

## GEOMORPHOLOGIC AND PEDOLOGIC RESTRICTIVE PARAMETERS FOR AGRICULTURAL LAND IN THE PERESCHIV CATCHMENT OF EASTERN ROMANIA

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**Abstract:** The Pereschiv catchment is representative for the south-western subunit of the Moldavian Plateau, Tutova Rolling Hills respectively. Based on evaluation score, the average land favorability corresponds to the medium class for most land use types, excepting pastures characterized by a high favorability. Although the arable land has a medium favorability, the major crops such as corn and sunflower have an evaluation score that fits them in the low favorability class. Among the geomorphologic factors that present restrictiveness for agricultural land use, the slopes and landslides are stretching on 81.2% of the area. Generally, they show a relatively low intensity, the average land score being penalized with only 11% of maximum suitability. The soil cover gives the highest restrictions for agricultural land use. The cropland presents at least low restrictiveness to 94.2% of basin with an average penalty that rises to 43%. The main pedological restrictive processes are represented by carbonation, alkalization & salinisation, gleysation and surface-water gleysation which affect 17.6%, 10.7%, 3.2% respectively 1.6% from entire area with average penalties less than 5%. Severe restrictiveness is induced by physical matters, namely the clayey-sandy or sandy-clayey texture, high porosity, low edaphic volume that affect 17.5%, 14.8% and 13.4% of the fields presenting also penalty values less 4%. In particular, soil chemical problems are due especially to the low humus reserve on large area (80.7%) and less to alkaline pH (10.1%) with a higher intensity value of 16%, respectively, 1%. Other parameters such as the degree of base saturation, groundwater depth and pollution do not introduce restrictiveness. In synthesis, the geomorphologic and pedologic parameters induce high and very high restrictions on 28% of the research area, medium restrictions on 42%, respectively, low and very low restrictions on 30% of the Pereschiv catchment.

**Keywords:** agricultural land use, land suitability, land degradation, restrictive parameters, Eastern Romania

### 1. INTRODUCTION

A representative basin for Tutova Rolling Hills of Eastern Romania, the Pereschiv catchment (23,266 ha) is a typical rural area, poorly developed, where over 90% of the active population is working in the primary sector. Actually, this region deals with subsistence agriculture, described by very low yields. It is based on crop production resulting in a high pressure on the forestland and from here the constant need for new agricultural land.

Undoubtedly, the soil is the most important local resource. Thus, the need to evaluate its capacity to support basic human activities in the area appears. In this context, the soil has to be regarded as a morphological and functional component of the

system "field", which also includes the landform conditions, the climate and the land use methods (Patriche, 2003). Under these circumstances, the land evaluation involves quantification of the intrinsic characteristics of the land both by the ecological value of soil quality data, landform and the climate characteristics (Lewandowski & Zumwinkle, 1999) and through the socio-economic value defined by location, accessibility, land assessment works, economic infrastructure, property system, etc. (FAO, 1976; Rossiter, 1995).

In recent decades, the specific literature includes a number of insights that emphasize on one hand the soil quality assessment (Klingebiel & Montgomery, 1961; Alexander, 1971; Andrews & Carroll, 2001; Andrews et al., 2005) and on the other hand, the

systemic assessment of land quality (Young, 1973; Vink, 1975; Beek, 1975; Rossiter, 1996).

The paper “*Framework for Land Evaluation*” (FAO, 1976, 2007) substantiates, using six principles of land evaluation, concepts, methods and procedures for a systematic biophysical and socio-economic assessment of the potentials for specific land uses likely to be relevant to the area. This paper has influenced many land evaluation methodologies developed since 1976, most of them based on agro-ecological principles (FAO, 2007).

Some of the most important land evaluation systems are as follow: *The Fertility Capability Classification* (Sanchez et al., 1982), *Land Evaluation and Site Assessment* (USDA, 1983), *Land evaluation and farming systems analysis* (Fresco et al., 1992), *Sustainable Land Management* (Dumanski & Smyth, 1994), *The framework for evaluating sustainable land management* (Smyth et al., 1993; Smyth & Dumanski, 1995).

Since the '90, the occurrence and development of GIS techniques and methods have covered the need for fast data processing and specializing that are more complex. By this time a number of computerized land evaluation systems have appeared, namely: *The automated land evaluation system* (Rossiter, 1990; Rossiter & van Wambeke, 1997), *MicroLEIS* (De la Rosa et al., 1992), *Sustainable options for land use methodology* (Bouman et al., 1998), *Intelligent System for Land Evaluation* (Tsoumakas & Vlahavas, 1999).

All these works generally aim to determine qualitatively and quantitatively the land suitability, which is the match of a given type of land for a defined use in its present condition, without major improvements or after improvements (FAO, 1976).

In Romania, based on a series of older studies (Teaci, 1980), a proper methodology for land assessment has been developed by National Institute of Research and Development in Soil Science, Agrochemistry and Environment - ICPA (INCDPAPM – ICPA) and published in 1987. That methodology has been applied throughout the country (Munteanu et al., 1999) and at regional scales (Ianoș, 2006). Through a continuous background (Vlad, 1996; Vlad, 2003) and taking advantage of modern GIS resources, it stands at the implementation and development of highly complex databases (Munteanu et al., 1998).

At a local level, the land assessments stand as components of soil studies conducted by the Pedology and Agrochemistry County Offices (PACO). However, recent published papers have been focused both on the soil quality (Vasiliniuc, 2009) and land assessment through the natural

hazards – land vulnerability system (Stângă, 2007).

Using the Romanian methodology and starting from the main geomorphologic and pedologic features relevant to land suitability in the studied area, the present work attempts to assess the relationship between the main pedo-geomorphologic parameters and their induced restrictiveness to land use.

Two main objectives have been emphasized:

- The overall estimation of land suitability for the major crops and land uses, by observing the most important ecological conditions;

- The identification of areas affected by restrictive factors and their degree of effectiveness intensity regarding each parameter. Only the geomorphological and pedological factors have been taken into account.

## 2. THE STUDY AREA AND THE WORK METHOD

### 2.1. The study area

Spindle-shape in form the Pereschiv catchment is located in the Tutova Rolling Hills, Southern Moldavian Plateau, Eastern Romania and covers 23,267 ha (Fig. 1).

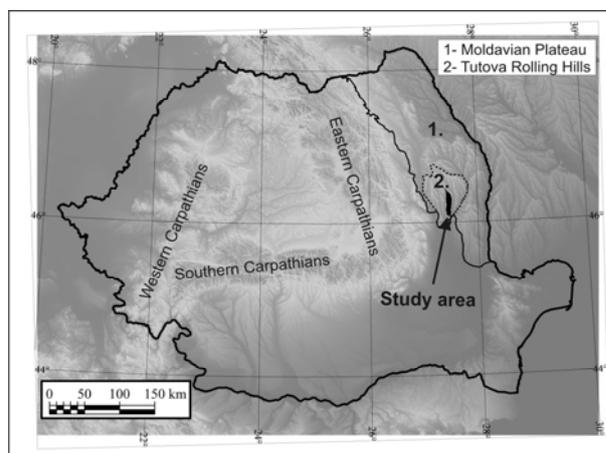


Figure 1. The Pereschiv catchment position in Romania

Sandy - clayey Miocene-Pliocene layers with a gentle dipping of 7-8 m/km NW-SE have outcropped from the sedimentary substratum because of the erosion (Jeanrenaud & Saraiman, 1995). Slopes within the plateau are mantled by mollisols (chernozems – 22%, faeozems - 19%) and forestry soils (entic luvisols – 24%, typic luvisols – 1%). In addition, the azonal soils (e.g. regosols and anthropic sols) controlled by erosion amount 22% of the total (Niacșu, 2009).

Over the last two centuries, the native vegetative cover has been dramatically changed.

Thus, the proportion occupied by forestland decreased from over 60% to only 12.2%. Conversely, the agricultural land has extended up to 80.3% and arable land up to 54.3% of the total basin area. At the same time, it is obviously the predominance of the row spacing crops such as corn (58.5%), sunflower (16.2%) against close growing crops as winter wheat and rye (22.4%).

The improper human activity, mainly the up and down hill farming and inadequate road network resulted in a significant land degradation especially through the development of soil erosion (Ioniță et al., 2006), gulling (Rădoane et al., 1995; Ioniță, 2000; Ioniță, 2006) and to a lesser extend of landslides (Pujină, 2008).

## 2.2. The Romanian land suitability assessment methodology developed by INCDPAPM – ICPA, Bucharest

In Romania, the land assessment was achieved within the framework of the Soil Studies Development Methodology – SSDM (INCDPAPM – ICPA, 1987). It takes into account 18 indicators of the environmental conditions, which are important for crops. Of those indicators, 12 describe the *soil* conditions and refer to the appearance and intensity of some pedogenetic processes such as *carbonatation* (the total CaCO<sub>3</sub> content in 0-50 cm range), *gleysation*, *surface-water gleysation*, *salinisation or alkalization*. The following soil physical properties have been taken into account: *texture in the Ap horizon* (or in 0-20 cm range), *total porosity*, *physiologically useful volume*, *groundwater depth*. The *soil reaction within Ap horizon* (or in 0-20 cm range), *the humus storage* (in 0-50 cm range), *the degree of base saturation* and the human influence on the *pollution* are some of the chemical properties. Other factors are: the *landforms* depicted by *slope* and *landslides*, the *climate* by *annual mean temperature* – corrected values and *annual mean precipitations* – corrected values, and the *drainage* through the *flooding* and *excess surface moisture*.

Each of the 18 indicators has assigned a value (Land Evaluation Index - LEI) depending on the natural favorability for a particular crop or land use. It varies from “1” for total favorable and “0” for total unfavorable (Table 1).

In this paper, the opposite notion of favorability namely “restrictiveness” is used. Thus, the “1” value of LEI means no restrictions while the “0” value means entirely restrictive (Table 1).

Finally, the evaluation scores (LES), grouped in 10 land suitability classes have been obtained

multiplying by 100 the result of the multiplication of the coefficients. The first class enters the evaluation marks between 90 and 100 associated to the maximum suitability for a particular cropland. The last class, the 10<sup>th</sup> enters the evaluation score values below 10 showing the minimum suitability. In addition, in this study, the land suitability groups with evaluation scores values at a rate of 20 will be used (Table 2).

Table 1. The favorability and restrictiveness classes estimated on land evaluation index (accord. SSDM)

<i>Land evaluation index (LEI)</i>	<i>Favorability class</i>	<i>Restrictiveness class</i>
1.00	total favorable	no restriction
0.99 – 0.81	very favorable	very low restrictions
0.80 – 0.61	favorable	low restrictions
0.60 – 0.41	medium favorability	medium restrictions
0.40 – 0.21	unfavorable	high restrictions
0.20 – 0.01	very unfavorable	very high restrictions
0.00	total unfavorable	entirely restrictive

Table 2. The land suitability groups estimated on land evaluation score (accord. SSDM)

<i>Land evaluation score (LES)</i>	<i>Land suitability group</i>
>81	A – very high
61-80	B - high
41-60	C - medium
21-40	D - low
<20	E – very low

## 2.3. The land suitability assessment for different crops and land use in the Pereschiv catchment

For the entire Pereschiv catchment, using SSDM methodology, the land evaluation scores have been calculated, in order to determine the degree of natural land suitability for both the most common crop such as winter wheat, corn, sunflower, peas & beans, and the main type of land use such as arable, vineyard, orchard and pasture.

By using the TNTmips 7.3. GIS software (MicroImages, Inc., 2008) and integrating various soil surveys for nine communities that have been undertaken by the Pedology and Agrochemistry County Offices, the soil map of the entire basin was drawn (PACO Bacău, 1985, 1992a, 1992b, 1993; PACO Galați, 1988; PACO Vaslui, 1997, 1998, 2004). Using also a series of representative soil profiles supported by laboratory analyses (Lungu et

al., 2007; Rizea et al., 2007; Niacșu, 2009) an attached database was created. The previous soil studies undertaken by 2003 have been adjusted according to the new “Romanian Soil Taxonomy System” (Florea & Munteanu, 2003).

The geomorphologic maps present those parameters that have been obtained by both the field observations and the interpretation of aerial photos in the scale 1:5,000, delivered by the National Agency for Cadastre and Land Registration (NACLR, 2005). In addition, using the same GIS software some morphometric parameters have been calculated, such as hypsometry, slope etc. (Moore et al., 1993; Hengl & Evans, 2008).

The climatological and hydrological raw data were obtained by courtesy of National Meteorological Administration and “Prut” Water Department.

According to the methodology, a LEI map was drawn at a resolution of 5x5m, in raster format, for each indicator separately. Then, a final LEI raster has resulted automatically by multiplying the same pixel value on each individual LEI layer. Thus, the LES raster was achieved through multiplying by 100 the resulting raster. The basin average score for the four uses (arable, grape vine, cherry and pasture) is 45.7 and it is consistent with the third suitability group (Fig. 2).

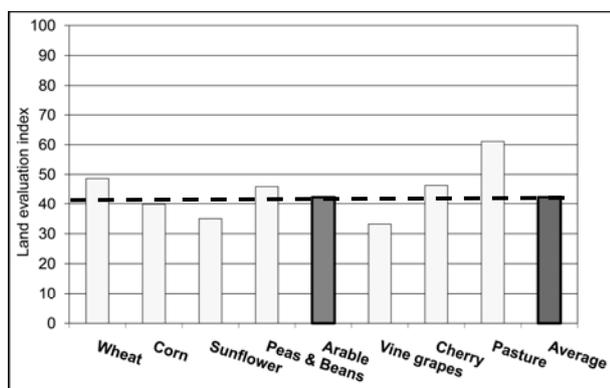


Figure 2. The medium land evaluation score for different crops and land uses

Among land use categories, with a LES rating of 61.1, the pasture shows the highest average score, meaning high suitability. The orchard and the arable follows with medium suitability of 46.3 and 42.3 LES, and finally the grape vine with a low suitability of 33.2 LES. Although the average values of evaluation score are generally low, as for arable, their spatial distribution is extremely heterogeneous (Fig. 3).

At the entire catchment, over 10,400 ha (45.2%) show a low and very low suitability and 7,700 ha a medium suitability for arable use. Only 4,900 ha (21.5%) have a high suitability of which 90 ha (0.4%) are with very high suitability (Fig. 4).

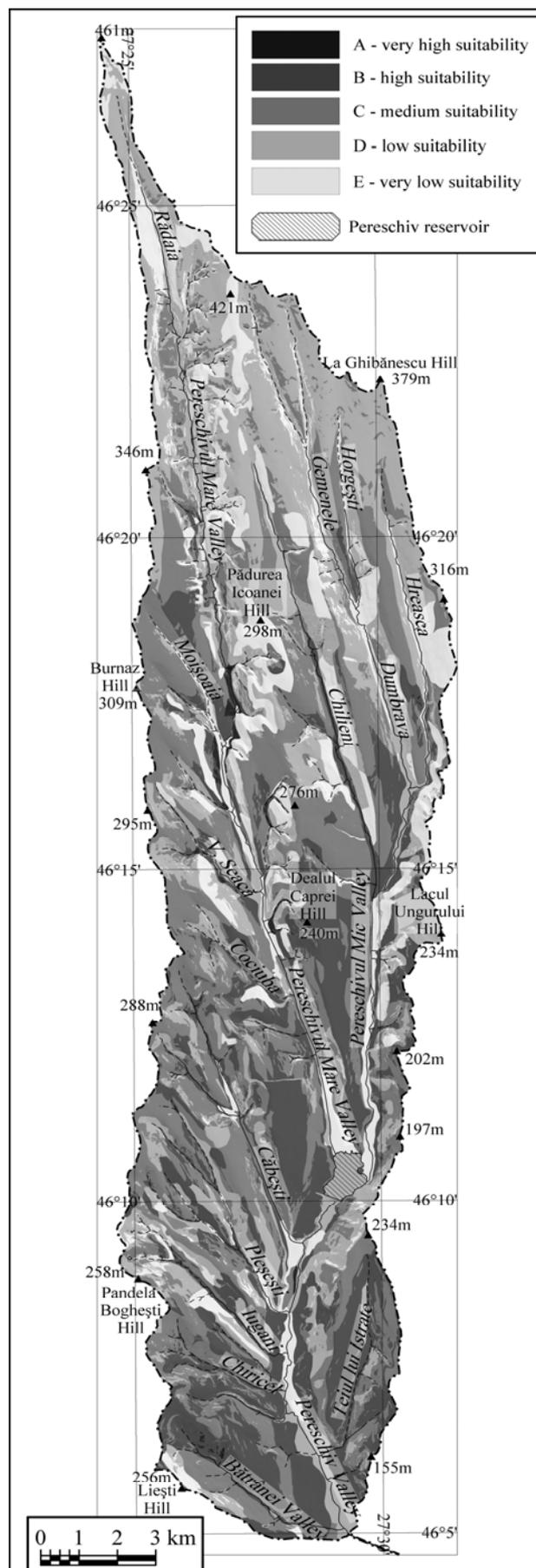


Figure 3. The land suitability map for arable use

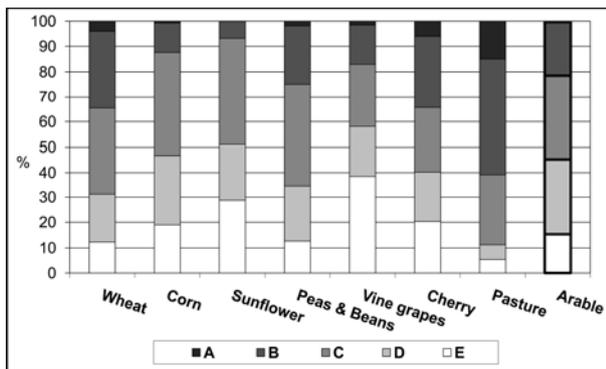


Figure 4. The share of land suitability groups for main crops and land use

The winter *wheat* has the best conditions in terms of better protection to soil erosion. The eastern and south-eastern looking back slopes of *cuestas* and the quite extensive *glacis* generate a medium suitability of 48.6 LES. Over 8,000 ha (34.6%) have high and very high suitability for that crop, of which about 1,000 ha exceeds the 80 value of evaluation score. The medium suitability exceeds 7,900 ha (34.2%) and low and very low comprises up to 7,300 ha (32.2%).

The *corn* is the most common crop through the entire Tutova Rolling Hills area, stretching over 7,300 ha that represents 58.5% of the arable land. Unlike that widespread use, the average suitability of 39.8% is low in terms of land evaluation score. Thus, an area of 2,880 ha (12.4% of the basin) presents land evaluation marks over 60 and only 170 ha exceed the level of 80.

The *sunflower* is also depicted by a low average suitability value of 34.4 showing the lowest pool of field crops. The highest marks appear in the southern part of the Pereschiv basin in both the fluvial terraces, colluvial deposits and the deluvial slopes subjected to slight erosion. Under these conditions, only 1,580 ha (6.8%) have high and very high land suitability, while over 11,800 ha (>51%) fit a low and very low suitability.

To calculate the land suitability for arable, the *peas* and *beans* have been also taken into account. Traditionally, within the small farms the beans accompany the corn while the peas are increasingly used. The land evaluation score of 45.9 is higher than the average. An area of 5,700 ha (24.9%) present over 60 land evaluation score meaning high and very high land suitability. Other over 9,300 ha (40%) correspond to the medium suitability but over 4,600 ha overlapping land that provide low and very low suitability for other three crops. Thus, the leguminous plants could successfully replace on a large scale corn and sunflower.

In the Southern part of Tutova Rolling Hills, the traditional vineyards present a low suitability,

with a 33.2 LES value. Despite the average lowest evaluation note for vineyard, the land has high and very high suitability for this crop on some areas within the middle and lower Pereschiv basin. For over 3,900 ha (16.9%) the LES value, which exceeds 60, shows a high and very high suitability. About 5,700 ha (24.9%) present a medium suitability with LES values between 40 and 60. Around 20% of the area has a low suitability, and in almost 40% the natural conditions enter with extremely low suitability.

Among the fruit trees, the cherry trees have been chosen because they encounter the best conditions if compared with apple or plum trees. For that use, the average evaluation note on the entire basin is 46.3, representing a medium value. The suitability is at least medium, with LES values over 60, in two thirds of the catchment. The high suitability occurs for 8,000 ha whereas the very high suitability comprises 1,400 ha.

The pasture has obtained the best average evaluation score of 61.1 among the seven crops and land uses. An area of 10,600 ha representing 60.8% of the basin has obtained a high suitability while 3,400 ha show very high suitability. The evaluation scores less than 40, depicting a low and very low suitability, represent 11.2% (2,600 ha) of the total.

### 3. RESULTS AND DISCUSSIONS

Since the climatic and hydric parameters do not induce significant restrictiveness for the agricultural land use, only the geomorphologic and pedologic parameters were taking into account to quantify the relationship between them and the associated amount of restrictiveness they induce.

#### 3.1. The geomorphologic restrictive parameters for agricultural land use

According to the Romanian methodology (INCDPAPM - ICPA, 1987) on land assessment, *slopes* and *landslides* represent the basic geomorphometrical parameters. The direct influence of those parameters in the Pereschiv catchment is relatively low as intensity but it occurs on large areas (Fig. 5). Indirectly, they have a large influence on the most pedologic parameters, and the resulting restrictiveness due especially to the slope is one of the most important in the area.

The geomorphologic parameters present a high and very high restrictiveness on 0.7% of the area, while the medium restrictiveness is typical for 3.7% (Fig. 6). Most of the basin (76.7%) has a low and very low restrictiveness and the remaining area of 18.8% does not show such an influence.



land use is 0.89 showing very low restrictions. If taking into account only this parameter and all other coefficients have maximum values, the land evaluation score may not exceed 89 points (Fig. 8).

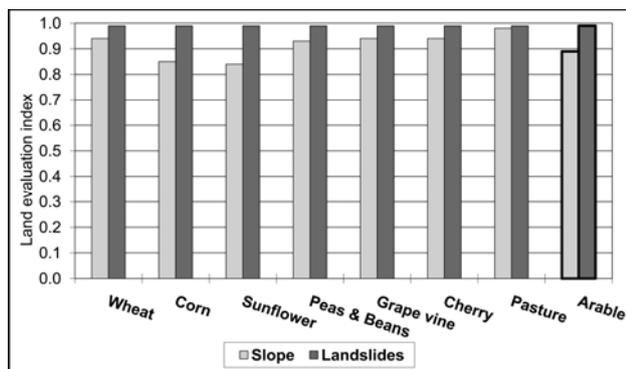


Figure 8. The mean land evaluation indexes for the main crops and land use given by the geomorphologic parameters

The lowest rate of only 0.85, which shows the highest intensity of restrictiveness to all crops and land uses, occurs at corn and sunflower. For the other crops and land uses, the slope significantly reduces its influence, to a mean LEI value of only 0.93.

Among the geomorphologic processes that have an important limitative role on agricultural land the landslides are of interest. Generally, landslides do not reach a significant development in the Pereschiv catchment but gulling was described as being the most characteristic process (Ioniță, 2000, 2006). However, gully erosion was not taken into account because area subjected to gulling felt in the category of unproductive land. In addition, the impact of soil erosion has been integrated to the restrictiveness induced by slope.

Only some spots representing 1.8% of the area are at risk to present-day processes and they generate very low restrictions to the agricultural land use (Fig. 7). The active landslides cover 0.47% of the area and deliver 720 t/yr of soil loss, representing only 0.2% of the total annual soil losses in the entire basin (Niacșu, 2009).

Actually, the 0.99 average values of LEI for all crops and land uses show a very low restrictiveness (Fig. 8). Often, on the sliding areas, the soil and gully erosion create a higher restrictiveness than landslides.

### 3.2. The pedologic restrictive parameters for agricultural land use

Among the twelve pedologic parameters listed in the methodology, only nine induce restrictiveness:

*carbonatation* (the total  $\text{CaCO}_3$  content in 0-50 cm range), *gleysation*, *surface-water gleysation*, *salinisation or alkalization*, *texture in the Ap horizon* (or in 0-20 cm range), *total porosity*, *physiologically useful volume*, *soil reaction within Ap horizon* (or in 0-20 cm range), *humus storage* (in 0-50 cm range). The others three parameters, namely *the degree of base saturation*, *groundwater depth* and *pollution* do not introduce restrictiveness in such geographical patterns.

*The degree of base saturation* meets very good and more rarely good conditions in the Tutova Rolling Hills. This is associated to the intense carbonated parent material, slight leaching of soil and to local climate conditions. Usually, the sum of exchangeable basis (EB) does not reach high and very high values. Since the exchangeable hydrogen (EH) has extreme low values an exchange capacity value (T) nearly equal to the EB value is resulting. Thus, the degree of base saturation presents values over 80%, which describes the eutric soils and indicates optimum conditions in the whole basin.

Land reclamation works were undertaken over the period 1970-1990 and under these circumstances *the groundwater depth* remained a restrictive factor for only 386.8ha (1.7%). That land covers the floodplain area around the Fichitesti reservoir.

As for *the pollution*, the determined values are far from the maximum accepted ones, making the study area one without pollution problems (Lăcătușu et al, 2003; Lungu et al, 2007).

However, the soil cover gives the highest restrictions for agricultural land use, and cropland presents at least low restrictiveness to 94.2% of the basin (Fig. 9). The Pereschiv catchment shows high and very high restrictions on over 9.1% of its area and medium restrictions on over 20.9%. The action of the pedological factors with low and very low restrictions characterizes the remaining areas (Fig. 10).

Between crops there are no major differences for low and very low restrictions. In the case of medium and severe restrictions it is noticed an increase of the summed values from 23.2% at winter wheat to 26.1% at peas and beans, 29.0% at sunflower and to over 32.9% at corn.

For other land uses, at least the minimum restrictions cover the biggest area in the case of the grape vine growing (89.8%). The percentage of the restricted area falls to 85.6% for sweet cherry trees and to a minimum of 73.3% for pastures.

As for the intensity of restrictiveness, the vineyard represent the highest medium and severe restricted areas of all crops and land uses (43.3%), while pastures present the lowest values (5.24%) indicating the highest favorability.

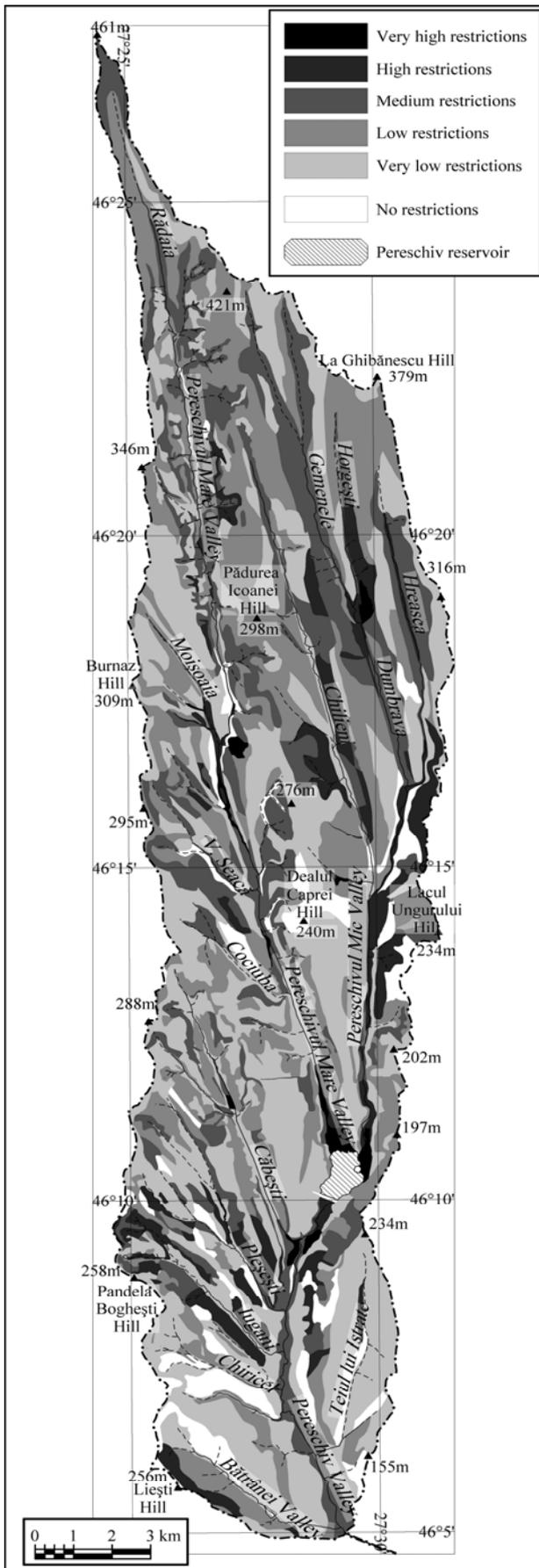


Figure 9. The land restrictiveness map for arable given by the pedologic parameters

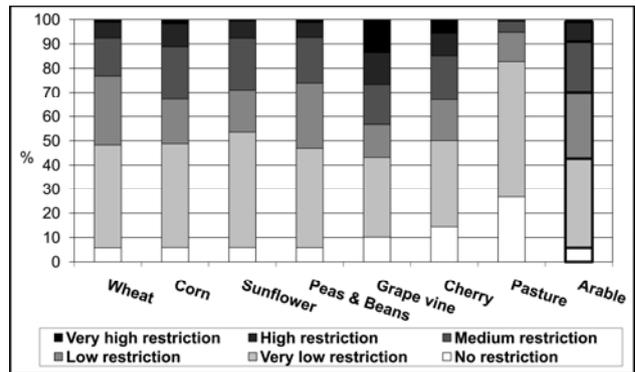


Figure 10. The share of land restrictiveness classes for the main crops and land use given by the pedologic parameters

### 3.2.1. Restrictive pedogenetic processes for agricultural land

Excepting the bioaccumulation, the carbonation is the most widespread pedogenetic process with the greatest restrictive influence towards the agricultural land use. Despite of this, *the total CaCO<sub>3</sub> content* is not a limiting factor of a high intensity.

The vineyard is the most sensitive crop to this process and presents restrictions for over 47% of the area (Fig. 11).

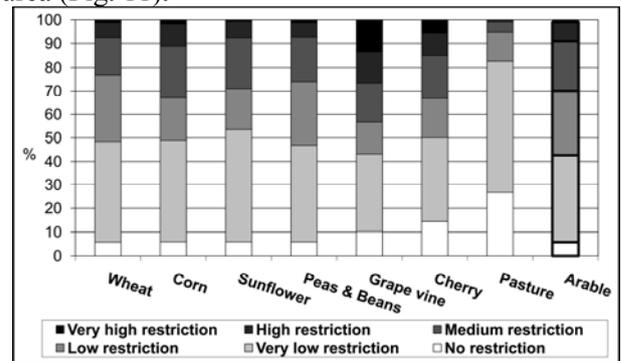


Figure 11. The share of restricted areas for the main crops and uses given by the pedogenetic processes

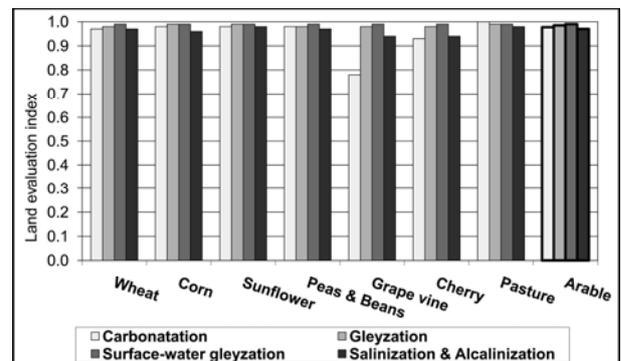


Figure 12. The mean land evaluation indexes for the main crops and uses given by the pedogenetic processes

The average intensity of restrictiveness, given by the average of the land evaluation index calculated for the whole basin is only 0.76 (Fig. 12).

If all other factors give a maximum favorability, the final land evaluation score reaches 76 points, which allows ranking of such land in the second suitability class.

The total  $\text{CaCO}_3$  content also brings significant restrictions for cherry trees but only 27% of the area amounts an average of 0.93 LEI. The arable with very low average intensity of restrictiveness (0.98 LEI) is drawing only 12% of the area. The pasture is the only use for which this parameter does not introduce any restrictiveness, the 1 LEI value showing a maximum favorability.

**The gleysation and surface-water gleysation** are restrictive factors for the studied crops and uses on very small areas. The gleysation both for all four crops and for pasture induce restrictiveness for 2.6% of the area with an extremely low average intensity (0.99 LEI). Only in the case of cherry trees and vineyard, the restricted area is slightly higher but not exceeding 4.1% with an average intensity close to other crops and land uses (0.98 LEI). The surface-water gleysation is lesser restrictive and never exceeding 2% of the area with the same extremely low intensity (0.99 LEI).

The **salinisation and alkalization** affect mostly orchards and vineyards in both the area (12.2%) and the intensity (0.94 LEI). For all other crops and uses, the average subjected area is 10.1% with a more reduced intensity (0.98 LEI).

### 3.2.2. Restrictive physical and chemical properties of the soil cover for agricultural land use

The cherry trees plantations are the most touched by the soil **texture** on 31.7% of the basin (Fig. 13).

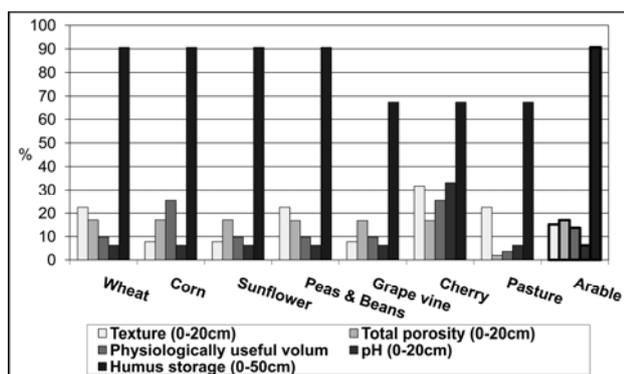


Figure 13. The share of restricted areas for the main crops and uses given by the physical and chemical properties of the soil cover

Although the restricted area is quite large, the intensity of the restrictiveness has very low LEI value of 0.96 (Fig. 14). In addition, the texture is restrictive for pasture and some crops such as winter

wheat, peas and beans on 22.5% of the area. Simultaneously, the vineyards, corn and sunflower are the least affected within an area of 7.8% showing an average LEI value of 0.98.

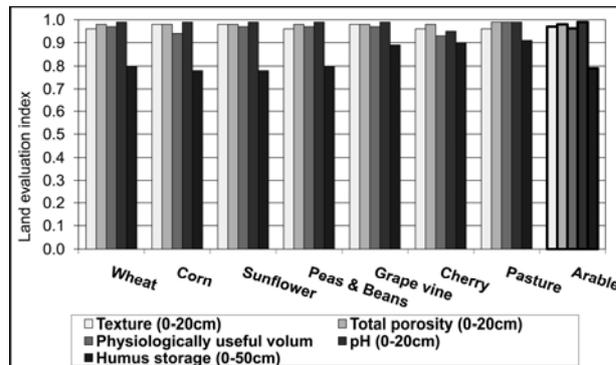


Figure 14. The mean land evaluation indexes for the main crops and land use given by the physical and chemical properties of the soil cover

The **total porosity**, excepting for pastures affect about 2% of the surface. Its restrictions occur on 16 – 18% of the basin with an intensity of 0.98 LEI for the other crops and land uses.

At its turn, the **physiologically useful volume** is restrictive for vineyards, cherry trees and corn with a deeper rooting on about 25% of the area at a weighted evaluation average of 0.93 LEI. The lowest values are associated to pastures for both the area (4%) and the intensity (0.99 LEI). Otherwise, the restricted areas do not exceed 10% at a low intensity (Fig. 13 and Fig. 14).

The **pH** values fall in the neutral to slightly alkaline range, with deviations starting from the weak acid type in some Ap horizons to moderately alkaline type on some parental materials. Under such terms, the pH is an important limiting factor only for the cherry trees on about 1/3 of the area. Otherwise, the restrictions affect no more than 6.5% of the area with the lowest average intensity (0.99 LEI) induced by all pedologic parameters.

The soil cover feature with the highest restrictiveness to plant growing in the Pereschiv catchment is the **humus storage** in the top 50 cm. This parameter is drawing limitations on productivity on over 90% of the area for those four crops: winter wheat, corn, sunflower, peas and beans (Fig. 13). In terms of intensity of that influence, the corn and sunflower are the most affected crops with an average index of 0.78, followed by winter wheat, peas and beans with a 0.8 index. For other uses (pastures, orchards and vineyards), the humus storage is insufficient to only 2/3 of the basin area at an average LEI of 0.9.

### 3.3. Geomorphologic and pedologic restrictive areas for agricultural land use

Depending on the relationship established between the geomorphologic and pedologic parameters that have repercussions in drafting of the main restrictive features, we can speak of a veritable regionalization of these restrictions (Fig. 15).

The areas with *maximum restrictiveness* cover the front cuesta slopes with west exposure (Ionita, 2000) where problems occur because of the deluvial slopes greater than 15°. This favors both the intense sheet erosion (Ioniță et al., 2006) and land sliding (Pujină, 2008). Conditioned by the clayey-sandy lithology, geomorphological and geomorphometrical features but also the existing land use patterns, intense gulling processes affect these areas (Ioniță, 2006). Under these natural patterns, on lands covered by undeveloped and strongly degraded soil types with high physical and chemical deficiency such as Regosols or other eroded soils, it is totally prohibited the arable land use.

The *high and very high land restrictiveness* calculated as average of these four most common uses (arable, vineyards, orchards, and pasture) occupies nearly 28% of the total area of the basin (Fig. 15). All the slopes on the right side of the main rivers in the studied catchment present such conditions. This is the case of the Pereschivul Mare, Pereschivul Mic, Dumbrava and Hreasca valley. On small southern areas, there are such extended areas associated to the front cuesta slopes with northern exposure.

On some restricted areas with southwestern exposure from the central-southern basin, benefiting of soil erosion control facilities, some vine and fruit plantations may be established. This is the case of the front cuesta slopes with western exposure from the Pereschiv Hill – Teiul lui Istrate valley area, where such plantations existed until 1990. In the northern basin, while respecting the prevention methods of soil erosion, lands may be used on large areas as hayfield or possibly pasture land. Otherwise, only the forest use is sustainable.

The highly and very highly restricted areas occur on the hilltops and plateaus, which do not meet the ecological requirements for plant growing. Covered by forest soil types, such lands appear in the northern part, on some areas such as the La Ghibanescu and Padurea Icoanei Hills. Although these surfaces are almost horizontal, stable, affected only by low sheet erosion, the arable crops do not meet here the optimum requirements mainly because of the current pedogenetical processes such as illuviation and surface-water gleysation as also to the poor physical and chemical properties: mainly

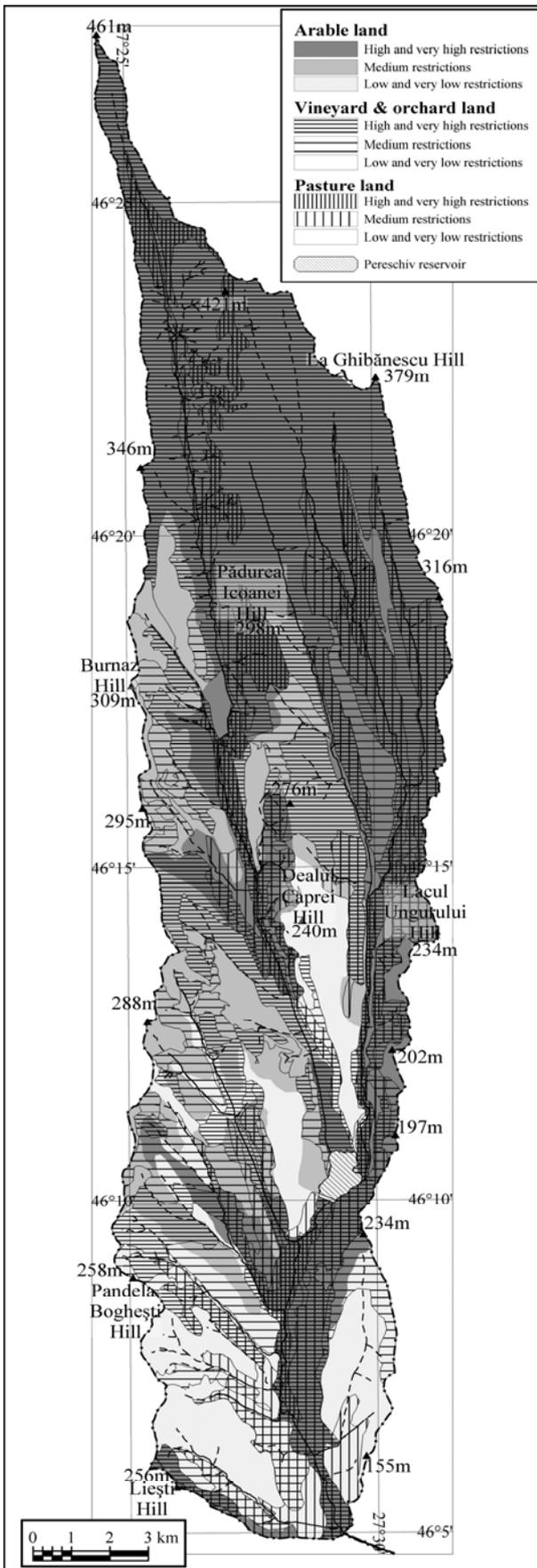


Figure 15. The land restrictiveness general map for agricultural land use given by the pedologic and geomorphologic parameters

clayey texture, low humus storage etc.

Other areas of major restrictiveness for arable land use occur in the south alluvial plains of Pereschivul Mare and Pereschivul Mic confluence, where problems related to the clayey texture and high concentration of soluble salts appear. In such circumstances, the pasture and hayfield represent the optimal land use mode for 11% of the total area.

The areas with *medium restrictiveness* characterize the deluvial back slope with eastern exposure (Ioniță, 2000) affected by moderate degradation processes and covered by high and moderate degraded soil types such as the chernozems and faeozems (Fig. 15). The maximum extension appears in the central part of the studied area (the Burnaz and Pandela Boghești Hills) and on less degraded hilltops in South (the Liești Hill). In such areas that have medium physical and chemical properties, the soil and water conservation works can decide the optimal land use. Among crops, there generally must be avoided the corn and sunflower which are the worst protective to erosional processes. If the slopes exposure is suitable, vineyard and orchard plantations may also be established.

The alluvio-colluvial and colluvio-alluvial plains, which encounter similar restrictions, have a large spread throughout the Pereschiv catchment.

The areas with *low restrictions* represent 29% of the basin and the very low restrictions ones slightly exceed 1%. They mostly cover the both slightly inclined deluvial slopes, developed on the cuesta back slope with eastern exposure from the central-southern side of the studied catchment and vast areas of colluvial and proluvial glaciis. Covered by well-developed chernozem and affected by weak sheet erosion processes, such lands have good physicochemical attributes, which promote all the land use types.

#### 4. CONCLUSIONS

Within the physical system that defines the studied area, the geomorphologic and pedologic parameters have the most important role to the land use. Over 30% of the studied area shows a *high and very high suitability* depicted by low and very low restrictions for the agricultural land use while the *medium suitability* (medium restrictions) covers almost 42%. Lands under *low and very low suitability* (high and very high restrictions) for the agriculture cover 28% of the entire Pereschiv catchment.

By comparing the suitability degree and the current land use, it is obviously that the plant crops

generally occur on huge areas. Therefore, farming is often unsustainable in terms of low land quality that offers only limited productions. The pastures appear completely random and being used only for livestock. Under such pedologic and geomorphologic patterns that define particularly the northern part of the basin, this land use type must extend to support the animal breeding on larger areas and to become the most important activity of the local people. In the south, the plant growing has to alternate with animal breeding on relatively large areas. In terms of sustained investment, good results can occur in vineyards and fruit growing.

After selecting the most suitable crops and land use types, the land management must be in full agreement with the main prevention and control erosion standards. Local outstanding economic results can be achieved by implementing these two components associated to sustainable agriculture.

#### Acknowledgements

This work was supported by the European Social Fund in Romania, under the responsibility of the Managing Authority for the Sectoral Operational Programme for Human Resources Development 2007-2013 [grant POSDRU/89/1.5/S/49944]. The continued support including the critical suggestions and helpful comments of Professor I. Ioniță deserves special thanks.

#### REFERENCES

- Alexander, M., 1971. *Agriculture's responsibility in establishing soil quality criteria*. Environmental Improving. Agriculture's Challenges in the Seventies, Natural Academy of Sciences, Washington, 66-71.
- Andrews, S.S. & Carol, C.R., 2001. *Designing a soil quality assessment tool for sustainable agroecosystem management*. Ecological Applications, 11, 1573-1585.
- Andrews, S.S., Karlen, D.L. & Mitchell, J.P., 2005. *A comparison of soil quality indexing methods for vegetable production systems in Northern California*. Agriculture, Ecosystems and Environment, 90, 25-45.
- Beek, K.J., 1975. *Land utilization types in land evaluation*. In: Land evaluation in Europe. Soils Bulletin 29, FAO, Rome, 87-106.
- Bouman, B.A.M., Schipper, R.A., Nieuwenhuysse, A., Hengsdijk H. & Jansen, H.G.P. 1998. *Quantifying economic and biophysical sustainability trade-offs in land use exploration at the regional level: a case study for the Northern Atlantic Zone of Costa Rica*. Ecological Modeling 114, 95-109.
- De la Rosa, D., Moreno, J.A., Garcia, L.V. & Almorza, J. 1992. *MicroLEIS: a microcomputer based*

- Mediterranean land evaluation information system*. Soil Use and Management 8, 89–96.
- Dumanski, J. & Smyth, A.J.** 1994. *The issues and challenges of sustainable land management*. In: Proc. International Workshop on Sustainable Land Management for the 21st Century, Vol. 2: Plenary Papers, Edited by Wood, R.C. & Dumanski, J., Agricultural Institute of Canada, Ottawa, pp. 381.
- FAO (Brinkman, R. & Young, A. ed.)** 1976. *A framework for land evaluation*. Soils Bulletin 32. FAO, Rome, pp. 72.
- FAO**, 2007. *Land evaluation. Towards a revised framework*. Land and Water discussion paper, vol. 6, Rome, pp. 107.
- Florea, N. & Munteanu I.**, 2003. *Romanian Soil Taxonomy System*, Estfalia Publishing House, Bucharest, pp. 182 (In Romanian).
- Fresco, L.O., Huizing, H.G.J., Van Keulen, H., Luning, H.A. & Schipper, R.A.**, 1992. *Land evaluation and farming systems analysis for land use planning*. FAO working document, Rome, Italy / ITC, Enschede, The Netherlands / Wageningen Agricultural University, Wageningen, The Netherlands, pp. 209.
- Hengl, T. & Evans, I. S.**, 2008. *Mathematical and digital models of the land surfaces*, In: Geomorphometry: concepts, software, applications, Edited by Hengl, T. & Reuter, H.I., Developments in Soil Science, vol. 33, Elsevier, 31 – 64.
- INCDPAPM - ICPA (Florea, N., Bălăceanu, V., Răuță, C. & Canarache, A. coord.)**, 1987. *Soil Studies Development Methodology (SSDM)*, part II, Methods, Reports, Guidelines, 20, pp. 350 (In Romanian).
- Ianoș, G.**, 2006. *Natural and technogenic risks on the Banat agricultural lands*. University of West Publishing House, Timișoara, pp. 230 (In Romanian).
- Ioniță, I.**, 2000. *Cuesta landform in the Moldavian Plateau*. Corson Publishing House, Iași, pp. 108 (In Romanian).
- Ioniță, I.**, 2006. *Gully development in the Moldavian Plateau of Romania*. In: Special Issue “Soil Erosion Research in Europe”, Edited by Helming, K., Rubio, J. L. & Boardman, J., Elsevier - Catena, 68(2-3), 133-140.
- Ioniță I., Rădoane, M. & Mircea, S.**, 2006. “1.13 Romania”. In: Soil Erosion in Europe, Edited by Boardman, J. & Poesen, J., Publisher John Wiley, Chichester, England, 155-166.
- Jeanrenaud, P. & Saraiman, A.**, 1995. *Central Moldavian geology between Siret and Prut rivers*, “Al. I. Cuza” University Publishing House, Iași, pp. 186 (In Romanian).
- Klingebl, A.A. & Montgomery, P.H.**, 1961. *Land-capability classification*. Agricultural Handbook 210, Soil Conservation Service. U.S. Government Printing Office, Washington, D.C. pp. 21.
- Lăcătușu, R., Lungu, M., Kovacovics, B., Plaxienco, D., Rizea, N., Constantin, C., Mihalache, D., Preda, M. & Lazăr, R.**, 2003. *Carcinogenic factors in soil-plant-water system from Romania I. Ilfov and Vaslui county areas and peripheral area of Bucharest*. Proceedings of the XVII National Conference on Soil Science, vol. 2, 558-569 (In Romanian).
- Lewandowski, A. & Zumwinkle M.**, 1999. *Assessing the soil system. A review of soil quality literature*. Minnesota Department of Agriculture, Energy and Sustainable Agriculture Program, Edited by Fish A., pp. 71.
- Lungu, M., Niacșu, L., Stângă, I.C., Aldea, M.M., Lazăr, R., Stroe, V.M. & Râșnovceanu I.**, 2007. *Macro- and microelements soils content from Bârlad Tableland (Tutova Rolling Hills)*. In: Impact of the hydro-climatic and pedo-geomorphologic risks on environment in the Bârlad catchment, Edited by Rusu, C., “Al. I. Cuza” University Publishing House, Iași, 161-168 (In Romanian).
- Moore, I.D., Turner, A.K., Wilson, J.P., Jenson, S.K. & Band, L.E.**, 1993. *GIS and land surface-subsurface modeling*. In: Environmental Modeling with GIS, Edited by Goodchild, M. F., Parks, B. O. & Steyaert, L. T., Oxford University Press, New York, 196-230.
- Munteanu, I., Grigoraș C., Dumitru, S., Dobrin, E. & Mocanu V.**, 1998. *ROMSOTER-200: A digital database at a scale of 1:200.000 for soil and terrain resources of Romania*. In: Land Information Systems - Developments for planning the sustainable use of land resources, Edited by Heineke et al., European Soil Bureau, JRC, EC, EUR 17729 En, pp. 197-214.
- Munteanu, I., Lăcătușu, R., Dumitru, E., Jalbă M., Latiș L., Ciobanu C., Dumitru, S., Andar, P., Mocanu, V., Moise, I. & Canarache A.**, 1999. *The main issues resulted from the application of the SOVEUR – project, 1:2.5 M in Romania*. In: Soil Degradation Status and Vulnerability Assessment for Central and Eastern Europe – Preliminary Results of the SOVEUR project, report 2000/04, Edited by Batjes, N.H., 77-82.
- NACLR**, 2005. *Aerial photos*, scale 1:5,000.
- Niacșu, L.**, 2009. *Soils atlas from Pereschiv catchment (Tutova Rolling Hills)*. Performantica Publishing House, Iași, pp. 78 (In Romanian).
- PACO Bacău (Mară M.)**, 1985. *Pedological study of Boghești territory. Includes Soils map of Boghești territory, scale 1:10,000*, pp. 128 (In Romanian).
- PACO Bacău (Mară M. & Gălățeanu M.)**, 1992a. *Pedological study of Glăvănești territory. Includes Soils map of Glăvănești territory, scale 1:10,000*, pp. 116 (In Romanian).
- PACO Bacău (Mară M. & Gălățeanu M.)**, 1992b. *Pedological study of Motoșeni territory. Includes Soils map of Motoșeni territory, scale 1:10,000*, pp. 136 (In Romanian).
- PACO Bacău (Gălățeanu, M.)**, 1993. *Pedological study of Podu Turcului territory. Includes Soils map of*

- Podu Turcului territory, scale 1:10,000*, pp. 118 (In Romanian).
- PACO Galați (Murariu, M.)**, 1988. *Pedological study of Priponești territory. Includes Soils map of Priponești territory, scale 1:10,000*, pp. 96 (In Romanian).
- PACO Vaslui (Ivan, G., Romașcanu, M. & Cazacu, V.)**, 1997. *Pedological study of Coroiești territory. Includes Soils map of Coroiești territory, scale 1:10,000*, pp. 88 (In Romanian).
- PACO Vaslui (Ivan, G., Negruți, V., Romașcanu, M. & Gorban, C.)**, 1998. *Pedological study of Ivești territory. Includes Soils map of Ivești territory, scale 1:10,000*, pp. 86 (In Romanian).
- PACO Vaslui (Ivan, G., Chișcă, R. & Romașcanu, M.)**, 2004. *Pedological study of Puiești territory. Includes Soils map of Puiești territory, scale 1:10,000*, pp. 106 (In Romanian).
- Patriche, C.V.**, 2003. *Biophysical and technical evaluation of the agricultural lands*. Terra Nostra Publishing House, Iași, pp. 242 (In Romanian).
- Pujină, D.**, 2008. *Landslides from Moldavian Tableland*, Performantica Publishing House, Iași, pp. 146 (In Romanian).
- Rădoane, M., Ichim, I. & Rădoane, N.**, 1995. *Gully distribution and development in Moldavia, Romania*, Catena 24, 127-146.
- MicroImages, Inc.**, 2008. *Reference Manual for the TNTmips Software*. Published in the United States of America, 11th Floor - Sharp Tower, 206 South 13th Street, Lincoln NE 68508-2010 USA, Business & Sales, 1700, pp. 241.
- Rizea, N., Niacșu, L., Stângă, I.C., Lazăr, R., Stroe, V.M. & Aldea, M.M.**, 2007. *Exchangeable cation properties of some representative soil profiles from Bârlad Tableland*. In "Impact of the hydro-climatic and pedo-geomorphologic risks on environment in the Bârlad catchment", Edited by Rusu, C., "Al. I. Cuza" University Publishing House, Iași, 179-188 (In Romanian).
- Rossiter, D.G.**, 1990. *ALES (Automated Land Evaluation System): a framework for land evaluation using a microcomputer*. Soil Use and Management 6, 7–20.
- Rossiter, D.G. & van Wambeke, A.R.**, 1997. *Automated Land Evaluation System*. Cornell University, Department of Soil, Crop and Atmospheric Sciences. New York, Ithaca, pp. 284.
- Rossiter, D.G.** 1995. *Economic land evaluation: why and how*. Soil Use and Management 11, 132–140.
- Rossiter, D.G.** 1996. *A theoretical framework for land evaluation. Discussion paper*. Geoderma 72, 165–190.
- Sanchez, P.A., Couto, W. & Buol, S.W.**, 1982. *The fertility capability soil classification system: interpretation, applicability and modification*. Geoderma 27, 283 – 309.
- Smyth, A.J., Dumanski, J., Spendjian, G., Swift, M.J. & Thornton, P.K.** 1993. *FESLM: an international framework for evaluating sustainable land management*. World Soil Resources Report 73. FAO, Rome, pp. 85.
- Smyth, A.J. & Dumanski, J.** 1995. *A framework for evaluating sustainable land management*. Canadian Journal of Soil Science 75, 401–406.
- Stângă I.C.**, 2007. *Natural risks. Terms and concepts*. "Al. I. Cuza" University Publishing House, Iași, pp. 114 (In Romanian).
- Tsoumakas, G. & Vlahavas, I.** 1999. *ISLE: An Intelligent System for Land Evaluation*. Proceedings ACAI'99 Workshop on Intelligent Techniques for Spatio-Temporal Data Analysis in Environmental Applications, Chania, Greece. 26–32.
- Teaci, D.**, 1980. *Agricultural lands evaluation*. Ceres Publishing House, Bucharest, pp. 296 (In Romanian).
- USDA**, 1983. *National agricultural land evaluation and site assessment handbook*. US Government Printing Office, Washington DC, pp. 95.
- Vasiliniuc, I.**, 2009. *Soil quality. Terms and concepts*. "Al. I. Cuza" University Publishing House, Iași, pp. 112 (In Romanian).
- Vink, A.P.A.**, 1975 - *Land use in advancing agriculture*. Springer, Berlin, Heidelberg, New York, pp. 392.
- Vlad, V.**, 1996. *Proposal for an integrated expert system for land evaluation in Romania*. Soil Science, XXX(2), 77-91 (In Romanian).
- Vlad, V.**, 2003. Considerations regarding the cadastral evaluation of the agricultural lands and the agricultural qualitative cadastre database. Soil Science, XXXVII (1-2), 162-176 (In Romanian).
- Young, A.**, 1973. *Rural land evaluation*. In: Evaluating the human environment, Edited by Dawson, J.A. & Doornkamp, J.C., Arnold, London. p. 5-33.

Received at: 11. 10. 2011

Revised at: 15. 03. 2012

Accepted for publication at: 30. 03. 2012

Published online at: 02. 04. 2012