1. INTRODUCTION

During its existence, the Earth’s surface has undergone and continues to undergo significant changes due to the action and interaction between the endogenous and the exogenous factors. The elevations and the sagging of the Earth’s crust, made by the endogenous factors, lead to the activation of the exogenous factors such as the erosion.

The ravines are minor landform while the ravines erosion is considered to be one of the most spectacular land degradation processes. The presence and the development deep erosion formations create serious problems to a certain region’s economy.

By their high rate of expansion, the ravines affect extended farmland, but they also function as important alluvial providers in rivers and lakes. The severity of ravines erosion in a hydrographic basin is often quantified as a percentage of the total surface or as density per km$^2$.

The thesis entitled “The assessment of deep erosion in degraded areas located in the Someş Plain by modeling the topo-geodetic data in GIS” has the purpose to create and use a GIS system that allows the incorporation of the topo-geodetic data and information, as well as the modeling of algorithms that can provide additional data regarding the values corresponding to the ravines’ increase in length, changes in volume and the surface occupied by the ravines etc.

The design, implementation and use of the Geographic Informational System (GIS), made to achieve the main objective of this thesis, namely to supervise and evaluate the evolution of some ravines located in the Someş Plain, was based on the use of high precision topo-geodetic data and geographic data that allowed, through a relational context, the derivation and the analysis of the parameters that are specific to ravines development, as well as the evaluation of the conditions under which the erosion has occurred or not, during a period of about 45 years.

The period in question starts in 1969, during which the aerial photography used in elaborating the 1:5000 scale topographic plans, was made by the Institute of Geodesy, Photogrammetry, Cartography and Land Management, and ends in 2013, when the new topo-geodetic measurements were developed.

As a result of these measurements, there were obtained new data concerning the typology of the soil profile for the considered ravines and satelite images of high spatial resolution.
Moreover, we also consider that in the future this study can contribute to a better understanding of the physical and geographical conditions that characterize the Someș Plain, of the soil cover, as well as of the land use categories for the purpose of developing new measures and technologies for agricultural land conservation and improvement, study that can be extended for other regions.

2. KNOWING THE MOTIVATION, OBJECTIVES AND AREA OF STUDY

Knowing the real motivation of this study is meant to provide a positive constructive attitude on understanding the methodology used, on the obtained results and, last but not least, on the assessments made based on the results that had been obtained, bringing important and logical sense to the study.

2.1. RESEARCH MOTIVATION

The built-up areas, especially from the villages, as well as the unincorporated areas, suffer continuous changes, mostly due to the erosion.

The results of these processes are often represented by ecological imbalance with its negative consequences such as property damage (constructions degradation), crops destruction, floods etc.

Therefore, the motivation of this study is sustained by the fact that erosion processes tend to have a negative impact on ecosystems as well as in making decisions regarding land use.

Thus, the present study wishes to assess erosion process using both old and new data, topo-geodetic methods and data which have been introduced and used in a GIS system.

2.2. RESEARCH OBJECTIVES

The first objective of this thesis would be obtaining data in analog or digital format and building a database in a GIS environment.

The database will contain and will represent the situation of ravines for the period between 1969 and 2013. 1969 is considered the starting point because it has 1:5000 scale topographic
plans, scanned on paper, allowing to acquire all the data in digital format necessary to represent the situation of the five ravines that have been considered.

The second objective is the design and construction of a methodology that must use the databases which was previously created in GIS environment and which leads to obtaining new digital numerical quantitative spatial information in order to make assessments on the development of ravines both automatically and semi-automatically.

The ultimate goal is represented by the stage of presentation and practical evaluation of how the erosion process has continued or has stagnated over time, based on the numerical results obtained and also on the digital maps resulted.

### 2.3 LOCALIZATION OF AREA OF STUDY

In order to assess the evolution of the deep erosion process using GIS, we have chosen five ravines located on the Someş Plain territory, a subunit of the Transylvanian Plain.
From a territorial-administrative point of view, the five ravine are located as follows:

- ravine 1, Tăușeni, is located on the territory of Bonțida vill, near the Tăușeni village;
- ravine 2, Buza, is located in the homonym vill;
- ravine 3, Unguraș, is located in the North-East part of the Unguraș village (Unguraș vill) on the border between Cluj county and Bistrița-Năsăud county;
- ravine 4, Mintiu Gherlii, is located on the territory with the same name, in the South of Mintiu Gherlii village;
- ravine 5, Fizeșul Gherlii, is located on the administrative territory of Fizeșul Gherlii vill, at East of the administrative border of Gherla municipality.

It should be mentioned that the names of the ravines were chosen arbitrarily. There were assigned names that coincide with the localities near the ravines or across the vills in which they are found. This was a necessary goal in order to be able to identify the ravines.

3. THE STATE OF RESEARCH CONCERNING DEEP EROSION PROCESS IN ROMANIA AND WORLDMIDE

3.1. DEFINITIONS

Almost every author who has dedicated his research to ravines felt compelled to offer a definition, usually accompanied by many marks and indications in order to give consistency. Unfortunately, this goal was not achieved.


- a canal with sloping sides, often with a steep descent point;
- ephemeral drainage;
- numerous thalweg crests;
- a rapid expansion in the area of origin;
- V-shaped cross-sections, when the unconsolidated deposits are relatively resistant to depression and U-shaped cross-sections, when the deposits are more eroded;
- they can't be removed by ordinary agricultural work.

In the definition draft of a ravine there are pointed out its main components, as follows:

- **the ravine’s top or the ravine’s origin**, which most of the times takes the form of a slope named *origin steep (headcut)*, having depths that exceed 20 meters in loess land. The peak is considered the ravine’s critical area, presenting a maximum rate of length, depth and width development in order to allow the access of water reception in the ravine, through this peak. In a ravine, there are usually several peaks, the main one being considered the one who receives the highest flow;

- **the alluvial cone** is a deposit area usually located out of the ravine; in most cases, the beginning of this area coincides with the mouth of the ravine and land elevation in this point;

- **the cone’s apex** is the ravine’s basic level.
In conclusion, the ravines are forms of deep erosion, sectioned in loose rocks, consisting of a canal with steep sides and thalweg crests, having a cross section that exceeds 1000 cm, with an origin crest characterized by an ephemeral leak and which are not removed by normal agricultural work.

Several Romanian and foreign authors cite the American Geological Institute Glossary (1972) the following definition of a ravine:

- a very small valley like a ditch on the face of a slope or a long and narrow canal built in unconsolidated materials by running waters after a rain or after the snow’s melting.
- any erosion canal so deep that it can’t be crossed by vehicles or removed through plowing, especially one dug the soil of an uncovered slope.

3.2. RAVINES’ CLASSIFICATION

Several attempts have been made in order to make a classification of the ravines, based on configuration, cross-sectional shape, location in the landscape etc.

The classification criteria used so far are:

a) longitudinal profile’s shape criterion, used by leopold and Miller (1956), taken and argued by Heede (1975), Bălteanu, Taolescu (1978).

Therefore, the ravines are divided into continuous and discontinuous ones.

b) plan configuration, criterion by which Ireland et al. (1939) (cit. Schumm et al., 1984) classifies ravines into six groups: linear ravines, bulbous form ravines, dendritic ravines, barred ravines, parallel ravines and composed ravines.

Using this last criterion, De Ploey (1974) suggests three types of ravines: axial ravine, frontal ravine or shore ravine.

c) localization in the river basin criterion, used by Brice (1966), Tufescu (1967), but also by reasearchers from the former URSS (Ahmadov, 1976; Kosov et al., 1982): bottom of valley ravines, origin ravines, slope ravines.

d) the cross-sectional shape criterion which leads to two main ravine types: ravines with an U-shaped cross-section and ravines with a V-shaped cross-section.
e) evolutionary cycle criterion, used by Poesen and Govers (1990) in their research on erosion in ravines from Belgium, criterion according to which ravines are as follows: ephemeral ravines or perennial ravines (with sides).

f) in the erosion control and land improvements domains there has been emphasized the depth, width and drainage surface of ravines.

In conclusion, a review of the most often cited classification allowed us to point out those that help us understand the expansion, diversity and genesis of the phenomenon which is the focus of this thesis’s study.

3.3 STUDIES MADE ON RAVINES AND EROSION PROCESSES

The first reviews and ratings concerning ravines and the processes that they imply come from investigations made by designers and conservators who have shown that ravines are a problem in the field of their sciences.

The fact that ravines are a problem results from a few reported data about their relative spread, especially for arid and semiarid regions.

The most spectacular processes of ravinations occurred in India and in China’s Loess Plateau.

In Romania, only in the area between Siret River and Prut River, were inventoried over 9000 ravines with average expansion rate of 1-1.5 m/year (Rădoare et al., 1995); measurements were made in order to determine the surface development rate on samples ravines from area of Soil Erosion Research Station Pereni Moțoc et al., 1979; Ioniță, 1998; Hurjui, 1998), in the region of the hills and plateaus outside the Carpathians Bălteanu, Taloescu, 1978) or in the deforested areas from the Fliș Mountains (Rădoare, 1980, 1988).

Ravines are important sources of alluvial sediments.

In a study made by Moțoc (1984) for the entire romanian territory is estimated that 31% of the alluvions that reach in the hydrographic network come from deep erosion (gullies, ravines, streams). In absolute values, the amount of alluvions due to these processes is 13,8 milions of tones out of a total of 44,6 milions of tones transported by the rivers in Romania.
In Heede’s opinion (1974) it is said that: „As long as the ravines can be described quantitatively in terms of their stage of development, there is a chance that the decision regarding their planning and control is going to be improved.” (Heede, 1974, p.261)

3.4 TERMS USED IN THE STUDY OF RAVINES

Ravine are included in the category of the microrelief along with the sinkholes, the ice wedges, the dunes and the terraces. This category contains very dynamic landforms, with age between one and several hundred years and sizes between $10^{-1}$ and $10^{-3}$ km (the proportion height/depth $H/D < 10^{-1}$m).

We consider that is important to specify the position of the ravines in the fluvial geomorphic system so as to clarify the relationship ravines – permanent watercourses.

Between these two categories there exist both similarities and differences, the ravines being located in the area of the lowest flows of the ephemeral watercourses.

S.A. Munteanu et al. (1991) defines the torrent as „a natural watercourse with an intermittent drainage (rarely with drainage throughout the year) and with a relatively small hydrographic basin (of hundreds of acres or maximum of several thousand hectares), with fast or irregular slopes and whose main hydrological feature is that, after large rainfall or rapid snow melting, brings out sudden, violent and brief growths of liquid and solid flow, generally accompanied by intense phenomena of erosion, of alluvion and sediments transport.”

Landforms occurred through torrential erosion are generically named torrential formations and, among them, authors distinguish, by dimensional criteria: runff channels (with depth $< 0,2$ m), runoff ditches (with depth $< 0,5$ m), gullies (with depth of $0,5 – 2$ m) and ravines (with depth of more than $2$ m).

About ravines it is said that they „may be isolated or may be seen as components of a complex torrential formations, which is the torrent itself”.

The torrential formations with an extreme density give the relief the appearance of so called „badlands”.
4. DATABASES, TECHNICS AND USED METHODS

A database is an instrument used for gathering and organizing the informations. The databases used in GIS can store numerical information using tables, digital raster images (for example scanned topographic plans, ortophotoplans, numerical models of the land, the distribution of the precipitations quantities, etc.) or vectors that represent the points, lines or the polygons resulted from the topographic measurements of the coordinates of some points (topographic point, limits, lots) and others.

The data source required for the database is comprised of old topographic plans but also of topographic measurements taken with the GPS device, digital ortophotoplans. The paper maps were scanned and used especially as a source for obtaining the required digital dates for the early stages of the erosion process.

In order to describe and define a geographical habitat, a database that contains elements with known x, y and z coordinates is needed. A cartographic database can be used for the representation of a variable distribution in the studied geographical area.

So, in order to follow a geomorphologic process, like the depth erosion type, using dates from different periods of time, the spatial data needed in the study must be in a unique cartographic projection. This will allow the use of the themed layers, obtained from different sources and periods of time, and the execution of several operations needed for pointing out and argumentation of the erosion process.

4.1. STEREOGRAPHIC PROJECTION SYSTEM 1970 (STEREO 70)

The Stereo 70 Projection is used in our country since 1973. It is based on the elements of the Krasovski-1940 ellipsoid and the reference plan for Black Sea-1975 levels. It was used at the topographic plans with 1:2.000, 1:5.000 and 1:10.000 scales, as for the topographic maps with 1:50.000 scales (http://earth.unibuc.ro).

The Stereographic 1970 Projection is pursuant to the linear perspective laws, does not distort the angles allowing the geodesical measurement to be processed directly into the projection plan without calculating the geographical coordinates, with the condition of using some prior corrections in order to reduce the measurements from the projection plan. The
Projection distorts the areas depending on their distance from the projection pole (http://earth.unibuc.ro).

4.1.1. COLLECTING DATA BY USING THE GPS DEVICE

The GPS System (Global Positioning System) is a satellite navigation system that provides information about the location and the time, despite any meteorological conditions, anywhere or near the Earth’s surface, where the visual field to four or more satellites is not obstructed.

The GPS can be used to obtain the required accuracy in all the applications mentioned above, the only difference being in the type of the receptor and the used working method.

4.1.2. USING GPS TECHNOLOGY FOR ESTABLISHING RAVINES’ GEOMORPHOLOGICAL CONFIGURATION

In order to fulfill the purpose of the proposed research topic, we proceeded in making measurements of the points that define the configuration of the five considered ravines. Thus we managed to obtain the Numerical Model of the Land, the line of the thalweg or the perimeter of the gully for 2012-2013, period considered to be the end of the period.

The GPS measurements were carried out using a Hi-Target receiver, V30 GNSS RTK model, the used measurement method being the kinematic one. This type of GPS can be used also in the statis method. In the case of kinematic method, the receivers are in motion (known in this case as the rover), and the results are obtained from a single age or several ages of measurement in every point.

4.1.3. GPS SPECIFICATIONS

The GNSS RTK L1L2 HI-TARGET V30 System in configuration Rover GPS/Glonass/Galileo has the following technical specifications (Hi-Target, 2010):

- Receiver: V30 GNSS
- Number of channels: 220
- Receives signals of the following satellites:
  - GPS simultaneously L1C/A, L2E,L2C,L5
- Glonass simultaneously L1C/A, L1P, L2C/A (restricted on GLONASS M) and L2P
- SBAS simultaneously L1 C/A,L5
- Giove-A : simultaneously L1 BOC,E5A,E5B,E5AltBOC1
- Giove-B : simultaneously L1 CBOC,E5A,E5B,E5AltBOC1
- Galileo : Upgrade
  Initialization time : 60 sec
  RTK initialization : <10 sec
  Refresh rate = 10 Hz
  Trimble BD 970 motherboard
  64 Mb internal memory
  Communication interface : I/O 9 and 5 pin connectors, Bluetooth class II 2.4 GHz with a range up to 50 m.
  Internal radio with 433 MHz frequency – for free in Romania
  Fixed internal GSM/GPRS Modem
  Serial port : CMR, CMR+, RTCM 2.1, 2.2, 2.3, 3.0, 3.1, input and output
  Hi-RTK Road Software for the rover mode : allows the alternation of the registration rate, elevation angle and naming of the RINEX file.
  Accuracy :
  - Horizontally static : +/-2.5 mm + 1 ppm
  - Vertically static : +/-5 mm + 1 ppm
  - Horizontally RTK : +/-1 cm + 1 ppm
  - Vertically RTK : +/-2 cm + 1 ppm
  Radio modem 2W for a distance of over 5 km
  Resistant to vibrations and dust
  Resistant to water immersion to a depth of 1m or 100% humidity
  Built to withstand shocks caused by free fall on the concrete from a height of 2 m.
4.1.4. COORDINATES TRANSFORMATIONS

The cartesian coordinates (rectangular) X, Y, Z of a point in space and considering a revolution ellipsoid with the same origin as the cartesian coordinate system, the point can be defined also through ellipsoidal coordinates B, L, h.

For the GPS applications, the most important is the inverse transformation because with the given cartesian coordinates, the ellipsoidally coordinates can be deduced. So, the problem is to transcalculate the ellipsoidal coordinates B, L, h into cartesian coordinates X, Y, Z.

4.1.5. ALTIMETRIC TRANSFORMATIONS

By positioning with GPS, the X, Y, Z coordinates are resulted. After applying the transformations, the allipsoidal altitudes become usable.

The GPS coordinates are denoted by the „GPS” index, and the terrestrial coordinates referenced to a local system are denoted by the „LS” index. Therefore, the GPS observations give the (X,Y,Z) GPS coordinates. The local plane coordinates (x,y) LS can be transformed using constant coefficients formulas, known from the „Mathematical Cartography”, in the ellipsoidal coordinates (B,L) LS. If the orthometric altitudes and the geoid ondulations are known, then the ellipsoidal altitudes can be calculated, obtaining a coordinate triplet (B,L,h). This coordinates can be transformed into cartesian coordinates (X,Y,Z) LS.

4.1.6. CARTOGRAPHIC DATABASE

Regarding the clasic paper cartographic database, nedded to assess the erosion process, has been used a database formed of:

- topographic plans, scale 1:5.000
- soil maps, scale 1:200.000
- topographic maps, scale 1:25.000
- geological and hydrogeological maps, scale 1:200.000
4.1.7. ANCILLARY DATA SOURCES

Data such as alphanumeric information and other secondary data types represent the auxiliary data source of the present project.

4.2. THE DERIVED GIS DATABASE

The integration of the geographical representations using databases can be done with the help of Geographic Information System (GIS). This system helps in this regard because it stores, takes, manipulates, analyses new results using a visual-interactive environment.

4.2.1. VECTOR AND RASTER DATA TYPE

The digital maps involved in GIS data processing represent what is called a spatial database. The used GIS database contains both vector and raster data. Among the vector primitives are known: the point (for example: the points measured with the GPS device), the line (for example: thalweg line, rivers, administrative boundaries, etc.), and the polygon (for example: the built-up of a village, a gully’s area, etc.).

Rasters are generally represented by vector processing results as the Numerical Model of the Land resulted from some topographic measurements and digitizing level curves; layers with that type of land cover resulted from maps vectorisation, topographic plans, ortophotoplans and other derivations obtained with the primary dates, mentioned above, that have been used to obtain other parameters of the erosion process.

4.2.2. ORTOPHOTOS

For this study, ortophotos from different periods of time such as 2005, 2010, 2012 have been used. With their help, it was able to reconstruct various morphometric characteristics of the gullies or land cover structure at the end of the period.

5. NATURAL ENVIRONMENT ASSESSMENT IN THE AREA OF STUDY

5.1. GEOMORPHOLOGICAL CHARACTERIZATION

The result of the morphogenetic and morphological analysis carried out on the filed, has favored the assessment within the subunits in northwestern Transylvania Plain, namely:
Unguras Hill, Cojocan-Sic Hills and Fizesului Plain, of the following genetic types of relief: denudational-fluvio relief and structural relief.

5.1.1. STRUCTURAL RELIEF
Within the horizontal and monoclinic structures, in certain areas of this regions, especially the Fizesului Plain and Cojocna-Sic Hills, slightly bellied portions called domes, are found. The basic element used in defining the structural relief is represented by the slopes and shapes that they can have.

5.2.3. FLUVIO-DENUDATIONAL RELIEF
Among the denudational-fluvio specific relief, that affected this region relief, are included: the slopes, glazes and alluvial cones.

5.2. CURRENT GEOMORPHOLOGICAL PROCESSES
The gravitational landslides are the most important shaping process in most of the Transylvanian Depression part, and their production has been imposed by the action of the geomorphological factors, lithological and climatic factors, to which was added the appearance of other casula factors.

5.3. LITHOLOGY ROLE IN THE RELIEF DEVELOPMENT
Regarding the lithology, the influence of the rocks has an important role in the formation of the hills and valleys from the researched northwestern Transylvanian Plain areas.

5.4. THE GEOLOGY AND THE LITHOLOGY OF THE SURFACE DEPOSITS
In terms of surface deposit lithology, the northwestern Transylvanian Plain teritorial subunits are characterized by both the presence of the miocene formations and tortonian and sarmatian floors (bessarabian, volhinian and buglovian), and those of the quaternary ones (higher holocen).
5.5. CLIMATE AND TOPOCLIMATES

The climatic factors, had, over time, a very important role in the formation and evolution of soils in this region, because it was considered that the climatic features are a consequence of the interaction between the active surface, solar radiation and the circulation of the air masses. The climate of this hilly area is influenced by position (being situated on the west and north-Bolean circulation path), altitude and landscape fragmentation. In the characterization of the specific climate, for the northwestern Transylvanian Plain subunits, data obtained from the weather stations Dej and Cluj-Napoca, have been used.

5.5.1. CLIMATE TYPES IN THE NORTHWESTERN SIDE OF TRANSylvANIA PLAIN

The type of the high plateaus and hills and type of the hills climate, low plateaus and depressions.

5.6. AIR TEMPERATURE

The air temperature is closely related to the geographical position of the northwestern Transylvanian Plain subunits adjacent to the close major morphological units, especially in relation to the western movement of the air masses.

Comparing the multiannual and monthly averages of the air temperature between the two analyzed weather stations, they were observed in the period considered, through highly differentiated values.

5.7. ATMOSPHERICAL PRECIPITATIONS

In general, the northwestern Transylvanian Plain’s rainfalls, and Ungurasului Hills, are distinguished by the highest amount of rainfall to regions with similar altitudes from the rest of the Transylvanian Plain, situation caused because of the exposure to the western circulation of the air masses through so called „Salajului gate”. Along with the air temperature, the rainfalls are an important factor in the genesis and evolution of the soils from this region.
5.7.1. CLIMATE RISKS

The meteorological phenomenas such as heavy rains, first and last freezing day (early and late frosts) are considered to be a risk phenomena with harmful effects for settlements or communication infrastructure and crops.

5.8. GEOLOGY AND SURFACE DEPOSITS

The sedimentary formations in the Transylvanian Plain are composed of paleogene, miocene and partial pliocene deposits.

In the hilly area of the northwestern Transylvanian Plain subunits, the lithologic substratum prints the slope shapes and mostly controls the vertical tier of the soils. At the bottom of the slopes can be found rocks such as marls, marly clays, colluviums, etc. and in the superior part can be found sandstones, sands, conglomerates, tuffs, etc. In the meadows, the lithological factor is represented by the colluviums, alluviums, prolluviums, etc.

5.9. HYDROGRAPHY AND HYDROLOGY

The northern sector of the Transylvanian Plain fits into the hydrographic collector of the Somesul Mic and Somesul Mare rivers. The hydrographic network consisted of alohtone valleys, has as main collectors, the two mentioned rivers, then Fizes and Ungurasului Valley. There are many ponds, lakes developed in salt massives by collapse (Cojocna and Sic) and lakes between the slipping steps (largely wetlands).

5.9.1. TYPES OF SURFACE WATERS

After Ujavari (1972), the average drain is different in mode of manifestation in the Transylvanian Plain, which led to the separation of the morphohydrologic system into two types.

5.9.1.2. THE CARPATO-TRANSYLVANIAN TYPE

This type of drain covers the major rivers, Somesul Mare and Somesul Mic, which have their sources in the Carpathians, specific to the peripheral areas of the Transylvanian Plain, that have a rich pluvio-nival which allows a high drain with high levels during spring (43-44 % of total flow).
5.9.1.3. THE TRANSYLVANIAN TYPE
This type of drain is specific to local rivers from the Transylvanian Plain; they have moderated pluvio-nival source due to high evapotranspiration (especially in the western half); many of them have a semipermanent feature.

5.9.1.4. THE LAKES
Most of the lakes were formed by subsidence and natural sealing, but they were maintained by additional dams. This lacustrine formations are represented by ponds that have a particular frequency in the Transylvanian Plain, especially Fizesului Plain, concentrated along the Fizesului Valley (Catina lakes, Popii 1, Popii 2, geaca, Sucutard, taga Mare, Taga Mica, Stiucii, Santejude, legii, etc.)

5.9.1.5. THE GROUND WATER
The level of the ground water (phreatic water) is found at different depths, depending on the relief and stratification.

5.10. NATURAL AND CULTIVATED VEGETATION
The whole region from northwestern Transylvanian Plain is included in the dacian province, in the three floors of vegetation: a superior one, the holm, an inferior one, the oak and another one of intraareal vegetation.

Along with the main crops, specific to these subunits from northwestern Transylvanian Plain, such as wheat, corn, barley, fruit trees, appear also the weeds. Of the total agricultural area in northwestern Transylvanian Plain, of approximately 25,000 hectares, the arable lands have the largest share (49%), grasslands have a relatively close area (25%), as well as the meadows, and the orchards with a reduced surface (8%), that are confined, especially in the Ungurasului Hills or around the localities that belong to this territory.

In the studied gullies, the vegetation is represented quite weak. It notes, however, the shrub vegetation area, in gully 4, Minitu Gherlii. Otherwise, at the surface of the gullies can be found either grasslands, or open ground, which promotes the surface’s erosion.
5.11. SOIL COVER

Built in pedogenetic conditions that had at the base the mentioned soil formation factors in this paper, the pedologic covering of the Transylvanian Plain is characterized by a certain specificity. This was imposed also by the presence of certain conditions that influenced the evolution of the soil over time.

In the distribution of the soils from this region, an important role was played by: time variations of the weather conditions, the human activity and moisture.

The soil classification adopted in this paper is based on the „Romanian System of Soil Taxonomy – SRTS (2012)” in which the soils are systematized after their intrinsic characteristics that reflect the pedogenetic and evolution conditions.

Types of soils:
- Cambic chernozem (Buza territory)
- Cambic faeoziom (Nicula territory)
- Cambic faeoziom (Fizesu Gherlii territory)
- Cambic faeoziom (tauseni territory)
- Erodic antrosoil (Unguras territory)
- Antrosol erodic (teritoriul Unguraș)

6. DEPTH EROSION PROCESS ASSESSMENT

The erosion, in the narrow sense, is a dynamic, physical- geological, kneading-displacement process of displacement, transportation and sedimentation of the soil and rock particles by the: moving water, air currents and/or by human.

An erosion cycle has three phases:
- initial spatial displacement
- transportation
- submission (Cimpeanu, 2008).
On the erosion agricultural lands forms of depth erosion can be found: gutters, gullies and ravines. In the forest area can be met the most advanced form of depth erosion – the torrent.

The characteristics erosion shapes of the gully components are:

- regressive erosion: takes pace at the top of the gully
- side erosion: takes place on the banks of the gully
- depth erosion: takes place on the thalweg line.

6.1. MONITORING OF THE RAVINES

In general, the monitoring and observation can be separated in terms of the time scale which is carried out in three temporally scales:

- short time scale: 1-10 years
- average time scale: 10-70 years
- long time scale: more than 70 years (Poesen et al., 2003).

In our study, we will try to estimate several parameters of the depth erosion of the gullies. We will use GIS algorithms in order to highlight the gullies evolution using data obtained from topographic plans, data obtained from GPS measurements and from aerophotointerpretation.

6.2. SPATIAL DATA DEVELOPMENT FOR EROSION ASSESSMENT

As I stated before, in order to create spatial data, I used topographic measurements took with the GPS device in 2013, topographic plans from 1969 and aerial images (ortophotoplans). If we take into account the monitoring type, we can say that the study falls into studies developed on average time scales, between 10 and 70 years.

6.2.1. BUILDING RAVINES’ DIGITAL TERRAIN MODEL

Given previous data obtained in the terrain phase, we passed to office phase. At this stage, the obtained coordinates and levels were introduced in the created spatial database. Thus were created for each gully considered as an point type entities. The position of the points was determined by using the x, y coordinated obtained from the measurements, and h level was introduced as type „Double” attribute.
The application used for the achievement of the Numerical Model of the Land, and not only, is represented by ArcGIS software. This application allows the integration of different types of data from various sources. This application has several tools that allow obtaining new informations from existing data, such as the GPS measured points. The used tool for the Numerical Model of the Land is called „Topo to Raster”. This tool allows the integration of the GPS measurements, or the data from digitized level curves, the thalwegs, etc. and use an interpolation algorithm, obtaining a MNT.

6.3. HORIZONTAL CHANGES QUANTIFICATION

We calculated the altitudes differences between two MTN of the gullies. The two rasters correspond to 1969 and 2013.

As a result, other rasters were obtained, as the ones below. The rasters show how the elevation from the ravens levels varied. It can be said, as a general observation, that the negative values are recorded mainly in the thalweg line, and the positive values are mostly at the tops, more obviously in 3 out of 5 of the analysed cases: 2. Buza, 3. Unguras, 4. Mintiu Gherlii.
Numerical Model of the land associated with the ravines in 2013
The quantification of the altitude differences in 1969-2013


6.4. EROSION VOLUME ASSESSMENT

In order to achieve this estimation, it is required the Numerical Model of the Land, both before and after the changes. In our case, the needed data are represented by the two MNT of the obtained raster for 1969 and 2013. Besides these data, was also needed the Cut Fill tool from ArcGIS software.

6.4.1. CUT&FILL OPERATION

The running module Cut Fill from ArcGIS requires a procedure in which the elevation of a landform is modified by the elimination or the accumulation, in our case the erosion, of the surface material (www.esri.com).

The Cut Fill tool summarizes all the areals and volumes resulted from the „cutting and filling” operation. Taking into consideration the surface of a given location, from two different time periods, the tool identifies the region in which the surface material is eroded (removed), the surfaces on which the material accumulates at the surface and the surfaces where there is no change (www.esri.com).

Following the execution of this operation, a special rendering is applied in order to highlight the locations in which is lost or accumulated the material. The determinant of this fact is the attribute table of such a raster resulted from the running of the operation.

6.4.2. USING CUT FILL FOR GULLY GEOMORFOLOGY

When used to assess the evaluation of the gullies morphology, it is necessary to make several cross sections. This is necessary in order to identify the areas with accumulations or areas where erosion is present.

For each region with gain or material loss, the algorithm calculates the area of the specific region. This algorithm is simple because it counts the cells in both cases and then multiply them with the area of a cell.
6.4.3. RESULTS OBTAINED AFTER APPLYING CUT FILL TOOL

The transformation of the studied gullies over the past 44 years is captured very well in the data presented either under a tabular or graphical form. In this figures it can be observed the spatial distribution of the erosion process, in the analyzed period of time. The erosion process is presented in all 5 analyzed gullies, but in gully 2. Buza and 4. Mintiu Gherlii, this has a more pronounced feature and this is why it was tried to create some detail profiles in order to see better which part of the gully’s section is affected by the erosion.

Gully 1. Tauseni is one of the least affected by the erosion. More obvious in this gully is the process of the surface accumulation (red color on the map).

![The evolution of the erosion and accumulation processes in ravine 1. Tăuşeni, 1969-2013](image)
The evolution of the erosion and accumulation processes in ravine 2. Buza, 1969-2013

The evolution of the erosion and accumulation processes in ravine 3. Unguraș, 1969-2013

The evolution of the erosion and accumulation processes in ravine 5. Fizeșu Gherlii, 1969-2013
6.4.4. THE ASSESSMENT OF TEST SECTIONS

Given the previous results, both tabular and graphical, I decided that it is important to present the extreme cases, namely the ravine in which the erosion process is most present, the ravine in which the dominated process is the substrate accumulation. This ravine are 2. Buza and 4. Mintiu Gherlii. In order to succeed this, we realised, with the help of GIS software, ArcGIS Desktop, cross sections lines and also longitudinal lines when the thalweg line was used.

It was used the 3D Analyst extension of ArcGIS software. This extension allows the exportation of both the numerical and graphical data which allows us to evaluate quantitatively the evolution of this erosion process.

7. DEPTH EROSION CONTROL ACTIONS

The multitude of the works used in depth soil erosion control, follows either the reintegration into the agrarian or silvan circuit occupied by the formations of the depth erosion, or their development in order to extinguish the erosion phenomena.

The main problem is the fight against erosion where ravines or torrents threat the populated centers, ways of communication, water management works, and when they affect the agricultural land, with high fertility occupied by valuable cultures, when the formations are found in full activity, persisting the danger of high coverage of the growing surface and thus when they meet on less productive lands or unproductive, that cannot be taken into consideration or are about to be extinguished.

In the first case, complex works will be applied, even if they require higher investments in order to stem in a short period of time the erosion phenomena so they can defend different targets and redeem the farming it’s lands.

In the second case, much more simple works will be provided, less expensive, using mainly biological methods of fighting (afforestation, grassing), through which provides the impairing of the depth erosion and improving of the hydrological regime.
Depending on the causes of depth erosion formations development, the stage of evolution and the size of the formations, as in relation to their parts, the work counters can be grouped into:

- works to dismantle the drains, gullies and small ravines, and the introduction of their occupied areas;
- works for the adjustment of the dribbling into the reception collector;
- works for establishment the drain network
- works for the evacuation of the waters in the deposit area.

7.1. GUTTERS, FURROWS AND SMALL GULLIES DISESTABLISHMENT METHODS AND THE INTRODUCTION TO AREAS OCCUPIED BY CROPS

The channels can be demolished either through typical agro-technical slope works, or through leveling, work that is done with some earthmoving machines, then smoothing with the help of the levellers.

In the case of small ruts and gullies, with depth less than 4-5 m, they will be covered by clay from surrounding areas, in this way, on one hand it is ensured to the agricultural circuit, the area occupied by these formations, and on the other hand, there are ensured optimal conditions for the mechanical execution of the agricultural works.

7.2. METHODS FOR CATCHMENT OF RUNOFF REGULARIZATION

In order to eliminate the causes that led to the development of depth erosion formations, it is necessary first to apply regularization works of the leakage, erosion control, in the reception collector of these formations. These type of works are specific to different categorises of use, such as antierosional agrofitotechnical works, hydrotechnical works and forestry works.

7.2.1. METHODS FOR RAVINE PEAK’S IMPROVEMENTS

The works from the peak of the ravines are designed to reinforce the top of the ravine and to stop the length development of this.
For the areas in which this termina part is naturally stabilized, adequate measurement are applied in order to maintain the stability and recover the surface of the area. If the head is obviously in a cascade, it should always be reinforced, first mechanical and then with vegetation. The mechanical consolidation can be done through the arrangement into inclined grounds, steps display amenities or the development of the fall from the top of the ravine through a dam or the arrangement into forced tubes.

7.2.2. METHODS FOR THE DEVELOPMENT OF FLOW NETWORK
This works are performed for the stabilization and consolidation of the banks and bottoms of the ravine or rainy valley, and also for the mitigation of the solid flow. The works can be earthworks, biological and mechanical. Their application must be differentiated from one rainy network to another. The first operation that must be done after the processing and interpretation of the study data, is dividing the rainy valley on different sectors, after features and ammenity requirements.

7.2.3. METHODS FOR THE DEVELOPMENT OF RAVINES BANKS
The arrangements of the ravines banks are done in the same time as the consolidation works of the riverbed bottom are made, consisting of grassing, celery furrows, fences, afforestation, clothing, contrabanquette, retaining walls, gabions, houses, etc.

7.2.4. METHODS FOR CONSOLIDATION OF RAVINE BOTTOM
The purpose of this works is to stop the widening of the riverbed, work that is called the extinction of the ravine or the torrent. rarely, seeks the liquidation of the formation, when it is considered the rainy formations to be extinguished, namely consolidated to the state they are today.

The strengthening of the gullies and ruts bottom is achieved through silvan plantations and cross-works constructions, like plate fills, fascines and gratings.
8. CONCLUSIONS

Agriculture, as one of the oldest business practices of human civilization, is developing. This thing is good because of it’s role in the modern global economy.

The geospatial informations lends themselves to many opportunities that can lead to better decisions, higher productivity and greater efficiency in agriculture. In agriculture, erosion is a very popular topic. The existance of such a process involves the detailed knowledge of it’s manifestation. This aspect will finally be reflected in the decisions taken to increase the efficiency and productivity.

This paper presents the implementation of a mapping methodology and analysis of the depth erosion process, where it exists. Erosion, by definition, implies the loss of the material that can be found in the layer from the land surface. This may be due to certain events, or due to some characteristic parameters such as the soil type, land cover type, land geomorphology, climate, etc.

The accomplishment of such a study it is possible due to the evolution of the technology. The cartography and agricultural sciences did not stay behing. The use of digital cartography software combined with several analysis software, help us to obtain numerical and spatial data that highlight the evolution of some nature process. The depth erosion is one of this processes. In this paper we used multiple methodologies in order to highlight the existance of the erosion process in all five studied ravines. It can be observed from the complexity of the used models that some of them are more simplistic, generalist and don’t lead straight to the pursued goal. The method by which we determined the lost or accumulated areas and volumes, is an easy one and gives timely results that depend only on the accuracy of the entered data.

The remaining parameters have also certain advantages because they establish a connection between the volumes and surfaces found to be affected by depth erosion and the explanation of the overall process.

The results obtained from an topographic-cartographic-GIS interdisciplinary approach, like the present one, highlights the aspects that need to be taken into consideration when preventing the degradation processes of the ecosystems, and also they complete the studies with a geotechnical character at a regional level.
The research conducted under this theme, are limited on one hand to the posing of some recommendation that can be analysed and fathomed in future projection phases, also representing a starting point for more complex studies.

The used methodology is not an easy one, it involves understanding of certain aspects regarding GIS and also the understanding of the obtained results, especially as they are offered.

Editing data is an interactive process, usually manually, being a time consuming. The data files, usually affected by errors, need to be corrected using more efficiently and convivial methods. In practice are seen more important operations for the economy of a Geographic Information Systen (GIS):

- adding certain entities
- deleting certain entities
- movement of certain entities
- changing the scale
- close of the polygons
- changing the shape of a bow
- the interpolation of bows thorough special functions such as Spline or Topo to Raster
- the assemblance of a bow using the intermediate points suppressing with the purpose of visualization at a much smaller scales.
- the adjustments of an entity using as a reference another one
- structurally modifying and updating an attribute.

Depending on the frequency of the changes suffered by the spatial data, and taking into consideration the importance of the alternations, the updating can be done as a simple edit or it can be complete, including all the field works done before, and then followed, partially or completely, as necessary, by all the GIS operating process exposed before.

The effectiveness of the GIS executed operations depends largely on the database’s volume, method used to encode spatial data and the conception of the file structure. In the case of spatial entities, it is necessary to use some complex procedures (a spatial index can be developed by successively dividing the region into squares, similar to quad-tree procedure).
The main feature of a Geographic Information System is the range of manipulation possibilities and analysis of the spatial data.

Some examples of spatial measurements that can be realized with help of the GIS procedures show the great capacity of processing that this top technology provides:

- distance between two points
- distance within a bow’s length
- perimeter of a polygon
- area of a polygon
- orientation or direction of a line
- angle between two lines
- calculus of the earthworks volumes
- number of points or other spatial entities contained in a polygon or at a certain distance from other entities, etc.

Reclassification is the impact of a value, of a descriptive polygon’s attribute according to the values taken by another attributes. This operation can be followed by an aggregation (merging pixels or adjacent polygons that have a property in common).

The study of the depth erosion process evolution for the five considered ravines, in 1969-2013, is a unique study in the evolution of the erosion process in this part of Transylvania.

The study of the deep erosion process is characterized by:

- the length of the considered period: 1969-2013; from this point of view, the study made is fitting in the studies spanning medium periods of time;
- the quality and quantity of the used data: there must be considered that for the initial situation of the ravines were used topographic plans and for the end of the analyzed period of time was used the GPS device. Since the accuracy of the level curves’ contour on the topographic plan is smaller than in the measurements made with the GPS device, we have established that the work resolution would be 2.5 m;
- the methodology’s precision: there is to be retained that in this case the results have heavily depended on the input’s acuity;
the thematic maps obtained and their accuracy.

The topographic measurements made with the GPS device help us especially when we do not have known geodesic points in that specific area, increasing at the same time productivity while surveying classical works.

The advantages of applying GIS technology in a study of erosion are:

• improvement of decision making based on fast GIS query;
• information integration regarding the ravines’ configuration;
• fast identification of the ravines;
• interactive producing of maps;
• ability to update data etc.

Assessment of deep erosion processes at the level of the five considered ravines was done using ArcGIS software and also computer programs such as Microsoft Excel for example. With ArcGIS software complete algorithms for detecting changes that have occurred in the geomorphology field were able to be run. In this way, there were able to obtain information which shown the change or evolution of erosion on a surface measuring at least 6,25 m² (area of 1 pixel in MNT).

The usefulness of the study can be found in those areas managers’ activities which aim a sustainable management consistent with environmental issues. It can also be found in the work of decision makers responsible for resolving emergencies, as well as those that assess risk producing phenomena that can cause damage, in this way being easier to identify sensitive areas prone to erosion.

A thoroughness of the present study could be done in the following directions: obtaining complete surveying measurements, possibly from multiple periods of time, the use of topographical plans with larger scale than 1:25000, increasing the number of points collected with GPS device, implementation of thematic maps obtained in complex calculation algorithms that can anticipate the production of erosion phenomena.
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