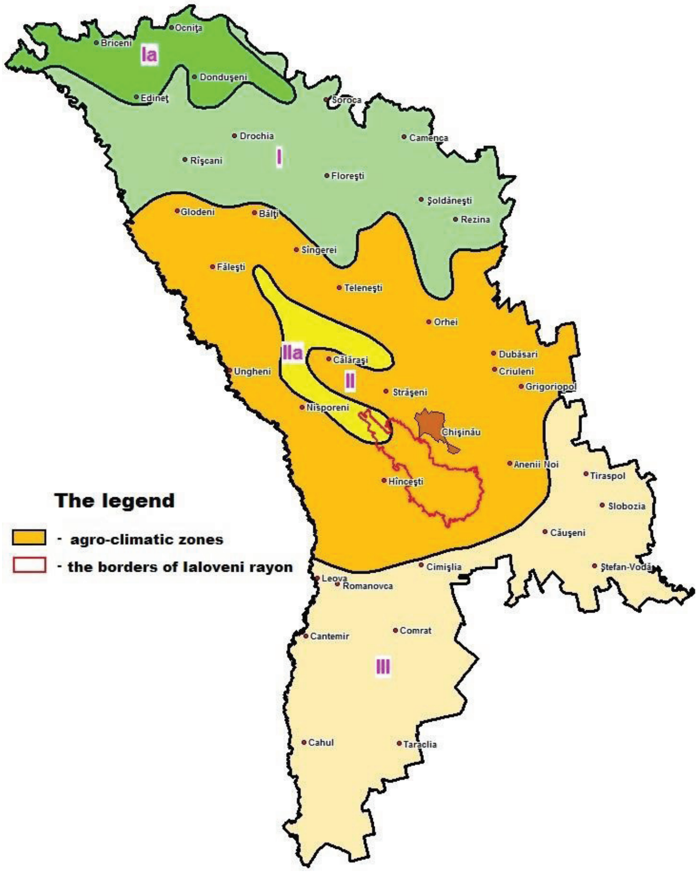

Figure 1. Agro-climatic zones of the Republic of Moldova

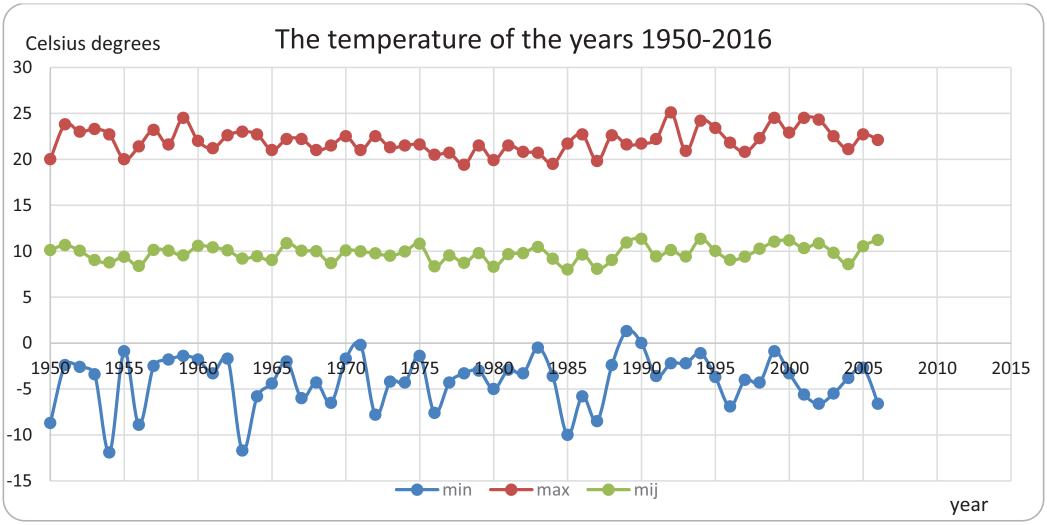

Figure 2. Diagram of annual average temperatures

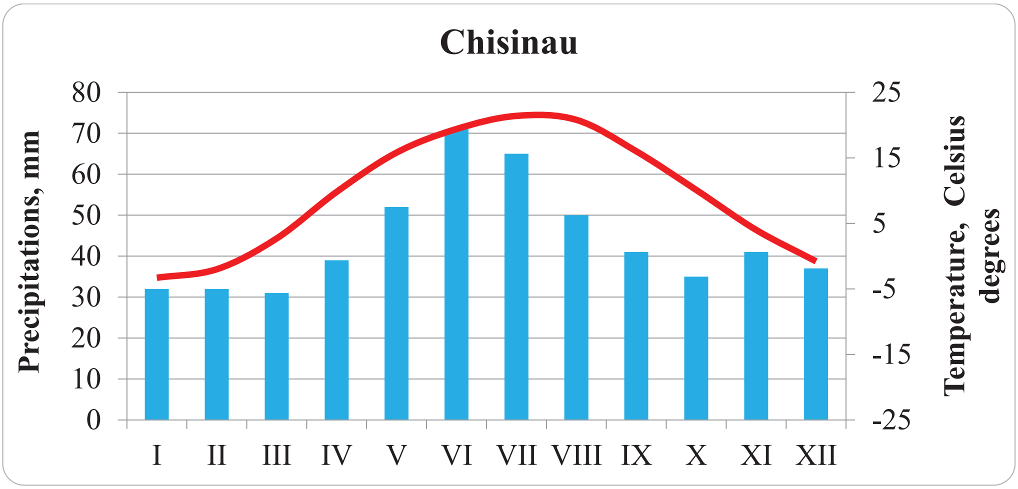

Figure 3. Diagram of atmospheric deposits and annual average temperatures over months

According to the multiannual data on the surveyed area the annual average precipitation is 500-600 mm, and during the period with temperatures above 10°C the atmospheric deposits are 380-400 mm. The number of droughts in 10 years alternates from 1 to 3 times. The value of the hydrothermal coefficient is 0.6 - 0.8, which results in insufficient humidity during the vegetation period of the plants.

The processing of climatic data between 1950 and 2016 shows that the average monthly average atmospheric deposition was detected in June 1952 and consisted of 230 mm. The minimum value was recorded in October 1953, 1969 by 1 mm. The average monthly average of 57-64 years is 46.3 mm (Figure 4).

During 1950-2016 atmospheric depositions had an uneven trend. The amount of prizes varied from 345 mm in 1951 to 774 mm in 1966. The annual average is 555 mm (Figure 5).

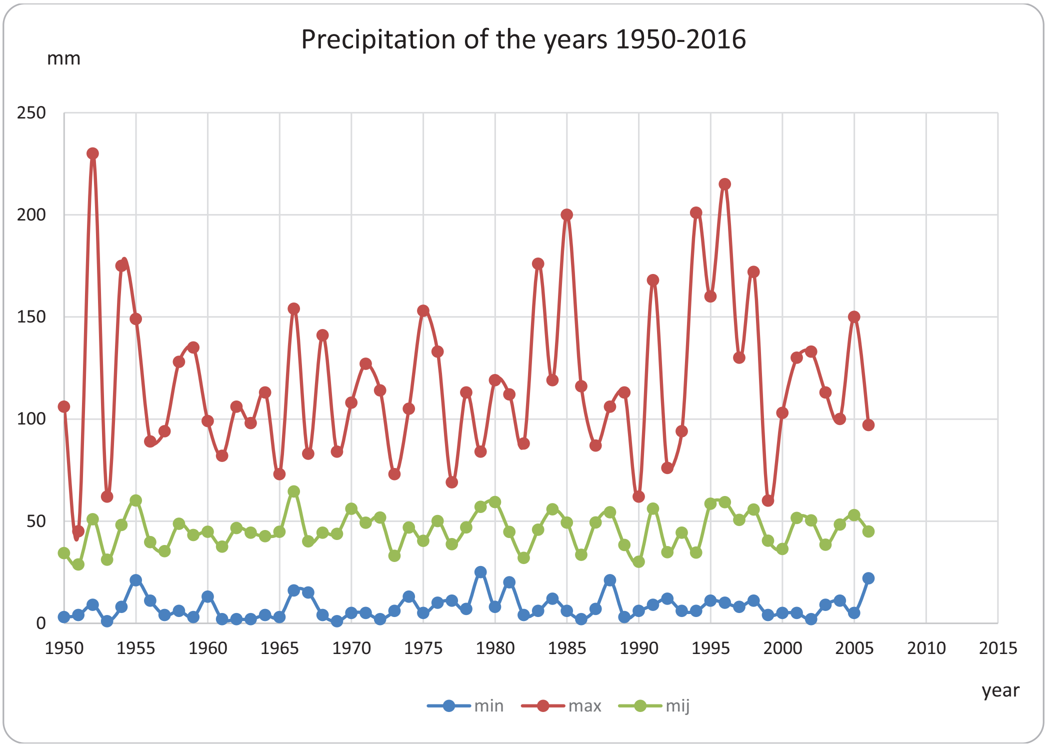

Figure 4. Diagram of annual average atmospheric deposition

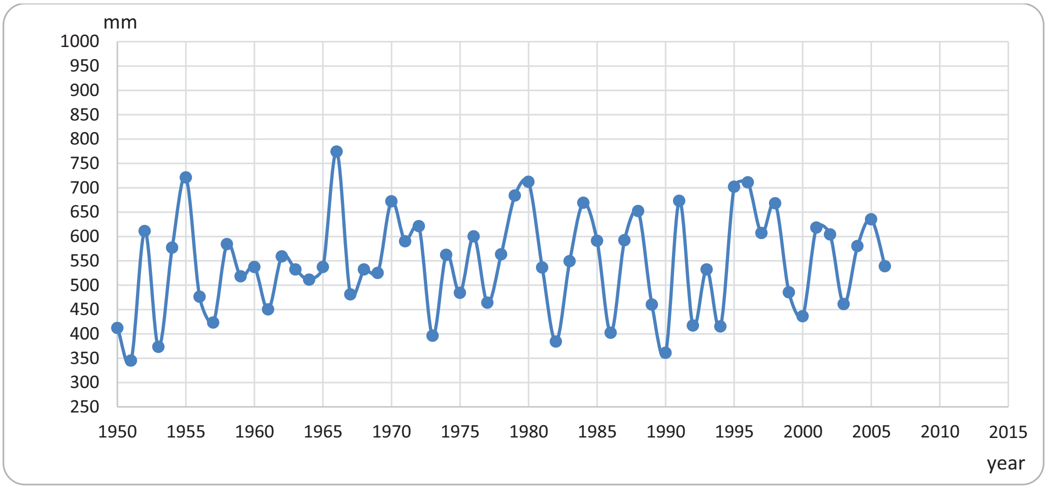

Figure 5. Diagram of the amount of annual atmospheric deposits

From the chart (Figure 3) it is observed that average monthly atmospheric deposits over the years range from 32 mm in March to 73 mm in June.

Digital Relief Model. An increased influence on environmental conditions has its relief. In the Republic of Moldova this was formed as a result of the interaction of the tectonic movements of the Earth's crust and the denudation processes in the contemporary conditions that took place at the end of the neogen. The geomorphologically researched region belongs to Codrii Plateau (55404 ha) and the South Moldavian Plain (22866 ha)

(Ursu, 1980). The territory of the Ialoveni district is characterized by a fragmentary relief and deep valleys (Photo 1). Here predominantly long slopes with a large inclination predominate, favoring the development and development of soil degradation through erosion and landslides. The general division of the basin is southern.

Photo 1. Landscape bazinar

For the object investigated, the Digital Relief Model has been developed that includes specific indexes such as relief plastics, slope classes, exhibition and altitude. From the GRID materials with 48955992 points, the relief plasticity was formed (Figure 6) and extracted the level curves, which make up 40499 in the total length of 168901 km, traced with a numerical equidistance of 10 m (Figure 7).

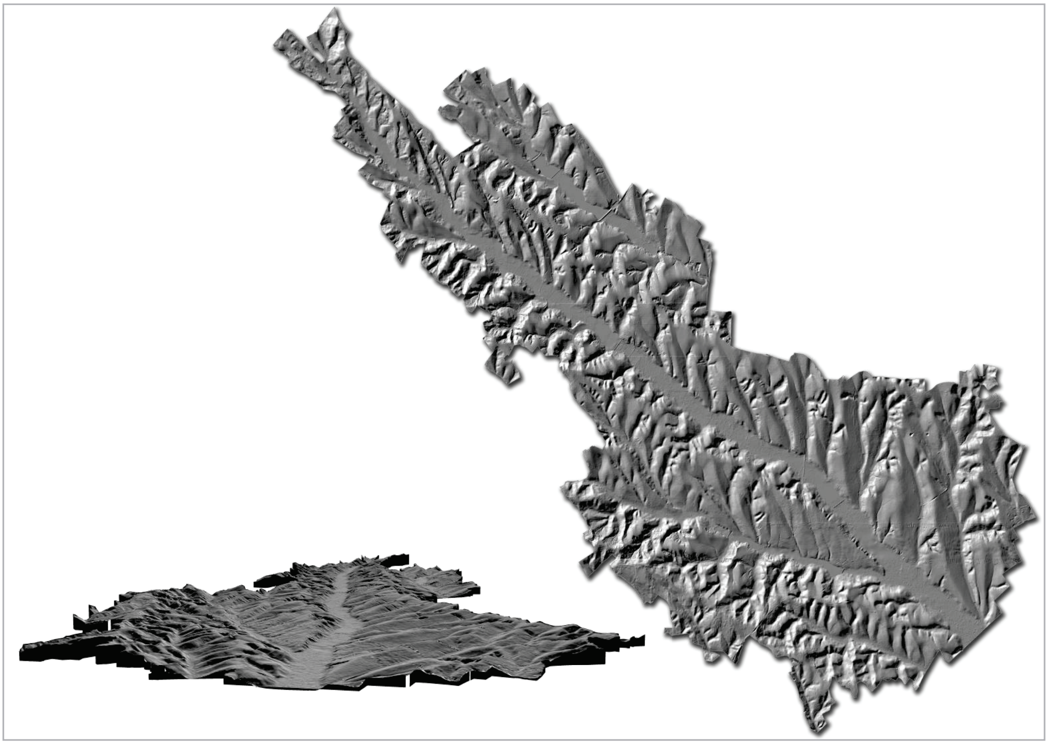

Figure 6. Relief plasticity (DEM)

Each level curve was assigned the absolute value (Z) in the MoldRef-99 reference system. In the case of the georeferenced trapezium it was identified in an altitude with a minimum of 34.7 m and a maximum of 346.5 m, which determines an amplitude of the relief of 325.5 m (Figure 8).

The elevation classes were formed and evaluated over 50 m and are shown in Table 2. Table data show a predominance of the heights class ranging from 120 to 160 m, occupying 29.3% of the territory. In the range of 80 to 200 m the land share is 76.76%.

Using the graphical data of the level curves, the TIN layer of the triangles (200931968 in number) was formed with the sloping slope characteristics and the aspect of the terrain.

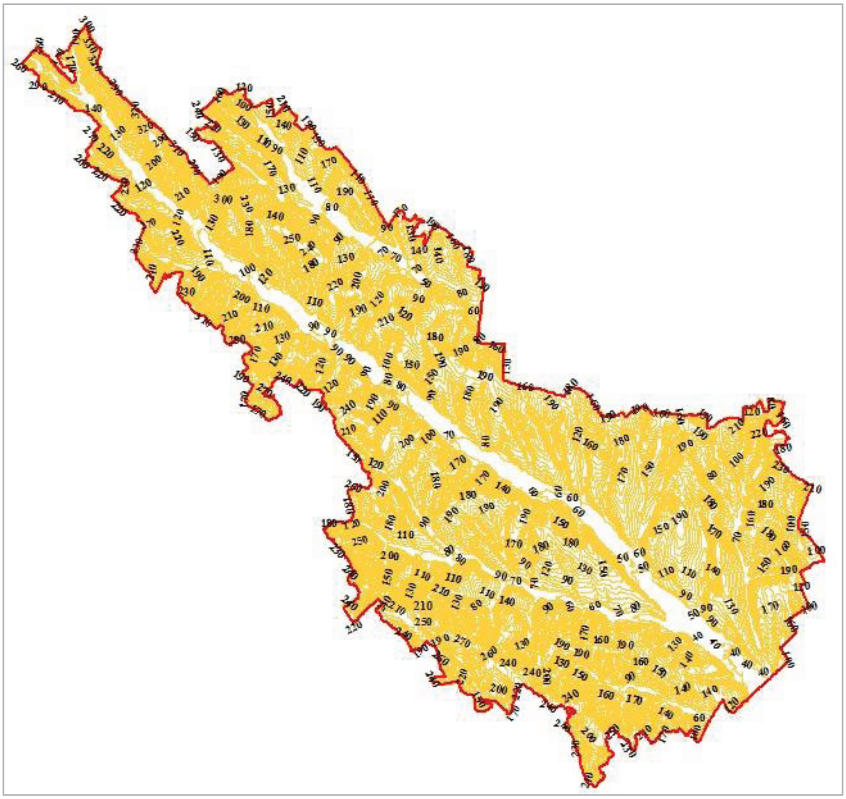

Figure 7. Level curves (10 m equidistance)

Table 2. Cartography of classes by elevation

Altitude range, m	Surface, ha	% of the surface
0-40	316.7324	0.40
40-80	7283.4858	9.30
80-120	18163.5594	23.20
120-160	22988.3524	29.33
160-200	18994.0336	24.23
200-240	6946.5216	8.87
240-280	2759.1877	3.52
280-320	848.8268	1.08
320-360	48.4124	0.06
TOTAL	78306.8155	**100**

From the numerical model of the land, the slope classes, as shown in Figure 1, according to the pedological study methodology were extracted (Florea et al., 1987). Most of the studied area (76.6%) is within the inclination of the slopes from 1º to 10º, where the slopes of 3º-5º predominate by 22.35% (Table 3, Figure 9). In the meadows, land with a slope of up to 1° predominates. The weighted average inclination of the slopes is 8.52º, which presents a very high risk of developing erosion on the surveyed territory (Table 3).

Prevention and control of soil erosion on land on the slopes of the studied area is recommended to be done depending on the size of the slope: - 1º - 3º (11896.83 ha) requires cracking of the slope; spring harvesting and cultivation at a depth of 6-8 cm for pruning crops; 3º-5º (17498.61 ha) requires plowing with plow under 20-22 cm depth and cracking of the autumn plow with hoof; 5º-7º (15500.92 ha) requires the work of the soil with the chisel or the scarifier without turning the furrow to the depth of 20-22 cm with the preservation of the vegetal remains; 7º-10º (15080.74 ha) requires the cultivation of perennial crops and perennial herbs, using the work of the soil with the chisel or the scarifier without turning the furrow to a depth of 20-22 cm with the preservation of vegetal remains and cracking over 10 m across the slope ; 10º-12º (5879.32 ha) requires the cultivation of perennial herbs. In multi-annual plantings, inter-row rooting takes place; >12º (5627.56 ha) requires the establishment of grasslands and forest plantations.

Table 3. Classes according to the tilt of the slopes

The interval	The classes of the slopes	Number of contours	Surface, ha	The average tilt	% of the area of the district	Risk of erosion
0º-1º	Horizontal	3972006	6822.85	0.09	8.71	very weak
1º-3º	Very weak sloping	9778135	11896.83	2.29	15.19	weak
3º-5º	Slightly inclined	29489221	17498.61	4.14	22.35	moderately
5º-7º	Moderately inclined	39035524	15500.92	6.00	19.80	high
7º-10º	Moderately inclined	53874375	15080.74	8.44	19.26	very high
10º-12º	Moderately inclined	27463181	5879.32	10.94	7.51	extremely high
12º-15º	Strongly inclined	23170176	4042.88	13.26	5.16	extremely high
15º-20º	Strongly inclined	10094719	1356.06	16.58	1.73	-
20º-45º	Very strongly inclined	3052796	218.37	25.15	0.28	-
45º-90º	Steep	1001835	10.25	47.76	0.01	-
	TOTAL	**200931968**	**78306.82**	**8.52**	**100**	-

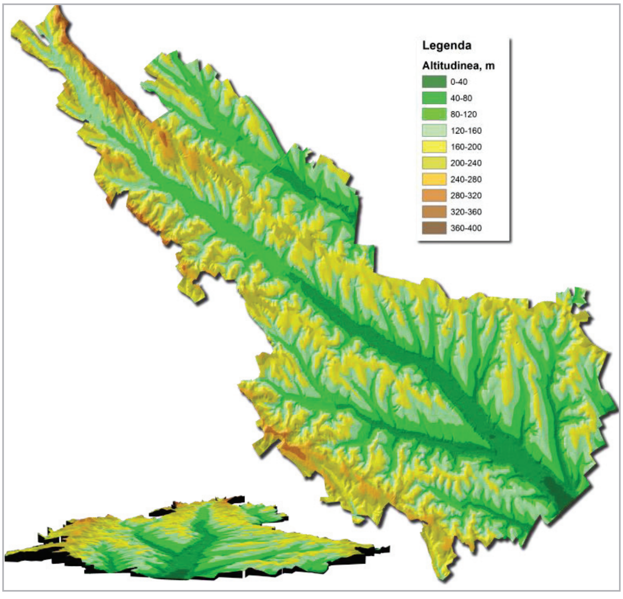

Figure 8. Altitude map of Ialoveni district

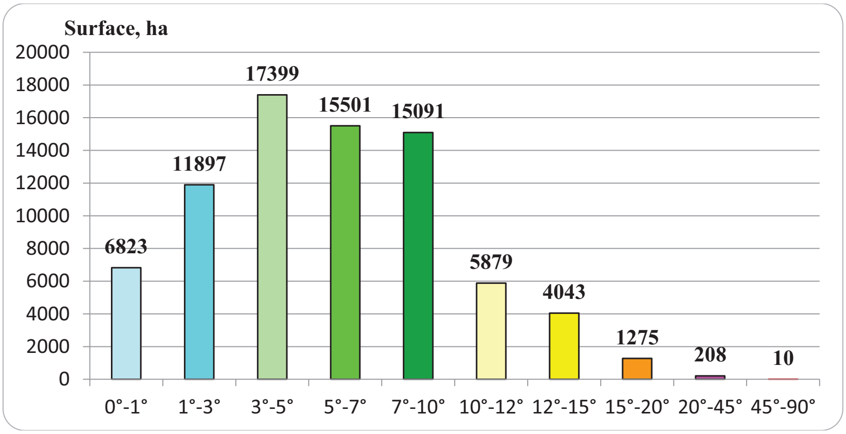

Figure 9. Surface of Ialoveni district

CONCLUSIONS

The researches carried out on the lands within the Ialoveni district were carried out using the geoinformation system. The applied technology has highlighted the deviations of the archival map material from the real situation in the territory. In particular, this refers to administrative boundaries between districts, communes and lands affected by landslides and ravines.

In the structure of land use predominates agricultural ones with a participation of 55% (arable categories predominate by 68% and multiannual plantations by 29%), followed by non-agricultural category - 32% (forests predominate by 54% and non-agricultural pastures by 26%) and 13% - infrastructure (the localities - 64% and roads with 20% with the length of 4684 km).

The hydrographic system is represented by 1669 objects covering 2144 hectares, where lakes with 1623 hectares predominate and 362 hectares of rivers and canals with a length of 568 km. About 2/3 of the surface water has a chemical composition and unsatisfactory quality indices for their use in irrigation.

Of the non-agricultural subcategories, land slopes predominate with 1640 ha - 82% and the ravines with 346 ha - 17% with a 190 km radius.

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