ADVANCED DTM GENERATION USING AIRBORNE LIDAR TECHNIQUE

A. Covasnianu[1], M.M. Cazacu[2], I. Balin[3]

ABSTRACT
Simulations of the hydrological risks and thus the decisions of assessment strategies are crucial in the context of extreme meteorological events due to the consequences of the fast changes in the climate. The remote sensing methods, such as LIDAR backscatter technique are allowing the elaboration of a high precision (5cm vertical and 3 points/m^2 horizontal resolutions) Digital Terrain Model (DTM) as basis of the hydrological modeling. In this paper is presented the airborne LIDAR technique, methodology of obtaining the DTM, the usefulness of the DTM outputs for hydrologic applications and the potential application for the Romanian Danube Flood Plain assessment strategy.
Keywords: LIDAR, laser, mapping, DTM, elevation model

*

1. INTRODUCTION

LIDAR is a relatively new technological tool (even in Europe) that can be used to accurately georeference terrain features. LIDAR is an acronym for **Li**ght **D**etection **and R**anging and in some literature it is referred to as laser altimetry. LIDAR represents an optical remote sensing technology which measures properties of scattered light to find range and/or other information of a distant target.

The prevalent method to determine distance to an object or surface is to use laser pulses. Although LIDAR and RADAR share similar detection principles, large differences exist in the physical processes, the treatment approaches, and the system hardware, due to huge frequency difference of the radiation used in LIDAR and RADAR. LIDAR uses the concept of photons, while radar uses the concept of electromagnetic waves. LIDAR technology has different application in archaeology, geography, geology, geomorphology, seismology, remote sensing and atmospheric physics.

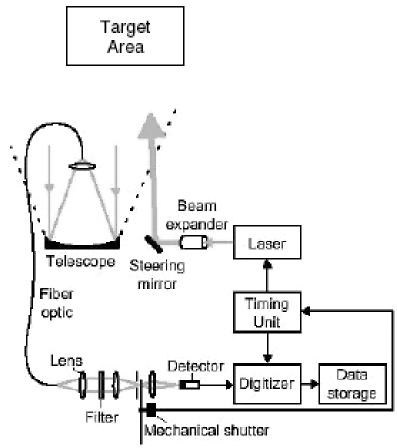


Figure 1: Schematic of Lidar system

2. DATA

The LIDAR technique is based on the detection and analysis of backscatter light that results from the interaction of a laser beam with target area (Fig. 1).

Schematic, the LIDAR system is compound by a source laser and a receiver consisting in a

1 "Al.I.Cuza" University, Iasi, Romania, Faculty of Geography, 700505, Iasi, Romania.
2 "Al.I.Cuza" University, Iasi, Romania, Faculty of Physics, 700506, Iasi, Romania
3 EnviroScopY SA, PSE - EPFL, Lausanne, Switzerland

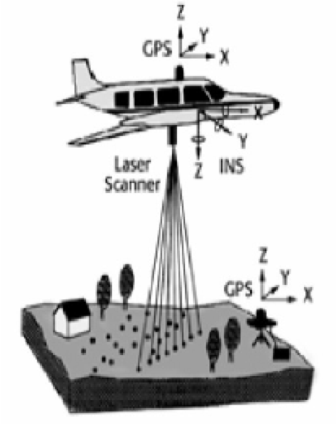


Figure 2: Airborne Terrain Elevaton Mapping Scanner System Outline

telescope, an analysis/selection system and a photo detector.

A LIDAR[1] system emits pulses of laser light and precisely measures the elapsed time for a reflection to return from the ground below.

Knowing the speed of light and the elapsed time, the distance to the target can be calculated.

The airborne LIDAR technique includes a scanning instrument which generates laser pulses and detects the reflected returns, an on-board GPS to determine the geographic position and the height of the sensor and aircraft attitude measurement using an *inertial measurement unit* (IMU) to record the precise orientation of the sensor. A second GPS located at a known ground position receives data at the same time as the over flight for later differential correction of the on-board GPS data (DGPS) (Fig. 2). By accurately timing the round trip travel time of the light pulses from the aircraft to the ground (water, foliage, buildings or other surface features) it is possible to determine the range with a precision of centimeters. The airborne LIDAR systems can produce accurate measurements of surface elevation to digital elevation models (DEM) with a high precision (5cm vertical and 3 points/m^2 horizontal resolutions- our case study). When a laser ranging system is mounted on an aircraft with the scan line perpendicular to the direction of flight, it produces a saw tooth pattern of ranges within a strip centered directly along the flight path (Fig. 2).

In Fig. 3 the general flight parameters of airborne LIDAR technique are represented.

So, the flight altitude is as maximum of 500 meters and the „angle of attack” is between 60 and 80 degrees. The width of the strip covered by the ranges, and the spacing between measurement points, depends on the scan angle of the laser ranging system and the airplane height of flight.

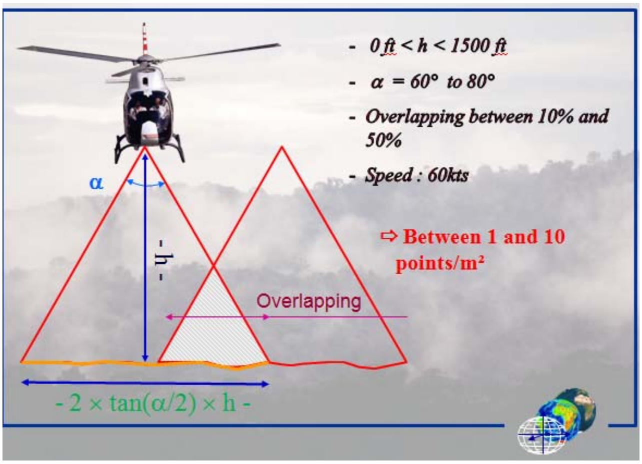


Fig. 3: *Flight parameters of airborne LIDAR technique*

[1] *LIDAR – Light detection and ranging*

DTM-LIDAR flight parameters	Value
Flight alltitude Speed flight	450 m 45 m/s
Band width	520 m
Lateral coverage bands	20%
Distance between bands	415 m
Laser emission frequency	65 kHz
Scanning angle	60^0 (+/- 10^0)
Scanning frequency	75 Hz
(Standard deviation) total planimetric precision of the measured laser points	20 cm
Medium density of laser points	4-5 pts / m^2
Medium distance between laser points (flight direction and perpendicular)	0,6 m

Fig. 4: *DTM-LIDAR flight parameters of the REELD campaign*

The overlapping varies from 10 % up to 50 %. These parameters enabled to obtain a density of points from 1 to 10 points per square meters.

The flight parameters depend on the application. In campaign REELD 2007[1]-Ecological and Economical Reconstruction of Danube Plain was kept a flight altitude of 450-500 m which permitted a relative altimetrical precision of 5 cm. The speed of 45 m/s enabled a high density of points (4-5 points per square meter). The lateral coverage of 20 % permitted the elaboration of a full scan of surfaces with low risk of gaps between bands.

The raw density of laser points of 4-5 pts/m^2 enabled the detection with no ambiguity and good representation of civil buildings, dams and channels.

3. DATA PROCESSING

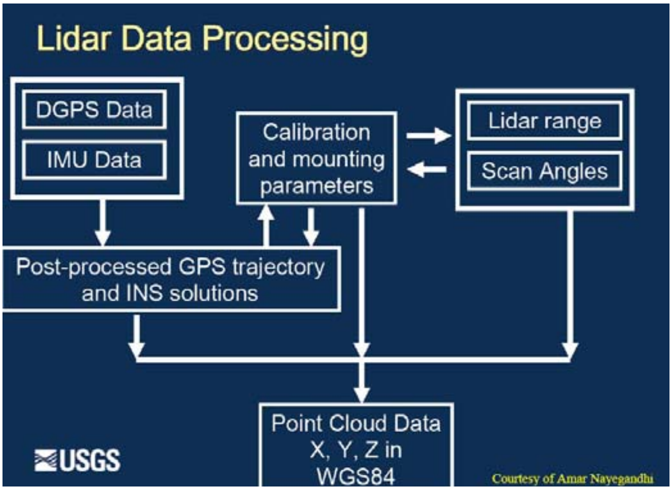


Fig. 5: *LIDAR Data processing schematics*

[1] REELD 2007-project for the Ministry of Environment and Sustainable Development elaborated by the National Institute of Research of Danube Delta-Tulcea.

According to Fig. 5 there are some steps to the final results of data:
- Data from IMU and DGPS must be right and should not contain errors
- The parameters of calibration and mounting must be established
- After these steps are respected, we can elaborate the measurements and obtain the point cloud data.

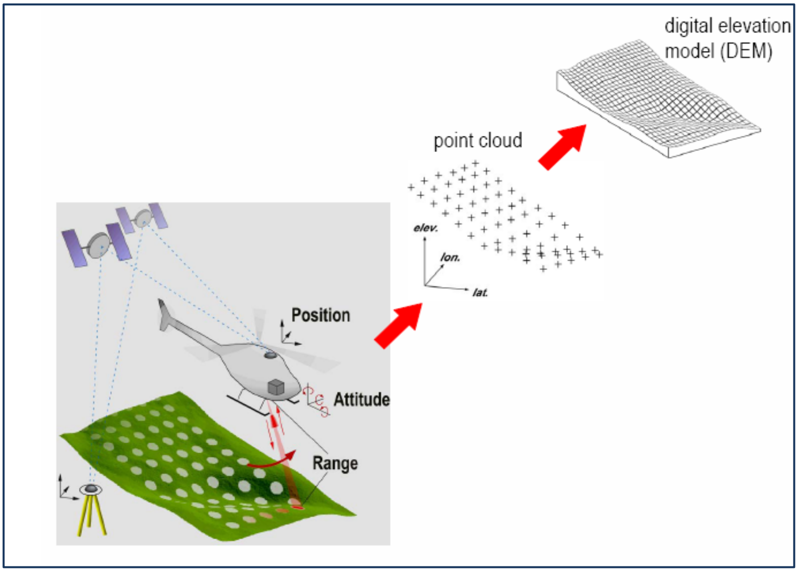


Fig. 6: *Airborne LIDAR Mapping*

The steps of the airborne LIDAR mapping are:
1. Recording the topographical data
2. Transforming the data into xyz files (ASCII files) containing values of latitude, longitude and elevation in WGS 84 coordinate system
3. Creating a 3d point cloud and in the end the DEM (digital elevation model)

In our case study, field campaign REELD 2007 airborne LIDAR systems produced accurate measurements of surface elevation to digital elevation models (DEM) with a high precision (5cm vertical and 3 points/m^2 horizontal resolutions).

4. RESULTS

From the campaign REELD 2007 resulted a very accurate DTM (Digital Elevation Model). This is due to the technical characteristics from the contract's conditions:
- Is needed the 3D DTM for the whole flow of Danube – 1075 km long
- The bands varies from 1 km to maximum of 80 km
- Seeing that we are in an area full o channels and dams are necessary bands for every 50 meters, with points at every inflexion of the terrain – at a dam with road territory at about 20 meters high – at least 9 points (2 points for base of slope, 4 points for dam berm

and 3 points per dam). This means that for a cross section of a dam are necessary 4 points per square meter.

- The Z precision (elevation) must be maximum of 5 cm.

Next, we exposed an area representing Galati shipyard which is located in the eastern part of Romania (as shown in Fig. 7).

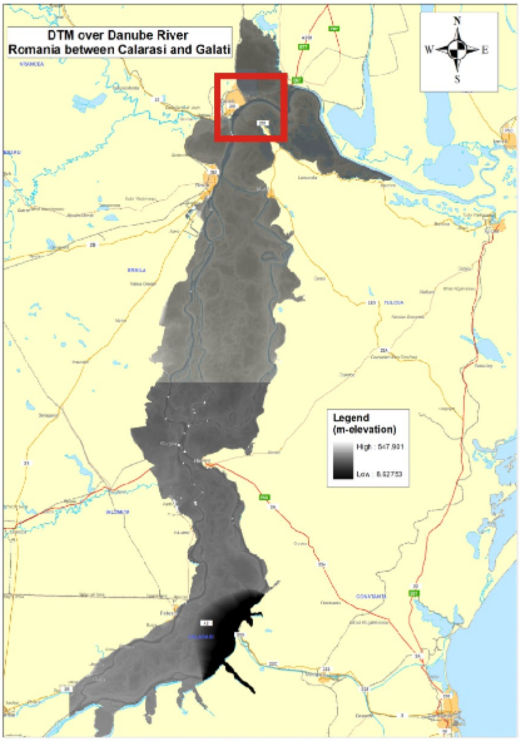


Fig. 7: *DTM over Danube river-red square-our area of interest*

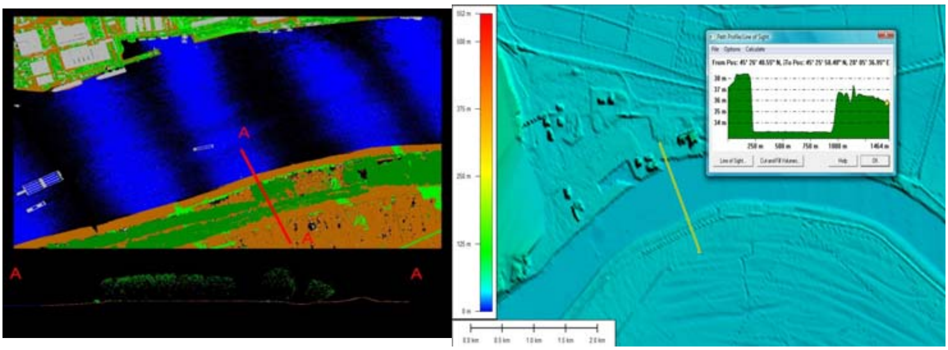


Fig. 8: *Topographical profiles*

In the left- profile over Danube dam, in the right-cross section over Danube River

So, in Fig. 8, we represent some topographical profiles. In the left part, there is a representation of the dam with vegetation. In the right one, we showed the cross section over Danube River in the area near Galati shipyard. As we can see the water level rises at about 30 m from the sea level.

Finally, in Fig. 9, from top to bottom we have:

- Different LIDAR flight bands width of ~ 500 m and 15 km long, with a Lateral coverage of about 20 % near Galati area
- The intensity of the signal's echo from LIDAR ("albedo") corresponds to the same surface. Danube is represented by the black color, on the left part meaning the lack of LIDAR signal.
- Representation in color spectrum of the altitude. With black color is Danube River on the left and with green and red colors there are represented the higher areas (hills).
- The altitude classes. Here we have the lower vegetation map.
- The Digital Terrain Model map. Clearly, it is distinguishable clearly the higher area, the channels, Danube's dam and the irrigation areas.

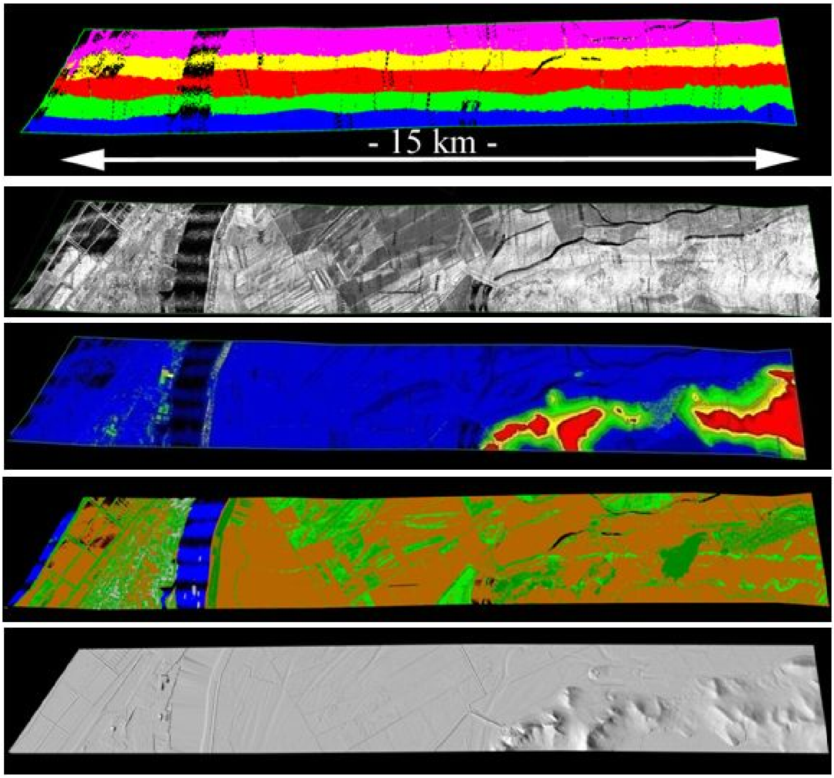


Fig. 9 *Different interpretations of the LIDAR data*

5. CONCLUSIONS

This set of data was used in order to obtain a very accurate DTM of the Danube River. After this is done, the next step is to use this data in the hydrology field.

In conclusion, airborne LIDAR mapping is the quickest and most precise way to produce high-resolution digital elevation data for flood risk management. This LIDAR data set allows planners and hydrologists to predict flood extends and plan remedial strategies.

Therefore, this technique is very useful in the establishment of hydrological risks on Danube River (our case study).

REFERENCES

W. E. Carter, R L Shrestha, (2000), *A Special GeoImaging Feature Submission, Department of Civil Engineering*, University of Florida & S P Leatherman, Laboratory for Coastal Research and International Hurricane Center, Florida International University.

A. Covasnianu,, M. Cazacu, N. Libralesso, L. Galisson , M. Memier and I. Balin (2007), *Digital Terrain Model by airborne LIDAR technique: an essential tool for hydrologic risks assessment,* Journal of Optoelectronics and Advanced Materials, Vol. 9, No. 11, p. 3529 – 3532

J. F. O'Callaghan, D. M. Mark, (1984), *The Extraction of Drainage Networks from Digital Elevation Data*, Computer Vision, Graphics and Image Processing, 28: 328-344.

Research project-REELD 2007-INCDD Tulcea, Romania

MONITORING OF SOIL MOISTURE USING THE BALANCE METHOD AND G.I.S

A. I. Crăciun[1]

ABSTRACT
This study has the role to test o model of indirect estimation of the soil humidity based on the pedogeographical, meteorological, geomorfological characteristics of the Vladeasa Mountain. Using the balance method assisted by GIS we aim to calculate the soil water reserve values in every moment and in each point of the watershed. This step wants to help to evaluate and prognoses the flood generated by torrential rainfall in real time.
Keywords: soil, moisture, balance method, water

*

1. INTRODUCTION

The soil moisture is one of the principal parameter that must be taken into account when analyze the hydrological characteristics of a territory. Infiltrated water and evapotranspiration represent the negative component of hydrical balance for the hydrographic basin. The quantity of water infiltrated and retained in soil depends, first, by the sum of precipitation in the analised period. In the same time the pedogeographical characteristics of studied area, forestation level, the slope contribute to the acceleration or slow-down of runoff.

The purpose of this study is to present some GIS applications to facilitate the estimation of soil water stock at one moment in time. The GIS importance in hydrology consists in:

- stock of a complex database;
- integration of some mathematic equations;
- cartographic representation of the results:
- to emphasize the risk areas;

The area proposed for study is Vladeasa Mountains (Fig.1). For this area will be evaluated, by maps, the soil water stock in certain precipitation conditions. The algorithm is based on the integration of a mathematic equation (balance equation) in GIS. In this way we can emphasize the areas that have an excess or deficit water. This aspect is important in hydrological extremes analysis (flood vs. drought).

[1] "Babeş-Bolyai" University of Cluj-Napoca, Faculty of Geography

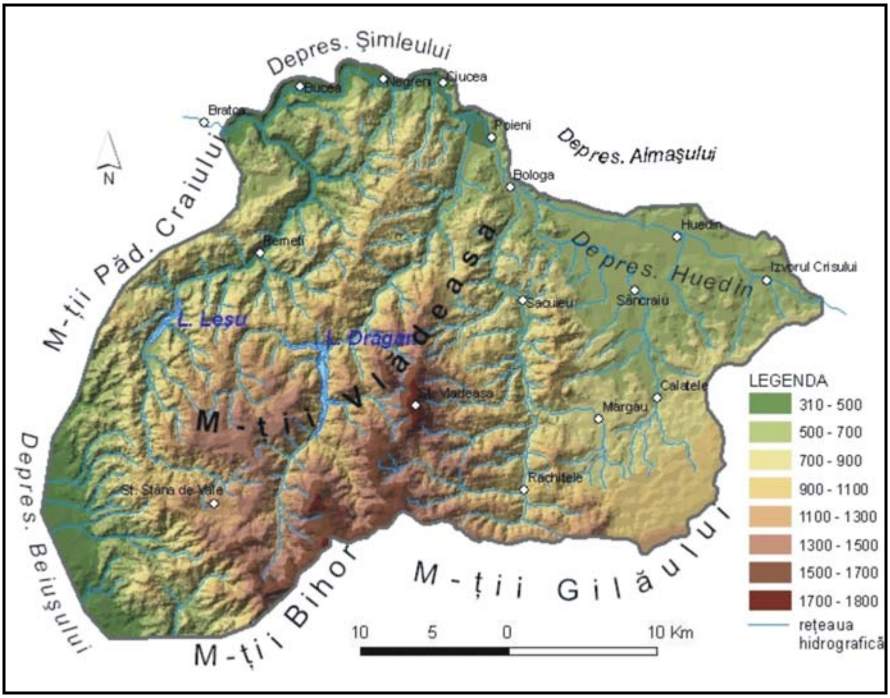


Fig. 1: *Digital elevation model and geographic location of the studied area*

2. METHODOLOGY

A method of pedospheric cover humectation is proposed by *Simota M.* and *Mic Rodica* (1993). This method is used, later, in maximum flow estimation study on flash flood (*Mic Rodica, Corbuş C., 1999*) and is based on a balance equation that takes into account the following parameters: runoff coefficient (α); *evapotranspiration* (Et); *sum of daily precipitations* (Pi) for ten days before the estimation day; number of days without precipitations (N) (*1*).

$$Us = (1-\alpha)\cdot(\sum_{i=1}^{10} Pi) - N \cdot Et \qquad (1)$$

Estimating of **runoff coefficient** was realised in terms of slope, land use, soil texture (*Mallant et Feyen, 1990*). For the spatial distribution of runoff coefficient (Fig.2), using G.I.S, had been followed some steps:

- making layers (slope, land use, soil texture) in raster format;
- reclassification of these three layers using **R**eclassify function;
- to totalise the reclassified layers using **R**aster **C**alculator function;
- assignation of runoff coefficient specific to each value obtained;

The Mallant-Feyen indices had been used for an hydrological study in South Italy (*Sole Aurelia, Caniani Donatella, Mancini I., 2003*). Studies about runoff coefficient distribution, using G.I.S, had been realized in mountain area from South of Brasov Depression (*Păcurar V.D, 2005*).

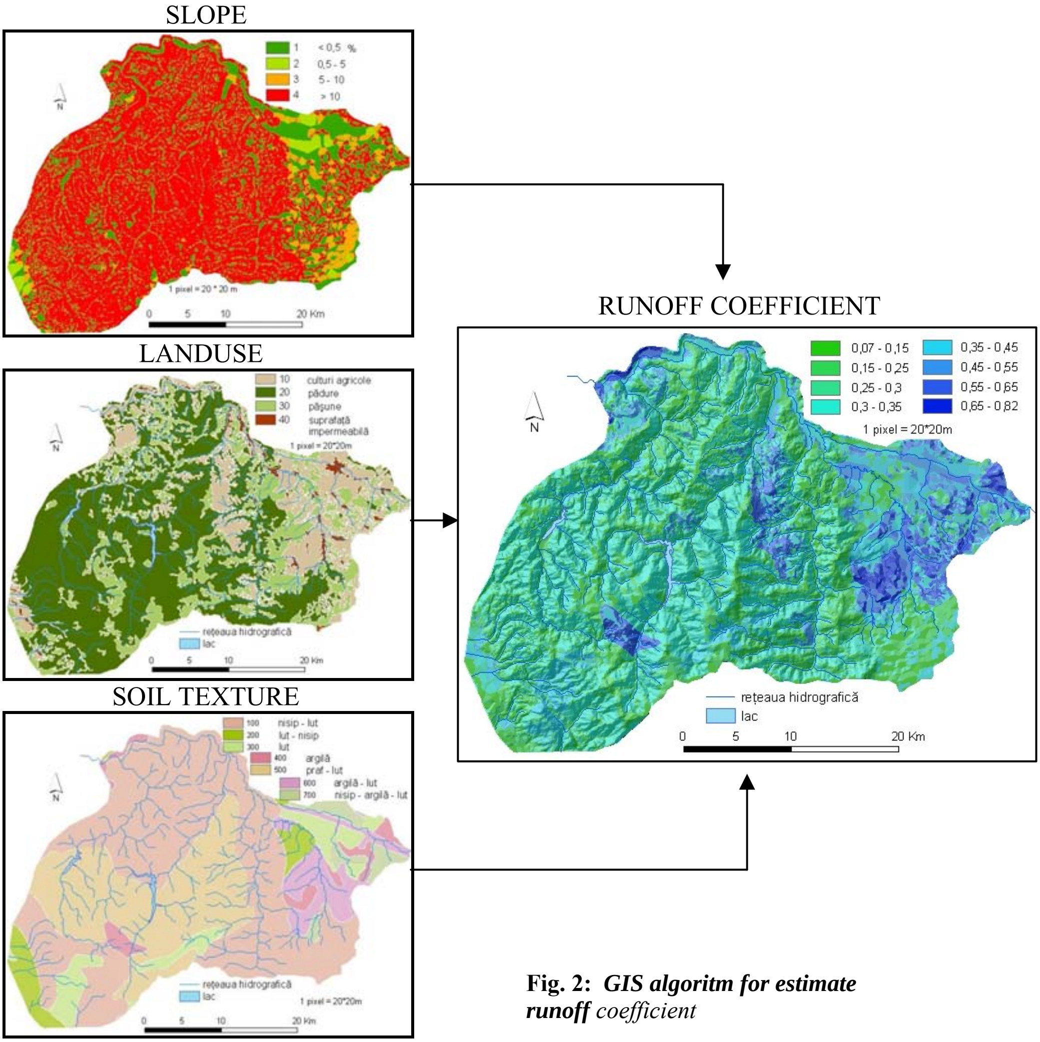


Fig. 2: ***GIS algoritm for estimate runoff*** *coefficient*

In a previous study (Crăciun A.I, 2007) I realised the spatial distribution of the runoff coefficient in the Hydrographical Basin of Căpuş using the Frevert indices.

The precipitation data had been taken from NCDC database (National Climatic Data Center) and these correspond to the meteorological stations: *Vlădeasa*, *Stâna de Vale*, *Huedin*. For growing the spatial resolution there had been taken into calculus another two station situated in studied perimeter neighbourhood – *Borod* and *Ştei* (Fig.2).

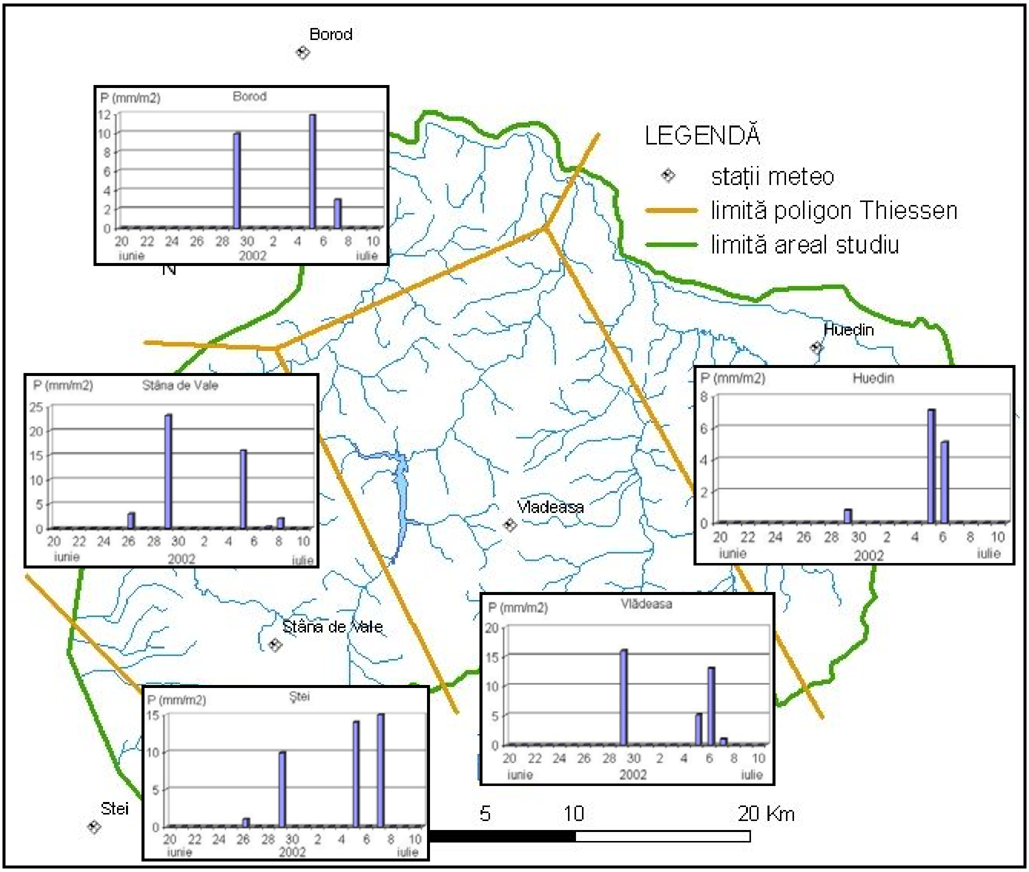


Fig.4: *Influence areas of meteorological stations using Thiessen method. Evolution of precipitations in studied period*

The spatial interpolation of precipitations was realized using a simple method – Thiessen polygons method – (Fig. 4). Even if this method is general, it emphasizes the area of influences specific to the control points, without taking into calculus the physic-geographical parameters of precipitations distribution, it was considered that it has a bigger relevance in case of daily precipitations. Trying to correlate the altitude and/or versants exposition, it would be difficult to realize with just five reference points.

For applying the balance method are sufficient precipitations sums for 10 days previous to the estimation date, so, it was selected a 20 days period of 2002 summer (20th June 2002 – 10th July 2002).

In order to calculate the daily evapotranspiration, it can be used classic models which take into account the air temperature, air humidity, wind speed, sunshine etc. (Penman, FAO Penman, Penman Monteith methods etc). Because of data insufficiency, for this study, the evapotranspiration was estimated depending on the month for which the soil moisture calculus was realized. (Table no. 1)

Table no.1: ***Estimating evapotranspiration depending on the period in year***
(according to Rodica Mic şi Corbuş C.)

Month	April	May	June	July	August	September	October
ET (mm)	0,5	1	2	3	3,5	3	2

3. RESULTS ANALYSIS

After locating the parameters of balance equations on grid support, the next step was the integration of the formula in **Arc GIS**, using **R**aster **C**alculator function. The calculus was realized for four days of the analyzed period (29 of June, 5th July, 6th July, 7th July) characterized by important quantity of precipitations.

From the results analyze, we notice, for 29 of June (Fig.5), a domination of negative values of the balance in conditions of eight/nine days period without precipitations. This fact can be explained trough a soil humidity deficit, in which the quantity of infiltrated water is smaller than the evaporated one or than the water involving in the runoff process. The area characterized by the highest soil humidity values corresponds to the west part controlled by the Stana de Vale Station.

For the 5th of July, we can observe a diminishing of the balance values in the area controlled by Vladeasa Station because of monitoring the smallest quantity of precipitations. The important increases of balance were registered in the west area, corresponding tot the Stei Station. (Fig.6)

In the next two days analyzed (6th July and 7th July), we notice the extension of the surface characterized by a positive balance in the central and western part of the Vladeasa Mounts (Fig.7 and Fig.8). The smallest values still remain in the depressions areas (Huedin, Borod, Crisul Repede Corridor).

Generally, we observe an increase of soil humidity from the east to west, according to the precipitation distribution.

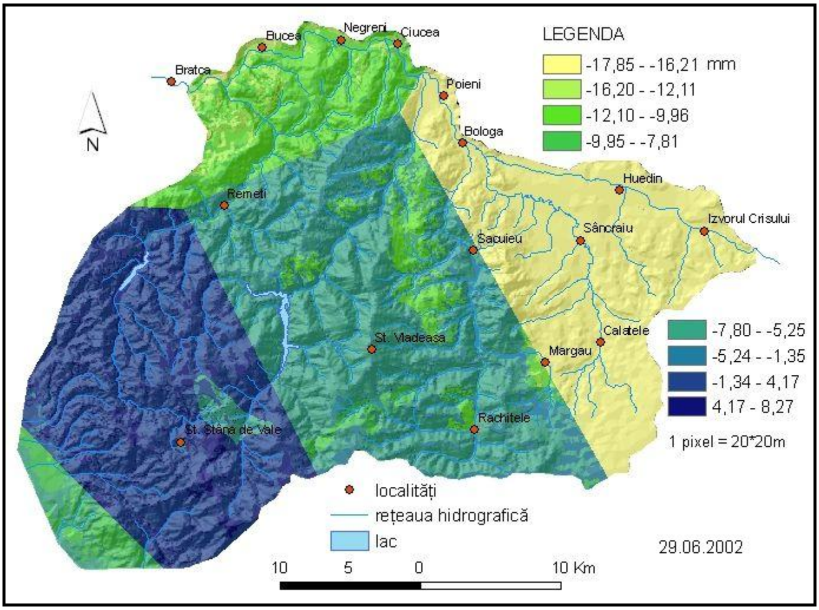


Fig.5 *Distribution of soil moisture values in 29 June 2002*

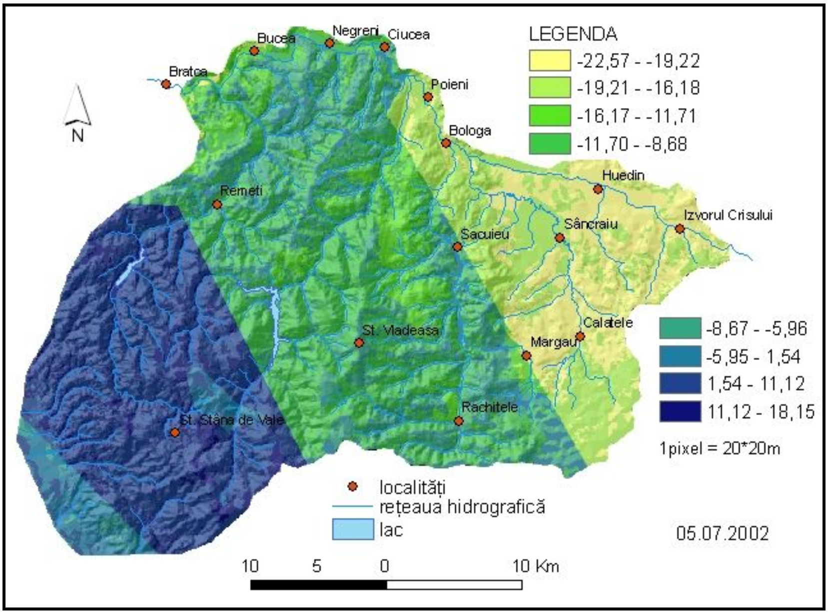


Fig.6 *Distribution of soil moisture values in 05 July 2002*

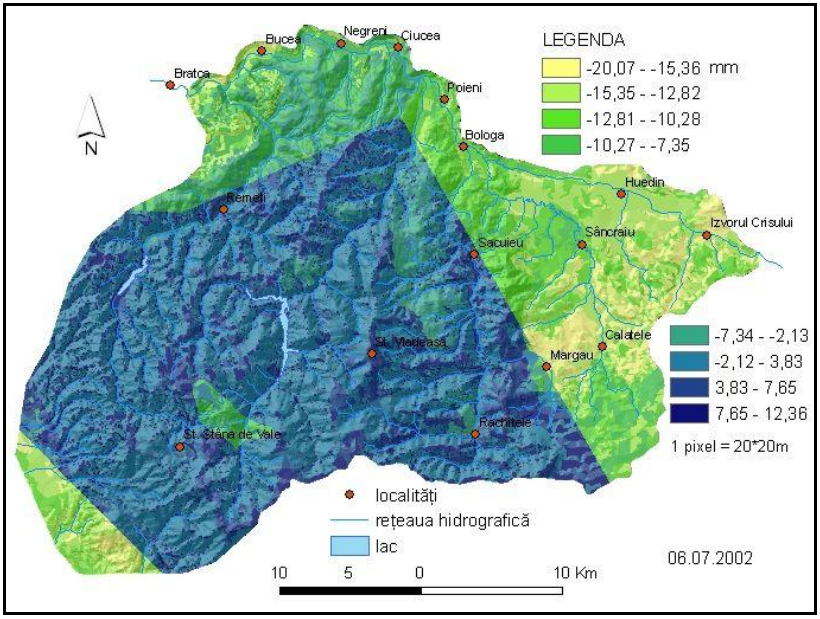


Fig.7 *Distribution of soil moisture values in 06 July 2002*

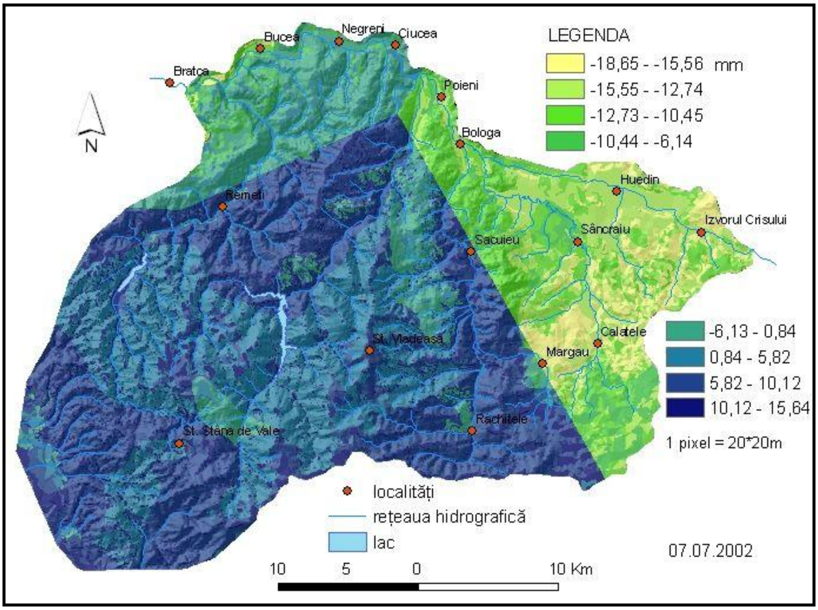


Fig.8 *Distribution of soil moisture values in 07 July 2002*

Locally, the differentiation of the soil water reserve values are determined by the *soil texture*, with consequences through the permeability, speed of infiltration, water retention capacity. So, in the analyzed area predominate the *sandy loam* texture (on the right versant of the Sacuieu Valley, the north half of the left versant of the Dragan Valley, the south of the Huedin Depression, the middle and inferior sector of the Iad Valley) and *silty loam* texture (on the left versant of Sacuieu, the superior of Dragan Valley, the superior sector of the Iad Valley). By hydrological point of view, these soils are characterized by a high permeability and low capacity of water retention. The presence of these soils explains the higher values of the soil humidity in the same precipitation conditions.

The fine texture soils (*clay, clay-loam*), which are predominant in Huedin Depression, are characterized by a low permeability and this cause an excessive humidity of the superior part of the soil profile.

4. CONCLUSIONS

Using this analysis algorithm permit to estimate the soil water reserve in real time, this fact has a huge importance in flood forecasting. The model efficiency depends on determination as precise as possible the parameters that compose the model.

The facility offered by GIS consists in evaluation this phenomenon in each point of the studied surface.

The results show, in the same precipitation conditions, a progress of the humidity values from the fine texture soils to the sandy texture. The bigger humidity values for the loamy and sandy texture soils are determined by their high permeability.

REFERENCES

Blaga, Ghe., Filipov, F., Udrescu, S., Vasile, D., (2005), *Pedologie*, Editura AcademicPres, Cluj-Napoca;

Crăciun A., I., (2007), *Use GIS to establish some parameters useful to measure the time of concentration and runoff coefficient – applied to: The Hydrographic Basin of Căpuş*, Geographia Technica no.2, ISSN 1842-5135, Cluj Univerity Press;

Ianoş, Ghe., (1999*), Pedogeografie*, Editura Mirton, Timişoara;

Mic Rodica, Corbuş C., (1999), *Estimarea debitelor maxime în cazul viiturilor rapide în Bazinul Hidrografic Crişuri pe baza precipitaţiilor şi a stării de umiditate a solului*, Institutul National de Hidrologie şi Gospodărire a apelor, Bucureşti

Păcurar, V.D., (2005), *Utilizarea Sistemelor de Informaţii Geografice în modelarea şi simularea proceselor hidrologice*, Editura Lux Libris, Braşov;

Petrea, Rodica, (2001), *Pedogeografie*, Editura Universităţii din Oradea, Oradea;

Sole Aurelia, Caniani Donatella, Mancini I., (2003*), A comparation between SWAT and distributed hydrologic and water quality model for the Camastra Basin (Southern Italy)*, International SWAT Conferences, 1-4 July 2003, Bari, Italy;

USING GIS TECHNIQUES TO DESCRIBE MORPHOMETRICAL FEATURES WITHIN THE MOUNTAIN HYDROGRAPHICAL BASIN OF THE IALOMIȚA RIVER

G.M.Cracu,[1] M.Popescu[1]

ABSTRACT
The morphometrical analysis of the landscape in the mountain basin of the Ialomita by the use of GIS techniques is made in several stages: the acquisition of the work materials represented by the topographic maps; the digitizing of all the map elements needed in the cartographical shaping of the main morphometrical parameters (level curves, altimetric quotas, the hydrographic network); the drawing up of the final maps by the use GIS specialized analysis programs. The main morphometrical parameters are analyzed: hypsometry, declivity, slope orientation, density and depth of landscape fragmentation taking into account the influence of the local factors on their spatial extension and on the values they register.
Keywords: morphometry, slope orientation, landscape fragmentation, declivity

*

1. INTRODUCTION

Located in full mountainous region, inside the Bucegi Massif, the superior basin of the Ialomita stretches over a surface of 78 km² and gathers waters from the two flanks of the so-called suspended synclinal of the Bucegi, which it closes nearby Peak Bucura in the north, while opening it wider in the south all the way to the confluence with the Bratei river, offering it its specific horseshoe shape. The main watersheds, western and eastern, which delineate the basin, follow a number of peaks, north to south, as follows: the western watershed (21.2 km in length) follows the alignment formed by Mountains Doamnele, Bãtrâna, Strungile Mari, Strungile Mici, Tãtarul, Deleanu and Zãnoaga, while the eastern watershed (22.4 km in length) covers Peaks Obârşiei, Babele, Cocora, Lãptici, Blana, Nucet, Oboarele, Dichiu şi Plaiul Priporului.

The morphometrical characteristics of the mountain basin of the Ialomita result from the interaction of two groups of factors: internal (represented by lithology, structure and tectonics) and external (represented by the morphoclimatic processes and the erosive action of the hydrographic networks). The diverse lithological substrate, represented by a succession of rocks of different ages (crystalline schists, limestone, conglomerates, grit stones) influence certain morphometrical parameters such as: declivity (the calcareous lithological substrate allowed the development of a landscape of gorges with steep slopes and high values of declivity, while the lithological substrate made up of marl and grit stone, highly susceptible to erosion, allowed the formation of erosion bassinettes with declivity values close to zero), depth and density of landscape fragmentation (through the resistance put up by the lithological substrate to erosion and through its permission or restriction in terms of the infiltration of surface waters underground).

The structural factors leave their mark on the hypsometric characteristics and on the slope orientation. The general north to south inclination of the Bucegi synclinal but also the fall of the two flanks of the synclinal towards its axis area (Ialomita Valley) represent

[1] *"Ovidius" University Constanța, Faculty of Natural and Agricultural Sciences, Department of Geography*

from north structural aspects with major implications in the distribution of the hypsometric steps and in the general orientation of the slopes. Studies of morphometrical characteristics in mountain zone was realized by authors such as: Velcea V. (1961), Marinescu E. (2007), Urdea Maria-Cornelia, (2008) ş.a.

2. DATA

In order to obtain the maps needed for morphometrical analysis, the following stages have been developed: 1. The scanning of the topographical maps scale 1:50 000 at a resolution of 300 dpi; 2. The geo-referencing of the map sheets by the use of the following parameters: Transverse Mercator projection system, Krasovsky spheroid, Pulkovo 1942 datum; 3. The "on screen" digitizing of certain map elements (watersheds, level curves, altimetric quotas, hydrographic network) by the use of point shapes, polyline and polygon and the assigning of values to each digitized point, surface or line; 4. The generation of the DTM by the interpolation of level curves and altimetric quotas through the TIN method; 5. The generation of maps for inclines, slope orientation, depth and density of landscape fragmentation by the use of options from the GIS software or by the use of certain extensions specific to the respective analysis (*feature density* and *depth fragmentation*). The following software was used: Erdas Imagine (for the geo-referencing of the topographical maps), Arc Map and Arc View.

3. RESULTS

Hypsometry. The map of hypsometric steps *(Fig. 1)* was generated by the interpolation of level curves and of altimetric quotas through the TIN method.

The north-south layered distribution of the landscape within the mountain basin of the Ialomita is evidenced by the differentiation of seven hypsometric intervals, between the minimal altitude of the basin in the

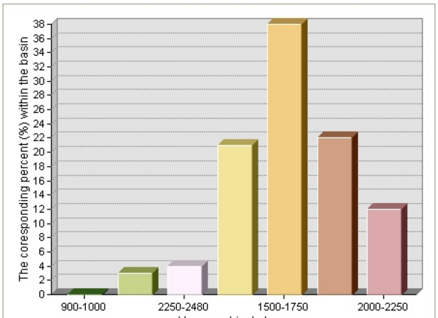


Fig. 2 – *Histogram of hypsometrical*

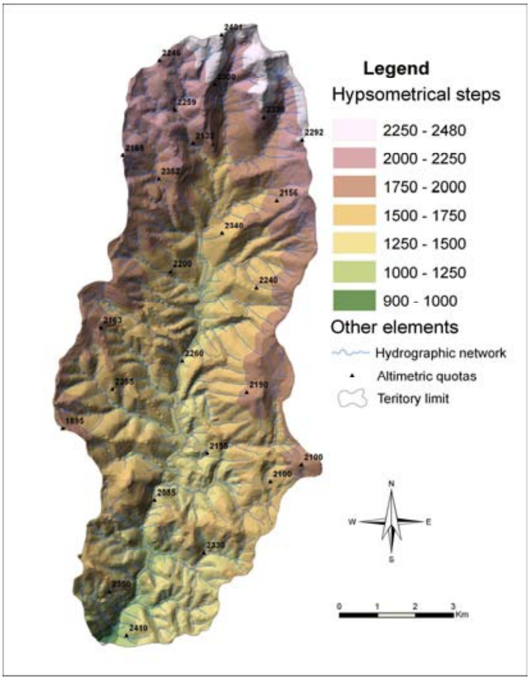


Fig. 1 – *Map of hypsometrical steps*

south (900 m at the confluence with the Bratei river) and the maximal one in the north (2480.4 m in Peak Obarsiei). This north-south layering in altitude, evidenced by the longitudinal profiles of the watersheds, but also east-west towards Ialomitei Valley, is influenced by the main characteristics of the Bucegi synclinal: the general north-south fall of the synclinal and the fall of the two flanks of the synclinal towards its axis area (Ialomitei Valley) (*Velcea,V.-1961*)

The analysis of the histogram of hypsometric steps *(Fig. 2)* reveals the fact that the largest proportion of the basin surface is held by the 1500-1750 meter step, with a surface of 29.64 km² (38%), followed by the 1750-2000 meter step, with a surface of 17.16 km² (22%) and the 1250-1500 meter step, with a surface of 16.38 km² (21%), while the smallest proportions belong to the 2000-2250 meter step, with a surface of 9.36 km² (12%), the 2250-2480 meter step, with a surface of 3.12 km² (4%), the 1000-1250 meter step, with a surface of 2.34 km² (3%) and the 900-1000 meter step with little over 0%.

Declivity. The analysis of the map of slopes *(Fig. 3)* reveals the clear differentiation between the declivity values from the various areas in the mountain basin of the Ialomita. An important role in the spatial distribution of declivity values is played by the lithological makeup but also by the structural characteristics of the mountain basin of the Ialomita.

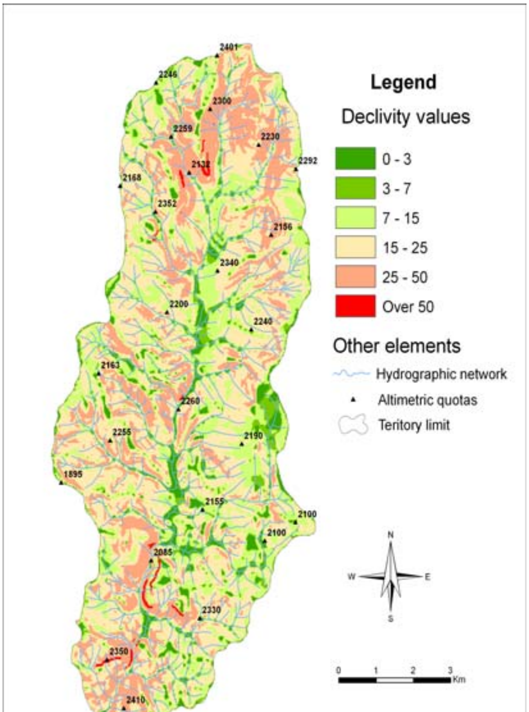


Fig. 3 – *Map of declivity*

The slopes with the lowest inclination of 0-3° and 3-7° occupy limited areas (5% each of the total basin surface) *(Fig. 4)* along the Ialomita river, characteristic to erosion bassinettes created by the Ialomita in the conditions of a lithological substrate highly susceptible to erosion represented by marl and grit stones, but also to the layer surfaces specific to the Bucegi Plateau.

The largest surface of the basin displays inclines with values between 7-15° (24 %) and 15-25° (45 %),

these being specific to most slopes, both in the east and west side of the basin. Inclines with values over 15° are also specific to the left slope of the Ialomita, in the glacier sector.

The steepest slopes, of 25-50° and over 50° characterize approximately 21% of the basin

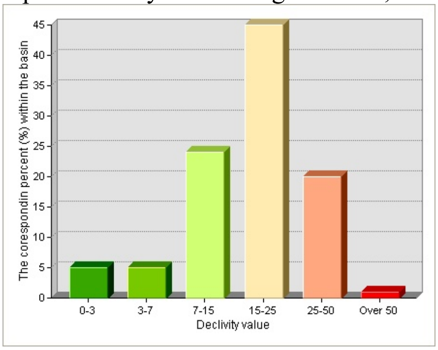


Fig. 4 – *Histogram of declivity values*

surface. This declivity is specific to the areas where cuesta landscape is predominant, especially in the north-eastern part of the basin, where the cuestas develop along a line that crosses through Peaks Babele, Cocora, Lãptici, Nucet, Oboarele and Dichiu,(*Velcea,V.-1961*) but also in the north-western part, close to Mount Strunga. Steep inclines can also be found inside the basin, in the glacier sector of the Ialomitei Valley, where the right slope displays high declivity values (over 35°) as a result of erosion in the layer ends but also as a result of glacier action. The highest declivity is specific to the gorge sectors in the calcareous areas: Peşterii, Tãtarului, Zãnoagei, Orzei Gorges.

Slope orientation. The map of slope orientation *(Fig. 5)* was obtained by the use of *Surface Analysis – Aspect* option in the *3D Analyst* menu of the Arc Map program, using the altitudes raster as input.

The fall towards axis of the two flanks of the Bucegi synclinal represents the most important characteristic that influences the orientation of the slopes within the mountain basin of the Ialomita. Overlapping almost entirely with the axis area of the synclinal, Ialomitei Valley collects its tributaries from both its flanks, which makes the orientation

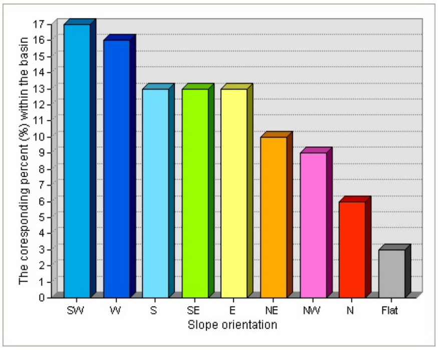


Fig. 6 – *Histogram of slopes*

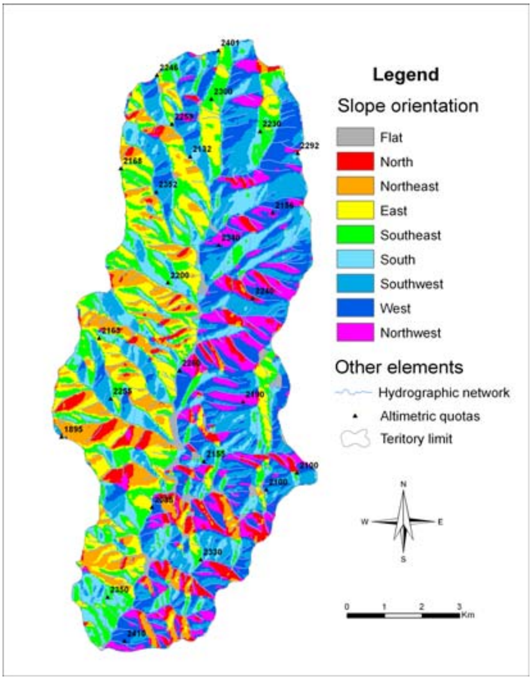


Fig. 5 – *Map of slopes orientation*

of the slopes of affluent basins be predominantly eastern for the western tributaries and western for the eastern tributaries. A particular situation can be found on the eastern flank, in the case of Oboarele Valley, where its superior course follows initially the north-south direction imposing at local level an eastern orientation of the slopes, atypical to the eastern flank. The analysis of the slope orientation histogram *(Fig. 6)* shows that the largest proportion is held by the slopes oriented south-west (17%) and west (16%), followed by the slopes oriented east, south-east and south (13% each). A less proportion is covered by the slopes with north-eastern orientation (10%), north-western orientation (9%) and northern orientation (6%), while the semi-horizontal surfaces, which overlap the erosion bassinettes along the Ialomitei Valley have a proportion of 3%.

Density of landscape fragmentation. In order to obtain maps of landscape fragmentation density *(Fig. 7)*, we used the script *feature density*, which was loaded into the Arc View program, alongside the grid with altitudes and the theme with the hydrographic network. After the application of the script, a grid of landscape fragmentation density was generated for cells with a length of 1 km. As the values displayed for this grid were initially expressed in m/m², we used the *Map Calculator* option from the *Analysis* menu in order to multiply the initial values of the grid by 1000, generating thus a new grid, with values expressed in km/km², which was classified in three intervals of fragmentation density. In order to display values of fragmentation density, we used the option *Extract values to points* from the *Extraction* menu of the Arc Map program.

The density of the landscape fragmentation *(Fig. 8)* for the mountain basin of the Ialomita has values between 0 km/km² and 5.26 km/km². The most reduced values of fragmentation density, between 0-2 km/km² occupy a surface of 8 km² (10% of the territory). These values are specific to the main inter-rivers in the eastern and western side of the basin. Higher values of fragmentation density, between 2-4 km/km², characterize a surface of 46 km² (59%) within the basin. These values are imposed by the predominance of the inferior river segments and by a high confluence ratio. The highest values of landscape fragmentation density, between 4 km/km² and the maximum value of 5.26 km/km² are imposed on the one side by the confluence between third and fourth order river segments and the Ialomitei Valley but also because of a large number of meanders of the Ialomita in areas with lithological substrate made up of marl and grit stone. Also, in some valleys, such as those in the glacier sector, the slopes are affected by torrents, contributing to the recording of high values of landscape fragmentation density.

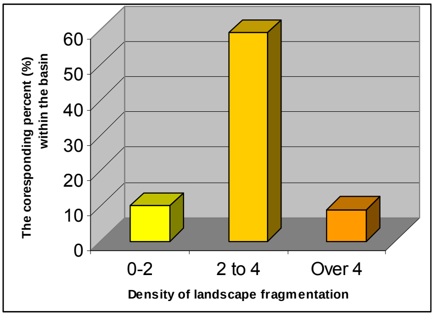


Fig. 8 – *Histogram of density of landscape fragmentation*

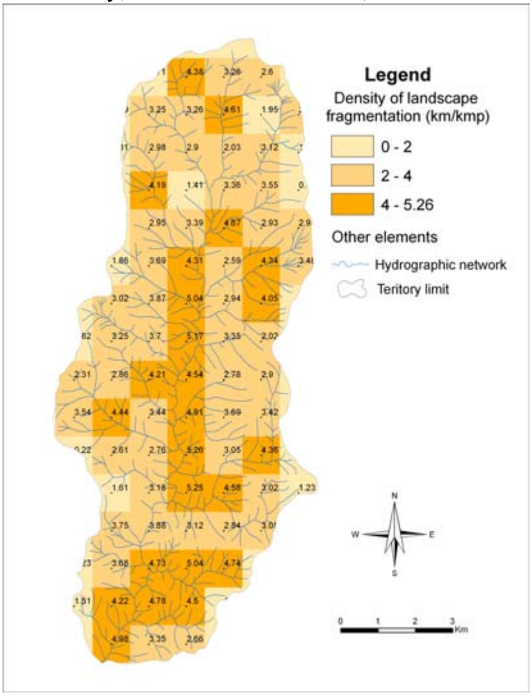


Fig. 7 – *Map of density of landscape fragmentation*

Depth of landscape fragmentation. The landscape energy within the mountain basin of the Ialomita *(Fig. 9)* records values between 100 m/km² and 480 m/km² and it is influenced mainly by the local lithology conditions that have imposed a certain erosion rhythm. The areas with the lowest fragmentation, with values between 100-200 m/km², occupy approximately 19% of the territory (14.82 km²) *(Fig. 10)* and generally overlap the sectors along the Ialomita where the river developed a number of erosion bassinettes in the conditions of a lithological substrate highly susceptible to erosion and made up of marl and grit stone. These reduced values are also characteristic to the main inter-rivers of the Ialomita basin, but also to the structural surfaces which represent a reduced inclination, both in the east and west part of the basin. The largest surface of the basin (40.56 km², approximately 52% of the territory) displays values of landscape energy between 201-300 m/km². This fragmentation characterizes the areas between Mounts Lucãcilã, Deleanu, Tãtarul and Ialomitei Valley and it is influenced by the calcareous lithological substrate which allowed the development of a gorge landscape (Tãtarul Mic and Tãtarul Mare Gorges) with steep slopes along the Ialomita, but also by the asymmetry of the Bucegi synclinal, as the western flank represents a higher fall than the eastern one generating thus more limited structural surfaces, with inclines that do not exceed 15°. The most obvious fragmentation, with values between 301-400 m/km² (14.04 km², approximately 18% of the territory) and between 400-480 m/km² (8.58 km², approximately 11% of the territory) overlap certain gorge sectors (Peşterii Gorge, Zãnoagei Gorge) and the cuesta front in the northern and north-eastern part of the basin. Also, the same values are specific to the slopes in the glacier sector of the Ialomita.

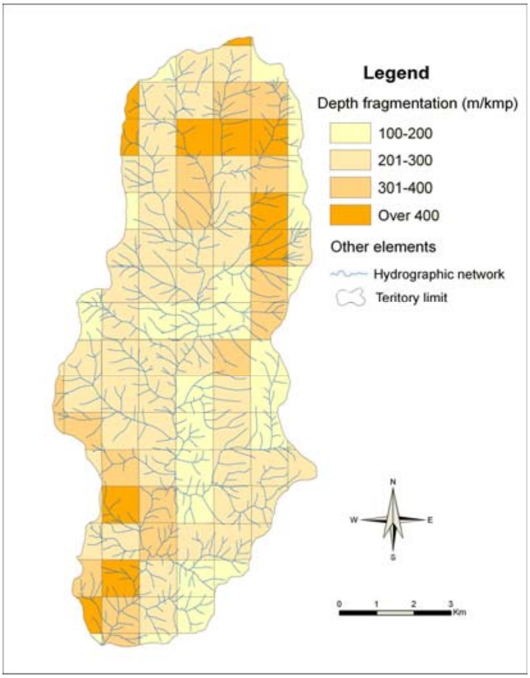
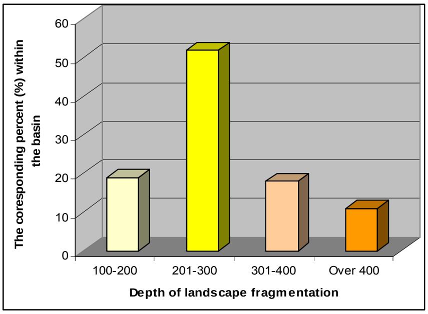


Fig. 9 – *Map of depth of landscape fragmentation*

Fig. 10 – *Histogram of depth fragmentation*



4. CONCLUSIONS

The use of the GIS techniques represents a current and efficient solution that allows us to quantify the main morphometrical parameters of the mountain basin of the Ialomita. Using topographical maps as work basis and following all the necessary stages in order to obtain results that are as close to reality as possible, from the geo-referencing of the topographical maps to the digitizing of certain map elements, plus the use of options and extensions of the GIS software, we obtained the maps of the morphometrical parameters searched for: hypsometry, declivity, slope orientation, landscape fragmentation density and landscape energy. Also, knowing the lithological and structural characteristics of the studied areas, we could appreciate their influence on the values recorded by different morphometrical parameters and on their spatial extension. Lithology conditions the values of declivity, landscape fragmentation density and landscape energy by the different behavior of rocks in what regards erosion or water infiltration underground, while the structural characteristics influence hypsometry and slope orientation.

REFERENCES

Haidu, I., Haidu, C. (1998), *S.I.G. - Analiză Spațială*, Editura HGA, Bucureşti

Marinescu E., (2007), *Morphometrical and morphographical features of the Gilort hydrographical basin*, Geographical forum – Geographical studies and environment protection research, Year 6, No. 6/2007, pag. 88-101

Patrulius D., (1969), *Geologia Masivului Bucegi şi a Culoarului Dâmbovicioarei,* Editura Academiei R.P.R..,1969

Urdea Maria-Cornelia, (2008), *Using GIS techniques to identify and analyse landscape. Case study: The Măcin Mountains*, Geographia Technica no.1, ISSN 1842-5135, Cluj Univerity Press;

Velcea V., (1961), *Masivul Bucegi. Studiu geomorfologic*, Editura Academiei R.P.R., 1961

http://earth.unibuc.ro/tutoriale

GEOMETRIC CORRECTION OF SPACE DATA (GEOREFERENCING) INTERMEDIATE STAGE IN A GIS PROJECT IMPLEMENTATION

R. Cuculici[1], G. Kucsicsa[1], R. Amza[2]

ABSTRACT
Geographic Information System **(GIS)** as an integrated multidisciplinary science includes several traditional branches of science, such as: Geography, Cartography, Mathematics, Remote sensing, Photogrammetry, Geodesy, etc.
Several stages must be undergone during the development of a GIS project, and one of them is the geometric correction of spatial data.
Keywords: Geographical Information System, geometric correction data, spatial data

*

1. INTRODUCTION

Geographic Information System (GIS) may be defined as information systems, which are used for the introduction, data hold, recovery, handling, analysis and for attaining information of geographic reference and geospatial data, for the purpose of supporting the decisions related to the planning and management of lands , natural resources, environment, transportation, urban facilities and of other administrative data.

Geoimage is a general term, which refers to the recording process of different phenomena or elements in an area, under all types of images of the terrestrial surface. *(Hincu Igor, 2004)*

New methods and techniques of processing digitised images have been developed along with the development of information technologies.

For a series of geoimages, scanning is the first step in processing a digital image and for moving from analogical to digital; it is equal to the data acquisition process in a digital system for geographic data processing.

The most important phase is the introduction of the map into the coordination system and this step is performed by selecting some point with familiar coordinates on the map (the corners of the map are usually selected). Digitising these points and introducing field coordinates will bring all objects on one level brought onto the coordination system of the map, through a Helmert, projective or affine transformation.

A precise digitisation is strongly related to these points of control.

The correction programs use first or second range multinomial transformations in order to determine the correct position of each pixel. The coefficients of the transformation polynomial are established based on familiar coordinates, called points of control (the corners of the map are usually used).

The new coordinates must be associated to a certain cartographic projection and based on the GIS, georeferencing may precede digitising/vectorization, and may be performed soon after the scanning operation – georeferencing of the obtained raster image.

---

[1] *Institute of Geography - Romanian Academy*
[2] *Military Topographic Directorate*

There are also applications, which do not require the introduction of real coordinates. They only require a local coordinate system (Cartesians).

Different ***projections*** are used for different types of maps, because a certain type of utilization needs an adequate projection. For instance, a projection, which presents a precise image of the continents, will distort their relative dimensions.

While the largest section of GIS information originates in the existent maps, it uses the computers processing power in order to integrate the digital information, provided by different sources in a joint project.

Two sources may not be entirely compatible because the digital data are differently collected and stored.

Hence, a GIS must be able to convert the data from one structure into another.

In a ***vector system***, the process consists in identifying with great precision the concrete coordinates of four points/dots and then in transforming all points, based on the transformation formulas. This process is called ***continuous georeferencing.*** The most common transformation formulas are those of the affine transformation:

$$X_c = A + BX_d + CY_d$$

$$Y_c = D + EX_d + FY_d$$

In the case of the ***raster system***, the procedure is similar, except that the coordinates of a pixel in the image are precisely identified, which means a higher level of difficulty.

This situation is due to the fact that the pixel represents a surface of land. The larger the surface (map resolution is smaller), the less precise the coordinates (more inaccurate). After identifying four of these pixels, map transposition into the real coordinates is performed by using transformation formulas.

In this case, transformation is more difficult and the user's experience is very important because an analogical map may suffer a series of distortions (Fig.1); the used transformation formulas depend greatly on them.

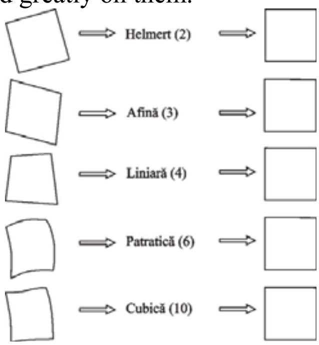


Fig. 1 - *Distortions, type of transformation and minimum number of points necessary during transformation process*

By pointing out three points with familiar coordinates, a six undetermined equation system is obtained, and its solving generates real geographic coordinates.

Practically, a map georeferencing in a raster system consists in generating a file (called *World file*), which includes several elements concerning the manner in which the initial map shall be modified/distorted in order to be transposed onto real coordinates. For

instance, if we have a TIFF initial map (ex. map .tif), the file that will contain the transformation characteristics will be map.tfw; the last letter in the extension comes from World file. The combination map*.tif* + *map.tfw* is called *GeoTiff*.
If the map is in a JPEG or JPG format, the extension of the file will be ”jgw”.

The georeferencing in a raster system is called ***discrete georeferencing***.
Most GIS/CAD may provide this kind of georeferencing, although not long ago this procedure was still a big problem,

Georeferencing within these programs can be performed interactively or a ASCII, may be written if all characteristics of the transformation are known (which is especially difficult and requires a very precise familiarity with the way these files are perceived by the programs).

The first case - ***raster georeferencing*** in an interactive manner – requires a table that includes the correspondences between the initial and geographic coordinates.

This is the case of ArcGIS, CADOverlay and VPStudio programs. Basically, you click the dot on the map with a familiar coordinate and a table will appear; all coordinates shall be recorded in that table while in the filed that corresponds the new coordinates, real coordinates shall be introduced. After introducing the dots/points, the transformation is performed but not before you calculate a possible error, based on the transformation formula.
Tabular correspondence may be done as following:

ID	initial X	initial Y	real X	real Y
10	X_1	Y_1	real X_1	real Y_1
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
.	.	.	.	.
n	X_n	Y_n	real X_n	real Y_n

In this case, at least three marker points are required (coincidence).

In the second case, the user must write the World file ASCII file. The file has the representation bellow and the symbols are detailed as follows:
(Example:)
2.1423581613889207 – *map resolution*
-0.0372035246153713940 – *angle of rotation /distortion compared to the initial map on Ox*
-0.0294183875108808770 - *angle of rotation/distortion compared to the initial map on Oy*
-2.1170503477420426 - *map resolution*
405921.79818481806 - *coordinate X (after the translation - false easting)*
686642.41316839459 - *coordinate Y (after the translation - false northing)*
Most programs are able to process this type of file.

However, direct transformations generate images where some pixels lack colour and some are overlaid.
In order to remedy this image transformation defect, determination of reverse transformations is required as well as the performance of a new sampling of the obtained image, based on transformation reverse relations.

The stages of the georeferencing algorithm are:
1 . Selecting a transformation type:
the minimum number of dots is determined during this phase, based on the following formula
N=(n+1)(n+2)/2+1

2. Collecting the pairs of corresponding dots
$(X_1, Y_1) \rightarrow (X_1, Y_1) \ldots .. (X_N, Y_N) \rightarrow (X_N, Y_N)$
3. Calculating the direct relations of transformation: setting up the equations for the determination of the transformation coefficients:
$X_1 = a_0 + a_1 x_1 + \ldots$
$X_N = a_0 + a_1 x_N + \ldots$
$Y_1 = b_0 + b_1 x_1 + \ldots$
$Y_N = b_0 + b_1 x_N + \ldots$
Solving the equation systems in order to determine the sets of ai and bi coefficients.
4. Calculating the reverse relations of transformation: setting up the equations for the determination of the transformation coefficients:
$x_1 = A_0 + A_1 X_1 + \ldots$
$x_N = A_0 + A_1 X_N + \ldots$
$y_1 = B_0 + B_1 X_1 + \ldots$
$y_N = B_0 + B_1 X_N + \ldots$
Solving the equation systems in order to determine the sets of Ai and Bi coefficients.
5. Applying the direct relations of transformation, in order to determine the size of the resulted image.
6. Applying the reverse relations of transformation, from the resulted image, in order to perform a new sampling of the image.
The sampling procedure may be worked out by several methods:
- the method of the nearest vicinity;
- the method of the bilinear interpolation;
- the method of the cubic convolution.
7. The final stage is dedicated to the image saving and the georeferencing file is generated during this phase, which enable the produced images to be used by other programs as well.

2. CONCLUSIONS

The experience from using the implemented GIS applications has proved that in digital cartography the image geometric processing has an important role, which represent their work support.
Both geometric corrected images and the georeferenced images allow the measuring of geographic coordinates and of the coordinates inside the system of cartographic projection, of the content element and thus the solving of many problems related to applied geography.

REFERENCES

Rusan L.,(1999) – *Metode de culegere a datelor în SIG, Referat doctorat* , Academia Tehnică Militară;

Timar G., Molnar G., Imecs Z., Păunescu C., (2007), *Datum and projection parameters for the Transilvanian Sheets of the 2nd and 3rd military survey*, Geographia Technica no.1, ISSN 1842-5135, Cluj Univerity Press;

Serediuc C.(2005) – *Notițe de curs Modelarea Numerica a Terenului*, Academia Tehnică Militară;

COLLECTING AND USING GPS DATA IN COMPUTER PROGRAMS

M. Domnița[1]

ABSTRACT
For most people, satellite navigation technology, and especially the GPS System is a technology used to see the current position on the Earth surface, to navigate with the help of a digital map or to find the way to an address with a car. Not many people know that GPS technology can be used for much more than that, by creating special applications that use GPS data. This work presents an application that offers the possibility of combining geographic data collected from a GPS device with metadata from digital images, to find out where each image was taken. The application uses this data to upload the georeferenced images to an online image storage application, or see the images on a map or in a satellite Earth navigation application.
Keywords: GPS, satellite, image, georeferencing, application

*

1. INTRODUCTION

The Global Positioning System is a satellite based navigation system that was built by the US Department of Defense in the 70's for military use. Although initially the system was only used for military purposes, the US government decided to offer free access to the system starting with the year 1999. From this moment, the GPS system started a very fast evolution, especially in the handheld device category. Lots of handheld GPS devices that could offer a lot of features to anyone were developed.

The GPS evolution combined with the computer systems evolution and the programming possibilities made the development of complex applications based on geographic location possible. The inmates from prisons in the USA that were freed but had limitations on their activities were tracked in real time using GPS devices. A transport company could track the position of all its vehicles from a single computer in real time using GPS technology and the Internet. Officials from a bike race could present the real time status of the competition on a screen without having them followed by cars or a helicopter.

The application presented in this article uses GPS data to locate digital images from a camera on a map. The georeferenced images can be used for presentation purposes or for different tourist applications. The georeferenced images can be viewed in free virtual map programs like Google Earth and directly on the internet using Yahoo! Maps technology.

2. THE GLOBAL POSITIONING SYSTEM

The **Global Positioning System (GPS)** is satellite-based navigation system that was developed by the U.S. Department of Defense (DoD) in the early 1970's.Initially, GPS was developed as a military system to fulfill U.S. Military needs. However, it was later made

[1] "Babeş-Bolyai" University of Cluj-Napoca, Faculty of Geography

available to civilians, and is now a dual-use system that can be accessed by both military and civilian users. GPS provides continuous positioning and timing information, anywhere in the world under any weather conditions. (Ahmed El-Rabbany,2002) The position can be obtained with sub-meter accuracy using certain equipments. The position that can be obtained with consumer units has an accuracy of about 3m or more.

To obtain the correct position of a receiver on Earth, the receiver uses distance data from 3 or more satellites and generates the position using a process similar to the resection used in topography. Resection is the method of locating one's position on a map by determining the grid azimuth to at least two well-defined locations. The satellites have a precise location at an exact moment in time, and this location is known by the GPS unit.

Each satellite sends a signal containing a timestamp, and the GPS unit determines the distance to the satellite by knowing the speed at which the signal travels and the time difference between the timestamp when the signal was sent and the time when the signal was received. So by ranging from three satellites we can narrow our position to just two points in space. To decide which one is our true location we could make a fourth measurement. But usually one of the two points is a ridiculous answer (either too far from Earth or moving at an impossible velocity) and can be rejected without a measurement. (Trimble, GPS tutorial)

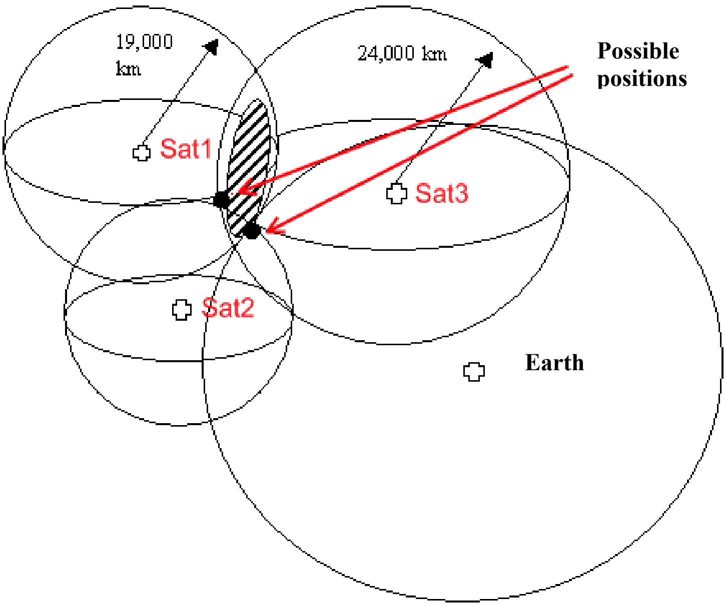


Fig 1: *Determining the position on Earth using GPS technology*

Figure 1 shows that 2 satellites (1 and 3) can determine a circle where the receiver can be located. Adding a third satellite limits the choice to only 2 points, one of which is eliminated. In reality, a GPS receiver needs at least 4 satellites to determine a correct position because it lacks an atomic clock and needs another satellite for time corrections.

The GPS System uses 24 satellites located on specific orbits around the Earth arranged in 6 orbital planes. Each satellite is directly above a given point under its orbit once a day and 6 satellites are visible from any point on the surface of the Earth at any time.

3. DIGITAL IMAGE GEOREFERENCING USING GPS

A digital camera records images of the world using a light sensitive sensor. The sensor has a light-sensitive surface. Similar to an array of buckets collecting rain water, digital camera sensors consist of an array of "pixels" collecting photons, the minute energy packets of which light consists. The number of photons collected in each pixel is converted into an electrical charge by the photodiode. This charge is then converted into a voltage, amplified, and converted to a digital value via the analog to digital converter, so that the camera can process the values into the final digital image. (Digital photography glossary, dpreview)

The final image is an array of values distributed horizontally and vertically on a surface. Each of these values corresponds to a color. So a digital image basically a mosaic of square tiles or "pixels" of uniform color which are so tiny that it appears uniform and smooth.

Besides information about the pixels of the image, most cameras store additional information such as the date and time the image was taken and most other camera settings. These data, also known as "metadata" are stored in a "header". A common type of header is the EXIF (Exchangeable Image File) header.

According to this information, the digital camera can give a user the information about the exact date and time when the picture was taken, and a GPS device can give the information about the exact location where the user was at that date and time. Combining these two pieces of information will result in a geographic positioning of the place where the image was taken.

This georeferencing presumes that the digital camera clock is set as close as possible to the GPS clock.

4. THE APPLICATION

The GeoUploadr application uses the data from the digital images and the data recorded by a Garmin GPS and uploads the images to the Flickr online photo organizer or exports them in a format that can be recognized by a Virtual Globe application like Google Earth.

Data from the Garmin GPS is transferred to a PC using a Data Cable. A data cable is pretty self-explanatory - it is a cable that is used to transfer data between a GPS unit and another device. That other device is usually a PC. When connecting to a PC, the port to which the cable connects is the serial port. The connector used is usually a 9-pin D connector. (Kathie Kingsley-Hughes , 2005)

Flickr is an online photo organizer/web album that allows the users to upload images for free and place them on a map offered for free. After this, any user can see the images at their correct location on the map and use them as a reference for a certain place.

The images from anyone can be seen for free on a map, (Fig. 2).

Besides from publishing the images online, the GeoUploadr application allows exporting the images locally in a format that can be seen with a lot of viewer applications: KML. KML is a specialized type of XML that enables you to build and organize points, routes, and other information.(Martin C. Brown, 2006) KML is a universal free and open geographic description language that can be used by anyone in any application. This format was first used in Keyhole, an application that evolved into the widely used Google Earth application.

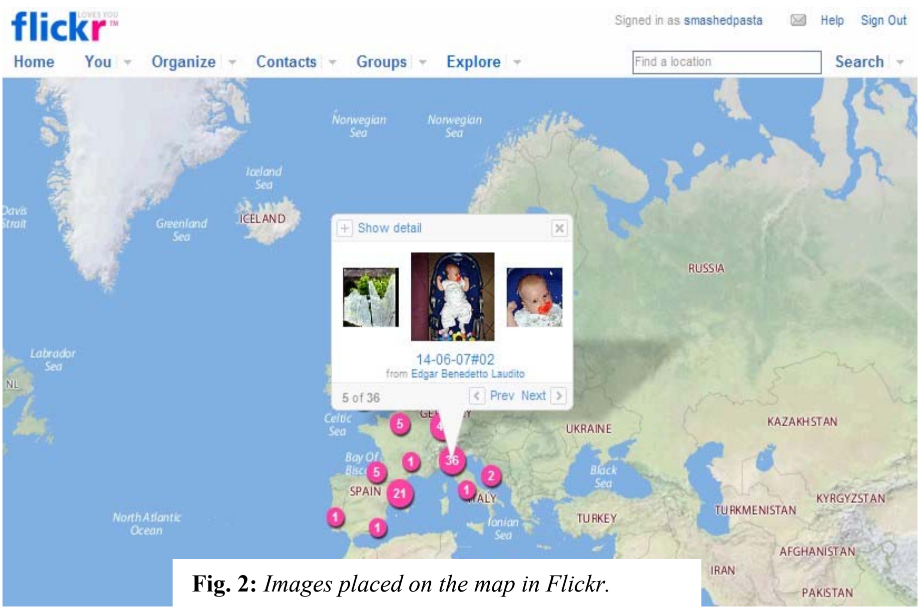


Fig. 2: *Images placed on the map in Flickr.*

Fig. 3 shows the interface of the application, which allows the user to select from the images in a certain folder. First, the date when the images were taken are extracted from the selected images. Then, if a Garmin GPS unit is connected to the computer using a cable, the application extracts track data from the GPS unit and determines the location where the image was taken.

Fig. 3: *The GeoUploadr application interface*

Finally, the images that have the geographic location determined are sent to the Flickr online photo organizer and automatically placed on the map or to a KML file for viewing in Google Earth or in other applications.

The images that do not have a geographic location can also be uploaded to Flickr, but cannot be shown on the map. The map is just an extra feature of Flickr, but images can be placed in an album even if they don't have geographic data.

The application also offers the possibility of placing the images in the correct location above a line that represents the track. Using an application that can offer a 3d view of the terrain, like Google Earth, the images can be seen in a beautiful environment for a presentation of a specific area or a route that can be visited by tourists.

Fig. 4 shows a set of images overlapped on a map in the Google earth application. The images were taken around Cluj-Napoca, Romania.

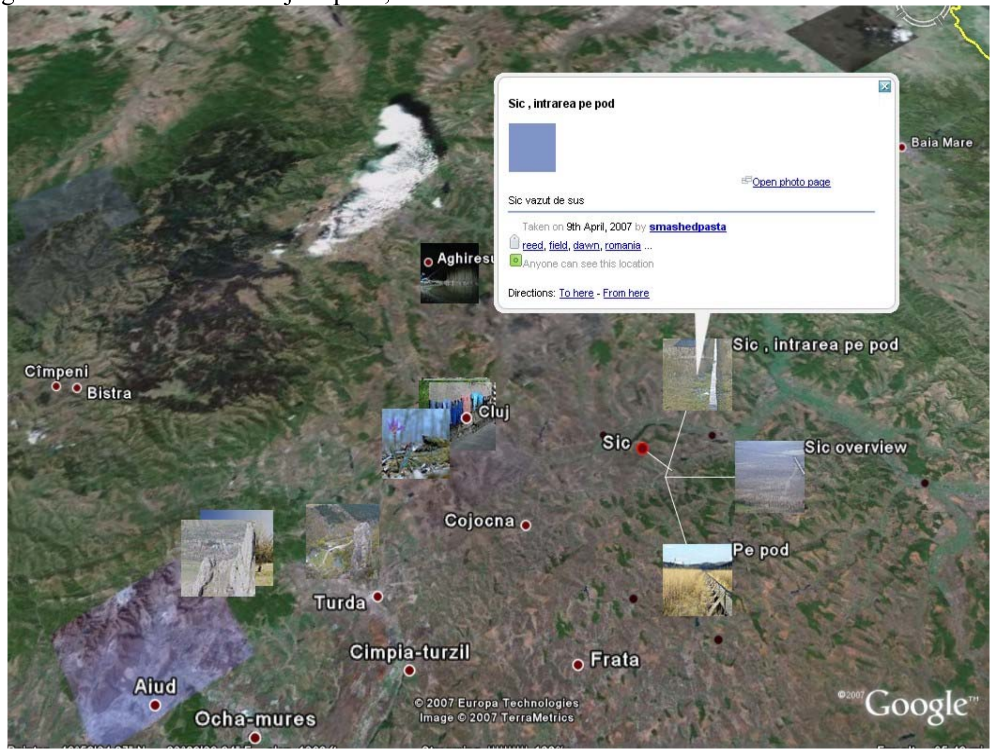


Fig. 4: *Images shown in Google Earth on the map*

5. CONCLUSION

The application presented a very simple use of GPS data in real-life tasks.

The images were correctly placed on the map according to the knowledge of the users that took the pictures and according to details on the map (rocks, roads, buildings, etc.)

The georeferenced images can be used in different applications, like complex slideshows or interactive tourist maps. The GPS communication technology allows automatic geographic positioning of the digital images in a very fast and simple manner for a normal user.

Also, people that visited the same places can communicate through images taken in those places and share thoughts of different areas in a location (for example, monuments or cathedrals in a big city).

Aside from the images, data collected from the GPS can be used in different applications like timing a certain bicycle route or offering accurate information on the time needed to go through a tourist path, and many others.

REFERENCES

Ahmed El-Rabbany (2002), Introduction *to GPS: the global positioning system* ,ARTECH HOUSE, INC

Martin C. Brown (2006), Hacking *Google® Maps and Google® Earth*, Wiley Publishing, Inc.

Kathie Kingsley-Hughes (2005), Hacking *GPS (ExtremeTech)* , Wiley Publishing, Inc.

Digital photography glossary on dpreview
http://www.dpreview.com/learn/?/Glossary/

Global Navigation Satellite System, Wikipedia, the free encyclopedia
http://en.wikipedia.org/wiki/Satellite_navigation_system

Resection : a method to determine your position with a map
http://www.map-reading.com/resect.php

Trimble, GPS tutorial
http:/www.trimble.com/gps/index.shtml

ANTHROPICAL CHANGES ON RIVER BED DIPSA AT THE CONFLUENCE OF DIPSA AND SIEU RIVERS

M. Dulgheru[1], Mioara Chiaburu[1]

ABSTRACT
Intensive anthropogenic disturbances have affected the channel morphology of Dipsa River. This study analyses the reach as an example to examine human impact on channel change. The topographical plans 1:5.000 used in the regulation project and cross-sections transects 1:100 were used to reconstruct channel change in the study reach. The results indicate that the morphology of Dipsa River have been widely changed by the human interventions comparing to its initial aspect.
Keywords: Channel change, regulation, cross-sections, Dipsa River.

1. INTRODUCTION

Any change of the bed due to engineering actions that have impact on water regime transport and sediments from the river by changing the land use or the regulation of the channel can produce instability, the shape and the dimensions of the river being adjusted. The nature study, the level and the reasons of the changes that occur in a channel have a great impact on the height cross sections of the channel disturbed by the engineering structures (Giver and al., 1999). The main focus of river channel regulation is to ensure the stability of erosion and accumulation processes as well as sufficient channel dimensions for the transit of water and sediments (Prezedwojski et al.1995).

The responses of the flow process and of the morphology of the bed to the engineering actions for the channel regulations have been widely studied by Knighton, 1989; Dutto and Maraga, 1994; Petit and al, 1996; Bili and Rinaldi, Kondolf, 1997; Surian, 1999). The results of these studies prove not only that the response of the process can generate strong changes on the river channel, but also that the type of changes and their response in time can be considerably variable from one river to another.

The cartographical sources are a useful tool to analyze the historical conditions of the hydrological network and to describe the planform evolution of the river system; Downward et al., 1994, Gurnell, 1997; Surian, 1999; Graf, 2000, Winterbottom and Gilvear, 2000).

2. STUDY AREA AND STUDY SITE

The river reach that have been analyzed is part of a small watershed, Dipsa, situated in Somes Plain from the northeast of Transylvania plain. The watershed area has 432, 2 kmp, with a hill shape landscape and altitudes that can exceed 600 meters. From a geostructural point of view, the landscape is part of Transylvanian Depression.

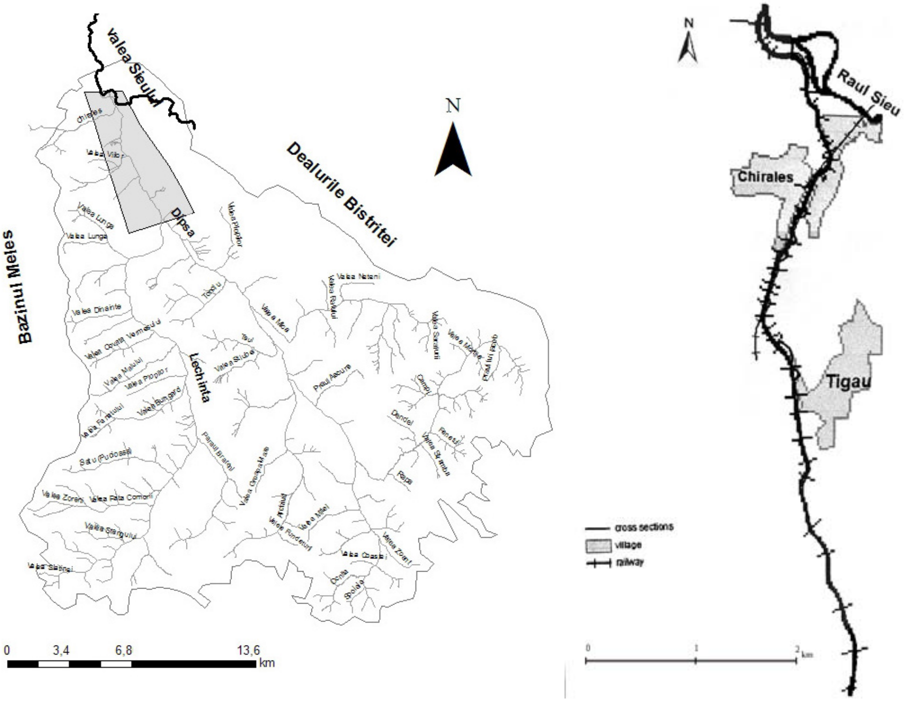
Dipsa`s watershed is dominated by the Sarmatian sedimentary rocks, Volhinian and bassarabian sedimentary deposits, represented by sandy- ashen, drab-bleu clay deposits. Morphometrical characteristics of the watershed point out small possibilities to

[1] *Babeş-Bolyai" University, Faculty of Geography, 400006 Cluj-Napoca, Romania.*

shape a flow able to generate height discharges (the annual mean discharge is about 1,42mc/s and the annual mean rainfall around 652,5 mm).

The trolling of the solid sediments into the river from the slopes is a frequent phenomenon in this area. When the river channel does not have the capacity to transport those solid sediments, another change of the existing configuration of the channel affects the river system. The thickness of the layer for Dipsa`s watershed is about 77, 6 microns/years (G. Pandi, 1997). This is the reason why the main valleys of the watershed, Lechinta, Dipsa, Pintic and Astupaturii Valley have had a sinuous aspect, a lot of meanders and bank erosion, aggravated reaches and shallow slope, insufficient to transport maximum discharges.

Because of its important agricultural potential and of the problems that occurred in the meantime with the management, Dipsa watershed had been and still is under powerful anthropical interventions.



a) b)

Fig. 1: *a) The Dipsa river watershed and the localisation of the study area; b) the study reach*

These anthropical interventions (meander cut, embanking and chenalization) were done in order to introduce the landscape into the agricultural circuit and to prevent the alluvial plain from flooding.

Inside Lechinta commune, Dipsa`s river channel presents along Chirales and Tigau villages a powerful meander sector with shallow slope flowing, the channel being agradated and unable to transport maximum discharges. For this reason, the agricultural land and a part of the establishments are submitted to floods every year, producing a lot of damages as well.

3. PROJECT DESCRPTION

In order to protect and to reduce socio-economics losses stream regulation projects were done on Dipsa river. Materials extracted from the bed river were stocked on the channel banks as stockpiles. Bank consolidation works for some typified active erosion areas accomplished the regulation project. All these stream regulations works were achieved by OGA Bistrita-Nasaud and projected by Somes-Tisa Water Department. The investment provided by D.A. Somes Cluj-Napoca plan started in the second term of 1982 and finished in the forth term of 1982.

Documentation plan analysis shows that the regulation works have created appropriate sectors to ensure the discharge flow from the upstream until the confluence with Sieu river for a entire length of 8,3 km. The initial regulation project on Dipsa river and Lechinta embraced interventions for a sector of 45 km without taking into account the confluence area.

The projected streamline section has a trapezium shape type where the thalweg width (the small basis) (b) has 8 m, the height between 4,3 and 5 m and embankments slopes between 1: 1,5 and 1:2 . The regulation works have been differently classified based on their importance: the IVth importance class, maximum discharge (Q max) 5%= 210 mc/s inside the villages, and the Vth class, maximum discharge 10%= 163 mc/s upstream Tigau village for 2,6 km.

4. METHODOLOGY

In order to analyze the river- channel changes, this study used data collected from the regulation projects and then we performed statistical analysis of morphometrical characteristics of 21 cross-sections from 40 of initial channel and of projected channel. Based on river thalweg`s levels we could trace the longitudinal profile for the study area section and to set off the general descending trend line of the bed river.

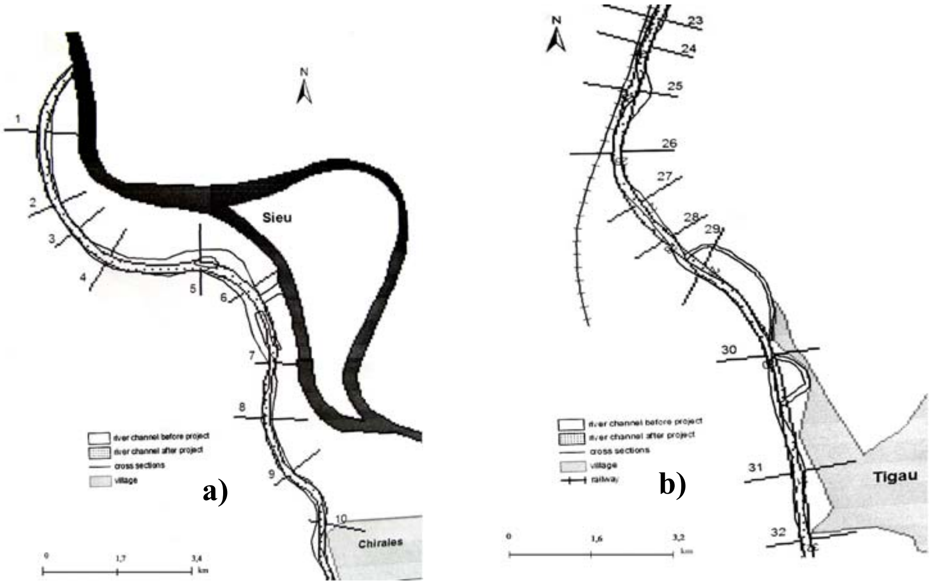


***Fig. 2** Examples of two study sectors: a) the confluence sector and b) the Tigau Sector*

The rate of change in channel sinuosity for the selected sections upon uniformity characteristics was calculated using GIS by overlaying situation plans 1:5000 executed during project regulations from 1982, based on the field studies made in 1977 by OGA Bistrita-Nasaud (Fig. 2). Sinuosity was calculated as the ratio between channel length and straight-line valley length for tree main sectors, following Schumm 1963.

5. RESULTS AND CONCLUSIONS

This paper deals with the channel changes of the Dipsa river at the confluence with Sieu river, that occurred in 1982, in response to human interventions in the fluvial system.

The purpose of this study is to analyze the changes of a river sector by understanding the anthropical impact of human actions on morphological elements of a river bed.

In order to characterize the planform change of river course, we have analyzed the river bed sinuosity (local channel shifts), disturbed by anthropical mender cut-off and abandoned mender comparing the river course before and after regulation project.

Sinuosity is a commonly used indicator of channel behavior (Ferguson, 1975; Lewin, 1977). The sinuosity analyzed for our three sectors (at the confluence, inside Tigau village and close to Chirales village), provides the following changes (where Tigau village sector sinuosity was the most influenced by the human interventions): (Table 1).

Table 1

Sector	Confluence sector	Chilales village sector	Tigau village sector
Sinuosity before project	1,52	1,25	1,6
Sinuosity after project	1,2	1,05	1,07

Morphological changes on cross section geometry have created a new configuration of the river bed dimensions, mainly on the width and the deepness of the bed. (Fig. 3) To analyze the cross section modifications we have used three main characteristics (maximum deep**,** thalweg width and bank full width) in order to extract the human impact on cross-section geometry.

A comparison between pre- and post-project-sections indicates a lateral shift in the planform of the river.

Quantitative data concerning the geometry of the river bed were extracted from 21 available cross-sections (the project provides the execution of 40 cross-sections), having a medium distance of 100 meters between them, achieved by OGA Bistrita-Nasaud in 1977.

Overlaying the initial cross-sections (before the project regulation works) and the projected ones (after the project regulation works) and measuring the geometrical characteristics we can realize that the extremely unregulated shape of the bed was reduced to a regulate shape, a trapezium, in most of the cases being made by the widening of the bank full width and of the thalweg width (Fig. 3).

The data values of maximum river bed deepness indicate a general decrease trend level after the project regulation works, excepting the 10-th cross-section transect area , where, the bed level being artificially raised.

Downstream Chirales village, between 10 and 15 cross-sections and 25 cross section, because of the height hydraulic capacity of the water, the initial bankfull width and thalweg width values were wider than the projected ones (Fig. 4).

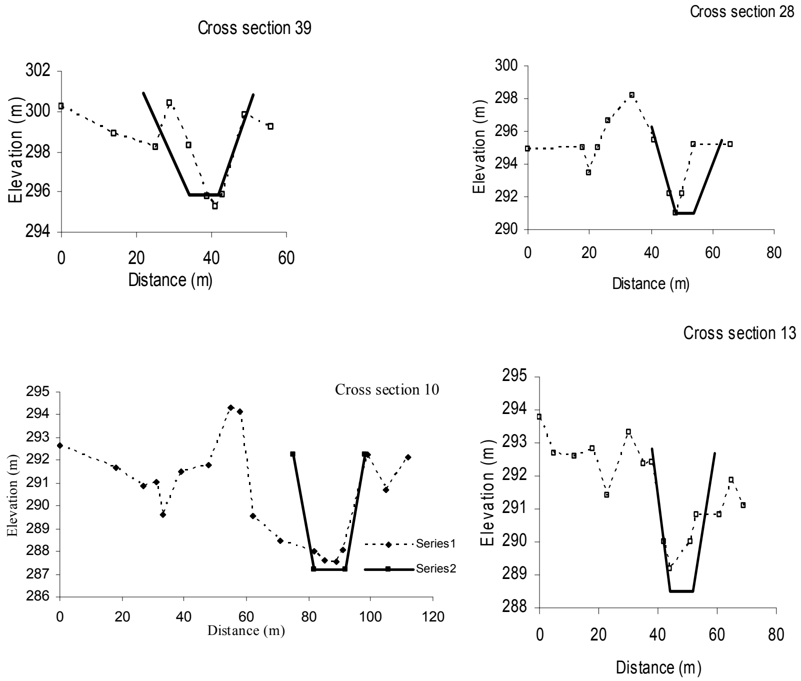
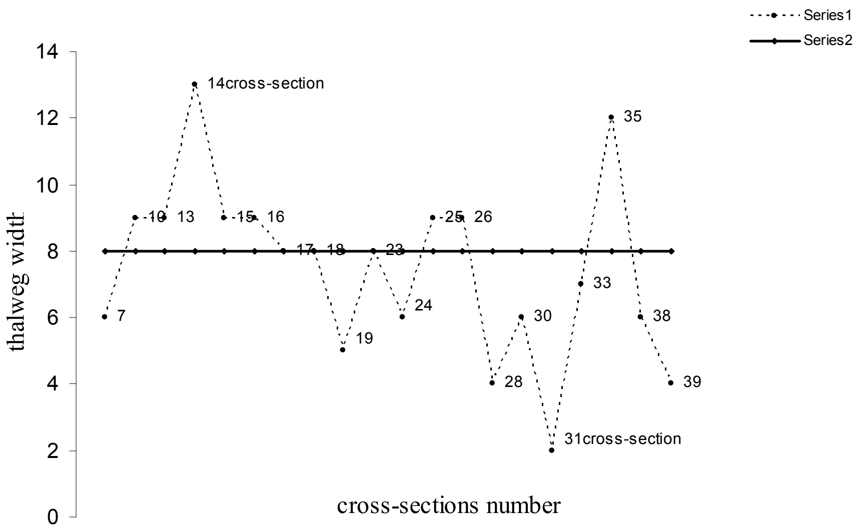
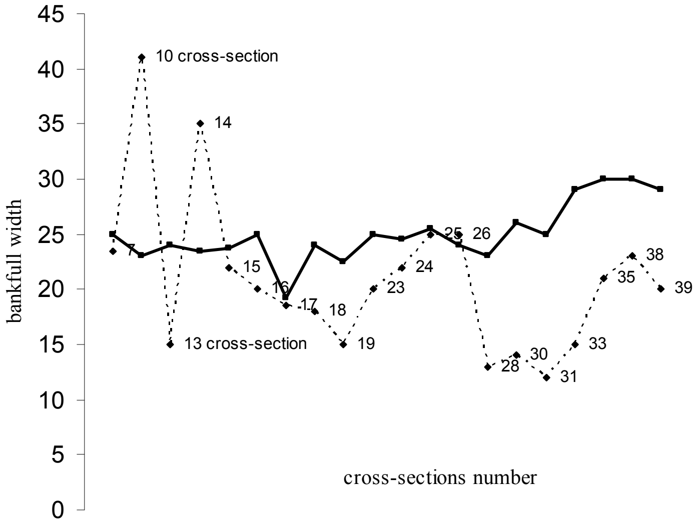


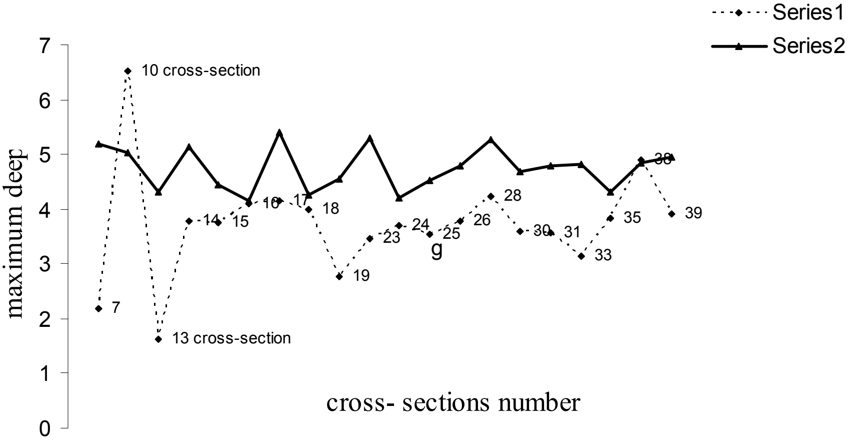
***Fig.3** Example of cross sections: Series 1- initial cross-section; Series 2- projected cross-section*


Series1
Series2
14
12
10
8
6
4
2
0
thalweg width
14cross-section
35
10
13
15
16
25
26
17
18
23
7
33
24
30
38
19
28
39
31cross-section
cross-sections number

a)


45
40
35
30
25
20
15
10
5
0
bankfull width
10 cross-section
14
7
15
16
17
18
13 cross-section
19
23
24
25
26
38
35
39
28
30
31
33
cross-sections number

b)



c)

Fig.4 *Values for: a) thalweg width; b) bankfull width ; c)maximum deep for the initial and projected river channel Series 1- initial cross-section Series 2- projected cross-section*

Based on river thalweg` levels (40 values of the thalweg level) we have traced the longitudinal profile for the study area section to set off the general trend line of the river bed. The trend of the projected longitudinal profile is much more regulated than the initial one recording a descending of the bed level for the entire reach profile and the diminution of natural irregularities (Fig. 5).

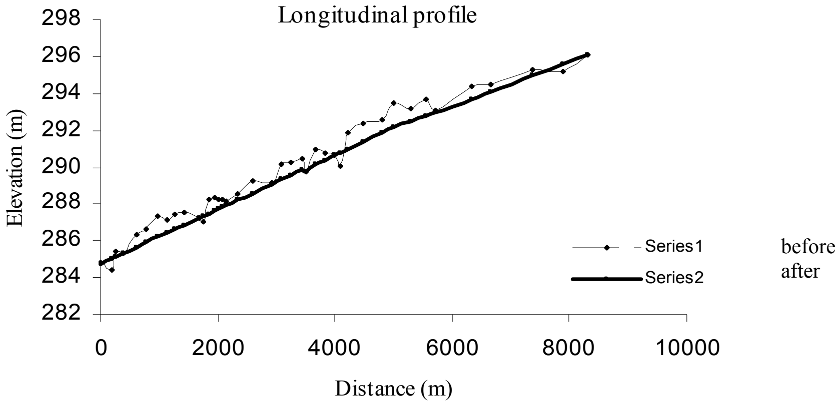


Fig.5. *Longitudinal profile of the study reach before and after project regulation works*

The consequences of the regulation works are complex, and hydrological correlations, damages assessment need to be performed in order to determine the efficiency of the project. Ecological and esthetical aspects are to be considered, as a dramatically change occurred on the riparian vegetation.

REFERENCES

Downward S.R., Gurnell A. M., Brookes A. (1994), *A methodology for quantifying river channel planform change using GIS.* Proceedings of the Camberra Symposium, December 1994, "Variability in Stream Erosion and sediment transport". IAHS Publ. no. 224, 1994.

Dutto, F., Maraga, F. (1994). *Variazioni idrografiche e condizionamento antropico. Esempi in pianura padana.* Il Quaternario 7, 381-390.

Ferguson, R.I., (1975). *Meander irregularity and wavelength estimation.* Journal of Hydrology 26, pp. 315–333

Gilvear, D.J. Sichingabula, H and Winterbottom, S.J. (2000), *Characteristics of channel planform change on the meandering Luangwa River, Zambia,* Earth Surface Processes and Landforms, 25, 421-436.

Graf, 2000 W.L. Graf (2000), *Locational probability for a dammed, urbanizing stream: Salt River, Arizona, USA,* Environmental Management 25 (2), pp. 321–335

Gurnell AM. (1997), *Channel change on the River Dee meanders, 1946–1992, from the analysis of air photographs.* Regulated Rivers: Research and Management 13: 13–26.

Knighton, A. D. (1989), *River adjustment to changes in sediment load: The effects of tin mining on the Ringarooma river, Tasmania, 1875-1984.* Earth Surface Processes and Landforms, 14, 333-359.

Kondolf, G.M. (1997), *Hungry water: Effects of dams and gravel mining on river channels.* Environmental Management 21(4):533-551

Lewin, J. (1977), *Channel pattern changes. In River channel changes,* ed. K. J. Gregory, pp. 169-84. New York: John Wiley and Sons. Mackin, J. H. 1948.

Pandi G. (1997), *Conceptia energetica a formarii si transportului aluviunilor în suspensie ,* Ed. Presa Universitara Clujeana, Cluj Napoca (partea I: Aspecte teoretice)

Petit F., Poinsart D.; Bravard J.-P. (1996), *Channel incision, gravel mining and bedload transport in the Rhone river upstream of Lyon, France ("canal de Miribel")* Catena, Volume 26, Number 3, pp. 209-226(18), Elsevier

Przedwojski, Bogusław (1995) *River training techniques: fundamentals, design and applications.* Rotterdam, Brookfield,VT: A.A. Balkema, 1995.

Surian N., (1999). *Channel changes due to river regulation: the case of the Piave River, Italy.* Earth Surfaces Processes and Landforms 24, 1135-1151.

Surian N. Rinaldi M., (2003). *Morphological response to river engineering and management in alluvial channels in Italy.* Geomorphology, 50, 307-326.

Proiect Nr. 113/1981. Amenajare *V. Dipsa de la Lechinta la confluenta cu R. Sieu- Jud. Bistrița Năsăud.* CNA- Direcția apelor Somes Cluj-Napoca

ALPINE CLIMATOLOGY AND TOURISTIC APPLICATIONS OF A SKIABILITY INDEX IN THE PANEVEGGIO – PALE DI SAN MARTINO PARK AREA (WESTERN TRENTINO REGION, ITALIAN ALPS).

M.Fazzini[1] & C.Bisci[2]

ABSTRACT

This study aims at describing climatic conditions favouring winter tourism in the test area of the Paneveggio – Pale diSan Martino Park (Western Trentino Region, Western Italian Alps), using a new statistical approach for climatic parameters.

The problem of duration, thickness and spatial distribution of the snow cover, progressively more relevant in the framework of the present global warming, besides its strong impact on winter tourism has a wide impact on the environment of mountain areas, inducing dimensional variations of glaciers and significantly influencing water resources.

We verified the actual distribution and entity of snowfalls monitored at different elevations to investigate on the real favorability of average climatic conditions for winter sports (extremely important for the local economy). Lessening of snowfalls sided by a slight but stable enhancement of average temperatures determines in the study area a relevant decrease of “skiabkle” days; obviously, artificial production of snow, possible also at the beginning of the skiing season, allows to balance this loss, at least at not too low altitudes.

Keywords: skiing, Alps, climatology, alpine, skiability index

*

1. INTRODUCTION

The study area (Fig. 1) is the territory of the Paneveggio – Pale di San Martino Regional Natural Park, located between the upper valleys of the Cismon (tributary of the Brenta River) and Travignolo Torrent (tributary of the Adige River). The above valleys are connected through the meadows of the Rolle Pass (1’974 m alt.) .

The Regional Park, instituted in 1967, originally included the state properties, some pastures and the Pale di San Martino mountain group: in 1987 it has been enlarged to its present size of 192 sq. km. To the East, the Pale di San Martino peaks, belonging to the Dolomites and

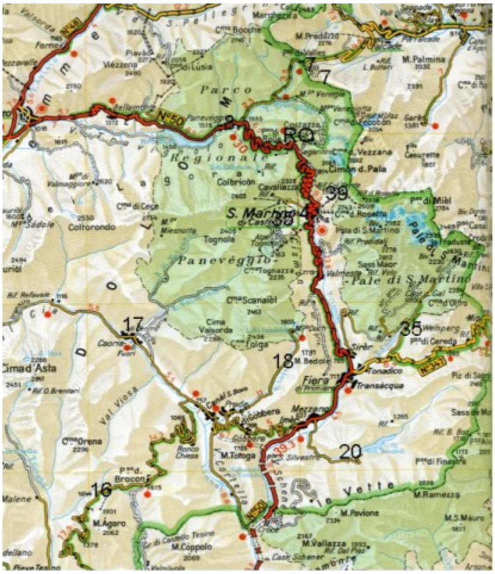


Fig. 1 – *The Study area: the red spots mark the studied meteorological stations and snow fields.*

[1] University of Ferrara, Italy, Department of Earth Sciences

[2] University of Camerino, Italy, Department of Earth Sciences

modelled on Ladinic limestone deposited along a coral reef, range from the Valles Pass and the Canali Valley: their altitude often exceed 3'00 m (Cima di Focobon, 3054 m; Cima della Vezzana, 3192 m; Cimon della Pala, 3184 m).

The Lagorai Range, located on the right side of the Cismon Torrent, has an almost semicircular shape and can be divided into two blocks: the older granitic massif of the Cima d'Asta (in the south-western portion of the study area) and the porfiric Colbricon massif to the East: to the North of the Cima d'Asta massif, elevation ranges from 2'400 and 2'600 m.

To the South, the Cismon Valley widens in the some kilometres large Primiero basin, oriented NE-SW and closed to the South by the dolomitic Vette Feltrine, reaching their maximum altitude at the Pavione Mt. (2'334 m).

Fig. 2 – *Winter view of the Pale di San Marino (a) and the Colbricon (b) Mountain groups with their ski slopes.*

All the territory of the Park is now a popular winter touristic destination for its beautiful ski slopes (over 100 km, Fig. 2)) and trails (over 150 km), as well as for its ski mountaineering routes. During summer, trekking and climbing are widely practiced thanks to a dense network of well traced and serviced tracks and routes.

2. DATA

Fig. 3 – *The snow field in Passo Valles (2'045 m)*

In the Park territory and its neighbouring a dense network of meteo-climatic recording stations is present (Fig. 1), covering some 500 sq. km: there 11 experimental snow fields (Fig. 3) are managed by the Forecast and Organization Office of the Trento Autonomous Province, where during the cold season experts daily (around 8 – 8.30 am) carry out surveys and fill in the AINEVA "Form 1".

The above snow fields cover a wide range of altitude and positions: their main geographic features are listed in table 1. The older stations, activated by the

Code	Location	Elev.	Slope / Aspect	Start	Notes
17 CA	Caoria	915	10° / SE	1981	
37 VW	Villa Wesperg	1'005	Valley floor	2001	
20 NO	Val Noana	1'020	?	1985	
18 SB	Canal San Bovo	1'265	5° / SE	1981	*
4 SMC	S Martino di Castrozza	1'465	Valley floor	1981	
8 PAN	Paneveggio	1'535	5° / SW	1981	#
16 PT	Passo Broccon	1'615	5° / SW	1981	#
35 VC	Val Cigolera	1'880	5° / NE	1997	
38 MP	Col Verde	1'880	10° - SW	2003	
RO	Passo Rolle	2'004	10° W	1982	#
7 PVA	Passo Valles	2'020	5° / S	1981	

*Table 1 – Main geographic features of the 11 snow fields: those located within the study area are evidenced. * from 2004, moved to Calaita (1'610 m); ** stations equipped with an ultrasonic nivometer.*

Provincial Snow and Avalanches Office in 1981, show remarkable homogeneity and continuity of high quality data: this allowed extending back to the winter 1981-82 the analysis of the most important nivologic and nivometric parameters, i.e. thick-ness of fresh snow, thickness and duration of snow cover. For the study, also the data recorded at the Rolle Pass, kindly furnished by the Military Aviation, have been taken into account, even though for them the AINEVA form 1 is not available: as a consequence, there nivometric parameters have been obtained basing upon the SYREP bulletins.

Since manual observations are mostly aimed at determining avalanche risk, snow fields are activated either immediately after the first relevant snowfall or when the skiing season starts (generally, the first week end of December): they end when the ski lifts are stopped (after the Easter holidays) or when the snow is almost fully melted. As a consequence, the global amount of fresh snow is underestimated for December and April, mostly at altitudes over 1'500 m: anyhow, it is reliable for their application to the evaluation of a skiability index. Therefore, the analysis has been limited

Station	Elev.	Dec	Jan	Feb	Mar	Apr	TOT
Caoria	915	28	36	30	29	4	127
S. Martino di Castrozza	1'465	55	50	49	59	50	253
Passo Valles	2''025	83	73	72	97	116	441

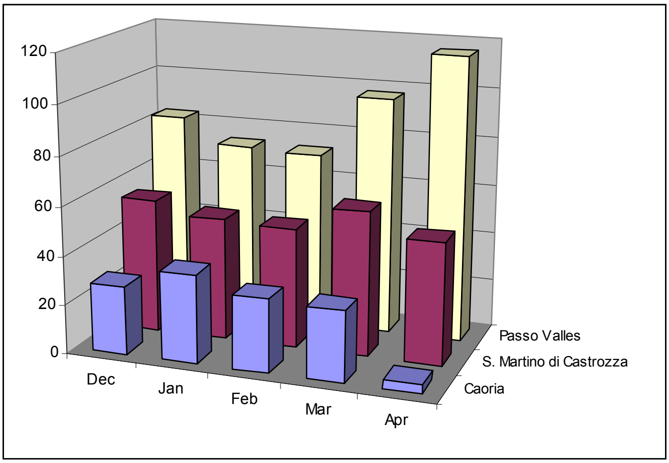


Fig. 4 – *Average monthly thickness of fresh snow (1981 – 2007).*

to months from December to April.

Basing upon a critical comparison of information recorded at all the 11 stations, it has been decided to carry out the analysis only taking into account the three most complete time series, i.e. those recorded at Caoria (close to the valley bottom at an elevation of 915 m), S. Martino di Castrozza (in the mid-upper Cismon Valley, 1'444 m)) and Passo Valles (on the divide, 2'020 m). This choice will anyhow allow individuating altitudinal and temporal variations of nivometric parameters. In Table 2, average values of the thickness of fresh snow are listed for the three above stations for the time span 1981–2005.

Average thickness of snow is generally abundant, thanks to the trend of the valleys, open to the South, and therefore to the southern air currents bringing snowfalls (Fazzini, 2007); moreover, morphometric features of the reliefs favour orographic precipitations.

Not only the total amount of snow, but also the nivometric regime strongly depends upon altitude (Fig. 4): it is typically "Pre-Alpine" (with a slight maximum in January) up to ca. 1'000 m to become "Equilibrated" (with almost homogeneous snowfall for all the cold period) at intermediate elevations and, finally, bimodal with a maximum in Spring at higher elevations (Fazzini & Gaddo, 2003).

Analysing the trends for the last two decades, confirming many observations carried out for all the Italian Alps, a significant reduction of snowfalls is evident (Fig. 5) that can be estimate in ca. 3 - 4 cm per year, as an average; this trend is more evident at elevations lower than 1'200 m, such as at Caoria (925 m) where it reaches a value of ca. 7 cm per year (Fazzini & Gaddo, 2003; Fazzini *et al*., 2005, Valt *et al*., 2005). At elevations exceeding 1'600 m, a slight increase of snowfalls can be observed in spring (when it is no more useful for skiing).

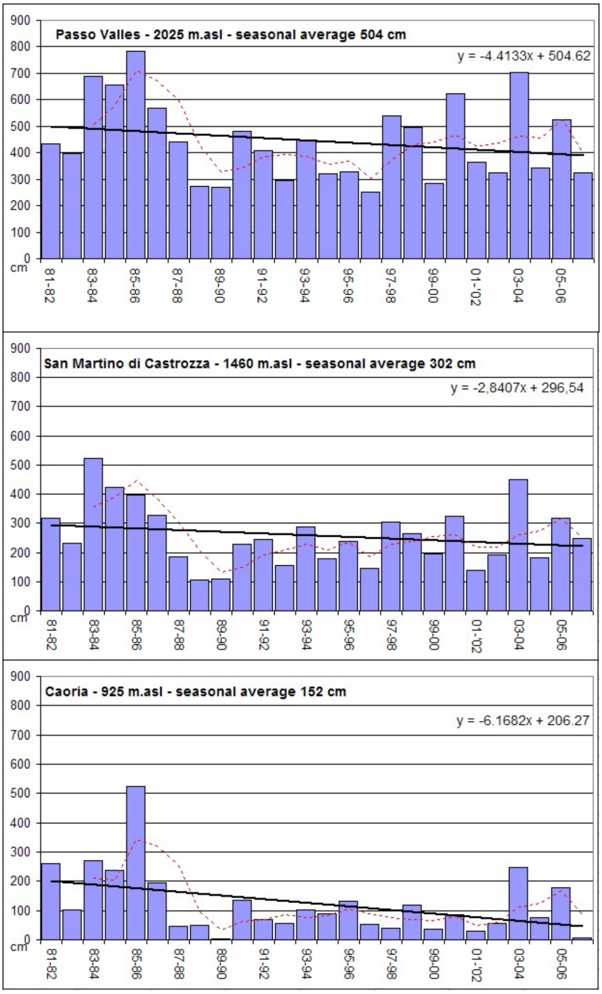


Fig. 5 – *Variations of the seasonal total amount of snowfall for the last 25 years in the study area. The regression lines evidence the trends.*

3 – THE SKIABILITY INDEX

In the last decades, mostly in France, some geographers deepened the experimental study of meteo-climatic conditions favouring leisure and sport activities, starting with seaside resorts to switch later to mountain areas, where the climatic change could be more effective. In Italy, some scientists worked on the skiability index introduced by Gumuchan (1986) applying it to some selected places in the Italian Alps (Fazzini *et al*., 2003, 2004; Biancotti *et al*., 2004. Barbier (1994) defined a “domain skiable” in the following way: at least 30-40 cm of snow are needed to ski; at least 120 days of effective snow cover are needed to get back the money invested, low wind speed is needed to avoid reworking of snow, slopes are to be sunny and risks are to be absent.

The skiability index answers to the two first conditions, corresponding to the average number of days per month that allow the practice of skiing (either alpine or Nordic), only taking into account the thickness of snow cover close to ski slopes and tracks. The threshold has been fixed in 30 cm: if the thickness is lower artificial snow can be produced. This can be done only where a relevant amount of water and adequate hydro-thermal complexes are available. Practically, even using the most modern snow guns, to obtain an adequate (i.e. skiable) snow cover minimal daily temperatures are to be nor higher than -3 °C with a relative humidity of 100%: the best performances are obtained when the temperature ranges between -6 and -8 °C and the relative humidity from 30 to 50%. Evaluating the number of days which are skiable as a consequence of artificial snow cover, we considered that 7 to 10 days of production of artificial snow are needed (with optimal thermal and hygrometric conditions) before the slopes can be opened for skiing when at the beginning of the cold season there is no snow cover along slopes (Fazzini *et al*., 2004, Fratianni, 2004).

Since in Italy the skiing season opens with the holidays of the Immaculate Conception (i.e. around December 8th) and generally ends after the Easter holidays (or, at the most, after the April 25th holidays) the total skiability index (obtaining summing up to the days with natural skiability those when the skiability can be artificially obtained) has been calculated for the semester from November to April.

Presently, a new skiability index is under testing that takes into account also other climatic parameters, such as minimum and maximum temperature, relative humidity, visibility, albedo and wind speed (Fazzini *et al*., 2004). Where meteorological stations detect those parameters further information cold therefore be furnished that are instrumental to individuate the periods and places that are the most adequate for practicing winter sports.

Station	Elev.	Dec	Jan	Feb	Mar	Apr	TOT
Caoria	915	7 (4)	16 (7)	15 (7)	9 (3)	1	48
S. Martino di Castrozza	1’465	22 (15)	30 (10)	26 (6)	24 (7)	14 (6)	118
Passo Valles	2’’025	26 (10)	30 (6)	28 (2)	30 (2)	28 (2)	142

Table 3 – Number of skiable days; between brackets those needing production of artificial snow.

4 – RESULTS

After a detailed analysis of the nivo-meteorological parameters, for each test site daily observations have been classified into three classes: days with more than 29cm of snow thickness, days with snow too thin but with climatic conditions favouring the production of artificial snow and days with no skiability at all.

Summing up for each month the first two, we obtained the total number of skiable days (Tab. 3 and Fig. 6).

Statistical analysis of the above data has shown that the total number of skiable days has a significant (R^2=0.92) linear correlation with altitude: Sd = 0.0828 E - 19,472 (where Sd is the number of skiable days and E is the elevation in meters) In other words, for every 100 m of elevation we have ca. 8 more days for skiing. Anyhow, the relation is not strictly linear, since it seems that at altitudes around 1'000 – 1'500 m the increase is even more rapid.

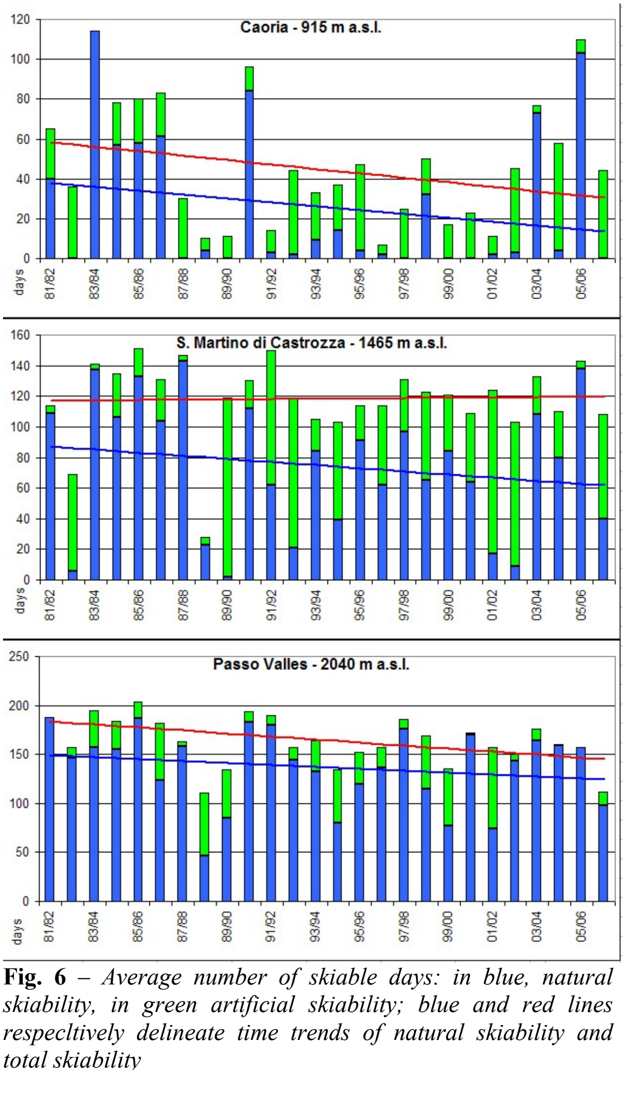


Fig. 6 – *Average number of skiable days: in blue, natural skiability, in green artificial skiability; blue and red lines respecltively delineate time trends of natural skiability and total skiability*

Analysing separately every month it is showy that in December production of artificial snow is instrumental for touristic purposes: in S. Martino di Castrozza, as an average they have only 6 skiable days whilst using snow guns this figure increases to 20, including all the second half of the month (this implies an almost complete opening of the ski slopes during all the Christmas – New Year holidays, the most productive period for winter tourism). Along the valley bottom - where presently the ski tracks and ski lifts that where popular in the '80s and in the '90s are no more active – it could be possible to practice again winter sports during the second half of December if artificial snow were produced.

During January and February, at least at altitudes over 1'200 m, it is almost sure that all the ski slopes could be opened thanks to the snowfalls (with the further advantage of the remnants of the snow previously artificially produced): only for a few days or in case an of exceptionally dry winter (such as in 1989 and 1990) artificial snow production is needed. Along the valley bottom relevant snowfalls and meteorological conditions favouring the use of snow guns (that can double the days of skiability) allow a fair touristic use of ski slopes and tracks, even though not for the full bimester (as an average, only half of the days will be skiable).

In March, the slight increase of temperature doesn't significantly reduce skiability at higher elevation (over ca. 1'500 m) but at lower altitudes, mostly in the second half of the month, causes relevant snow melting (that results in a marked worsening of snow quality) and reduces the chances of using snow guns. Therefore, during the Easter vacations (second half of March or first half of April) ski can be practiced only at higher elevations and requires a relevant effort of the societies managing the ski slopes which allow a good touristic exploitation of areas located over 1'800 m (including the slopes bringing back to S. Marino di Castrozza.

The number of skiable days is anyhow a figure that significantly varies prom place to place, even in radius of a few hundred metres. In fact, slope aspect plays an extremely important role in snow melting: it should therefore to be taken into account when evaluating snow persistence on the ground (and, subsequently, skiability indexes). This implies that in order to obtain a fair map of skiability monitoring of nivo-meteorological parameters with a high spatial detail should be needed.

4 – CONCLUSIONS

Examining the time trends of skiable days (Fig. 6) for the available time span (more than 25 years) it has to be highlighted a relevant reduction of the examined variable that implies a strong negative impact on the local economy based on tourism; this is particularly evident at elevations lower than 1'600 m. The causes of this behaviour are to be connected with the contemporary generalised reduction of snowfalls sided by an increase of temperatures which causes a faster snow melting and a slower and later creation of the snow cover on the (warmer) soil at the beginning of winter. In the Primiero basin and along the Vanoi valley bottom, ca. 20 of the 60 potentially skiable days calculated for the early '80s days have been already lost. A similar condition is that of S. Marino di Castrozza, where 24 skiable days have been lost of the former 92. At high elevations, where the reduction of snowfall is lesser, the loss of skiable days is less relevant and affects only the beginning of the skiing season standing the higher thickness of snow cover.

The above observations confirm the need for a rather precise evaluation of the possibility to produce artificial snow in order to eliminate or at least reduce the loss of "natural" skiable days (Fig. 6).

The increase of winter temperatures – as an average ca. 0.35 °C for the investigated period (Meteotrentino, 2008) – doesn't significantly reduce the chance of using snow guns, at least at altitudes exceeding 1'000 m. Therefore, it is possible to balance the negative effects of the present milder climate on tourism (particularly in December, when natural snow cover is lacking). Anyhow, critical condition persist along the valley bottom, where the present average meteo-climatic conditions strongly compromise the practice of Nordic ski. In San Marino di Castrozza, artificial snow almost completely recovers this situation and somehow prolongs the skiable period. In Passo Valles only a portion of the skiable days can be recovered since often at the beginning of the skiing season, when natural snow cover is not sufficient, temperatures are too high for the snow guns: however, form January to April natural snow cover is more then sufficient for the ski tracks.

The calculation of climatic-touristic indexes has a primary relevance in the governance of touristic mountain areas. It has to be considered a binding step in when projects are made for sustainable development of mountain resort, where tourism has to be managed in order to maximize both the economic revenues and the conservation of environment. This is even more relevant nowadays that a dramatic economic crisis is sided by the many problems more or less directly caused by fast climatic change.

Therefore, the study of present climatic trends and the forecast of short-term scenarios are instrumental for the choice of the most adequate touristic-economic measures to be adopted. However, it is to be underlined that to obtain sound results and optimize calculation algorithms for climatic-touristic indexes a much more close-spaced set of observations is needed for the determination of the actual spatial distribution of microclimatic and nivologic features characterizing touristic areas. This implies the creation of a strategically planned network of experimental fields (to be manually surveyed by well skilled personnel) and automatic recording station, since the present set of observation points is totally inadequate even for simple statistical climatologic and meteorological studies.

REFERENCES

Barbier B., Bevilacqua E., Billet J., Herbin J., Julg F., Graf P., Gosar A. (1994) - *Alpin tourism. 25° Congrès Intern.* Gèographie. Paris, 1, VI, pp. 51-168.

Biancotti A., Fazzini M. & Fratianni S. (2004) – *Recherche des tendances saisonnières des jours « skiables » dans les Alpes Italiennes.* XVII colloque de l'AIC Climat memoire du temps, Caen, 261-265.

Bisci C, Dramis F. Fazzini M. & Gaddo M. (2000) - *Definition of geographical parameters describing the spatial distribution of temperature and rainfall in three sectors of the Italian Eastern Alps.* ICAM 2000 - 26th ICAM – Innsbruck – 11-15 09 2000

Bisci C, Fazzini M., Dramis F., Lunardelli R., Trenti G. & Gaddo M. (2004) - *Analisys of spatial land temporal distribution of precpitations during the last 80 years in Trentino (Italian eastern Alps).* Meteorologische Zeitschrift – Special Issue of 27° ICAM-MAP 2003, Berlin, 13-3, 183-188.

Fazzini M., S. Fratianni, A. Biancotti, C.Bisci & R.Zasso (2003) - *Interaction between climate and tourism: a research on skiability condition in several skiing complexes on piedmontese and dolomitics Alps.* 27° ICAM-MAP 2003, Brig - Publ. of MeteoSwiss n°66; 354-358

Fazzini M. & Gaddo M (2003) - *La neve in Trentino: analisi statistica del fenomeno nell'ultimo ventennio.* Neve e Valanghe, AINEVA, 48, 28-35

Fazzini M., Fratianni S. & Gaddo M. (2003) – *Nivometrie dans le territoire du Trentino et ses implications touristique.* XVI Colloque AIC "Les relations climat-homme-climat " - Varsovie 2003 - Dokumentacja geograficzna n°29, 117-121

Fazzini M., S. Fratianni, A. Biancotti, & Billi P. (2004) - *Interaction between climate and tourism: a research on skiability condition in several skiing complexes on piedmontese and dolomitics Alps* Meteorologische Zeitschrift – Special Issue 27° ICAM-MAP 2003, Berlino 13-3. 134-139

Fazzini M., Frustaci G. & Giuffrida A. (2005) –*Snowfall analisys over peninsular Italy in relationship to the different types of synoptic circulation: first results.* Croatian Meteorological Journal – The 28th Conf. on Alpine Meteorology (ICAM-MAP), 650-653

Fratianni S. (2004) – Le risorse climatiche dell'Italia del nord ovest. *Studio finalizzato alla fruizione turistica.* Unpublished PhD Thesis - Università di Torino, 230 pp.

Gumuchian H. (1986) - *La neige dans les Alpes françaises du Nord. Edi. des Cahiers de l'Alpe,* Grenoble, pp. 102-124.

Meteotrentino (2008) – Personal communication.

Valt M., Cagnati A., Crepaz A. & Marigo G. (2005) – *L'andamento delle precipitazioni nevose sul versante meridionale delle Alpi.* Neve e Valanghe, 56, AINEVA, 17-26.

Fazzini M., Cenacchi F., Billi P. & Gaddo M. (2006) – *Climatologia alpina e sue applicazioni al turismo: calcolo dell'indice di sciabilità nell'area del Parco Paneveggio-Pale di San Martino.* Neve e Valanghe, AINEVA ed n°58 Spec. Vol. "Innevamento in Italia" – 58-67.

THEORETICAL SPECIFIC AREAL HYDROENERGETIC POTENTIAL MODEL: CRIŞUL REPEDE RIVER UPPER BASIN

Cs. Horváth[1], Mária Ivett Antal[2],

ABSTRACT
The inventory methods to measure hydroenergetical potential are various, depending mostly from the available database. In the studies for assessing the potential energy of the water are two important aspects, one is the concentrate runoff of water and the other one is the surface areal runoff. Even if technically only the concentrated water could be utilized to generate energy, it is very important to assess the potential of the surface water flow energy because this is the base of concentrated runoff. We present in this study a base method of assessing the areal hydroenergetic potential resolved with modern GIS methods.
Keywords: hydroenergetic, potential, Crisul Repede, precipitations, runoff

*

1. INTRODUCTION

In the process of assessing the hydroenergetical potential there were developed many types of methods which were adapted to the available data, also the process had crystallized several categories of hydroenergetic potential. Regarding the areal runoff, two important categories have been separated: one is the areal potential of the water from rain and the other is the hydroenergetical potential of the areal runoff.

The base formula regarding the energy generated from areal runoff is the same for the energy from rain or runoff, and it can be written like:

$$E = \frac{1}{367}\int H dV \left[kWh/an\right] \quad (1)$$

where, H is the elevation difference or the head of the water volume and V is the yearly water volume from the precipitation or the runoff

From this formula (1) we can separate, using the energy formulas, the formulas for the two different types of potential, so:

$$E_P = 2,725\sum_{1}^{n} h_i \cdot \Delta F_i \cdot H_i$$
$$E_S = 86\sum_{1}^{n} q_i \cdot \Delta F_i \cdot H_i \quad (2)$$

where, the values of the h_i, H_i, q_i are average values of the ΔF_i.area. The h, q and H values vary different in concordance with the studied surface, so we have to calculate the average values of precipitation (h_i), runoff (q_i) and head (H_i) for every ΔF_i surface to calculate the theoretical surface hydroenergetical potential.

So the formulas can be written like:

$$\Delta E_{Pi} = 2,725 \cdot 10^{-6} \cdot h_{mi} \cdot H_{mi} \cdot \Delta F_i \left[GWh/an\right] \quad (3)$$

1 „Babeş-Bolyai” University, Faculty of Geography, 400006 Cluj-Napoca, Romania.
2 Secondary School Viisoara, 407590 Cluj-Napoca, Romania

$$E_{Si} = 86 \cdot 10^{-6} \cdot q_{mi} \cdot H_{mi} \cdot \Delta F_i \left[GWh/an\right]$$

Also these formulas make possible the definition of a specific value for the hydroenergetical potential generated form precipitation (e_{pi}) and the runoff (s_{pi}), characteristic to every studied area ΔF_i.

$$e_{Pi} = \frac{\Delta E_{Pi}}{\Delta F_i} = 2{,}725 \cdot 10^{-6} \cdot h_{mi} \cdot H_{mi} \left[GWh/an \cdot km^2\right]$$

$$e_{Si} = \frac{\Delta E_{Si}}{\Delta F_i} = 86 \cdot 10^{-6} \cdot q_{mi} \cdot H_{mi} \left[GWh/an \cdot km^2\right] \qquad (4)$$

The specific values make possible the comparison of the hydroenergetical potential between different areas

2. DATA

To calculate the specific energetic potential, we have used yearly average precipitation and runoff data from the model basin meteorological and hydrological stations. In the studied model area, the upper basin of the Crişul Repede River, we used the data from thirteen hydrometrical stations and fifteen meteorological stations.

The spatial characterization of runoff had been made by finding synthesis functions between the precipitation, the specific average runoff expressed in $l/s*km^2$ and the average altitude of the river basins expressed in meters. This work method makes possible the determination of average precipitation and runoff values, at sections, where no measured data are available.

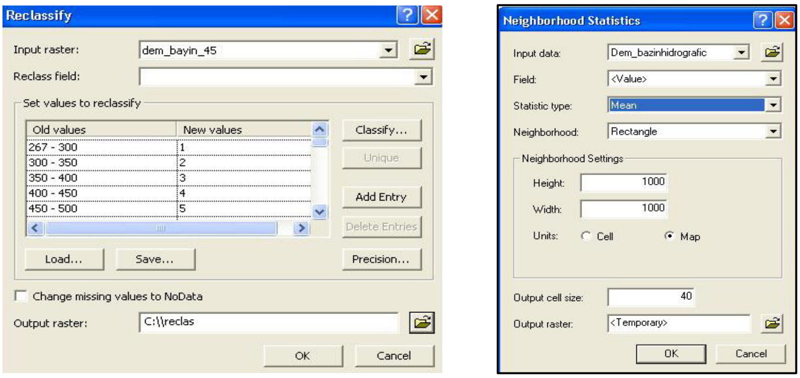


Fig. 1. *"Reclassify" and the "Neighborhood Statistic" from the Spatial Analyst extension of ArcMap-ArcInfo software*

The consideration of the altitude like the base cause of the spatial differentiation for the runoff water volume is justified, by the fact, that, this is the synthetic expression of the physical-geographic conditions which genetically influence the formation of the average runoff.

We delivered the maps of the yearly average precipitation and the yearly average runoff of the studied basin using the "valability zones" method, which implies finding the best functions (valability curves) between altitude and precipitation or the specific runoff for the valability zone. These calculations were made using Microsoft Excel, and the results were reintroduced in ArcGis from the Esri software group for every 50 m altitude strep.

With the reclassification (Fig. 1.) of the grid and applying the neighborhood statistic function on it we delivered 1 km^2 areas with values from the average data. After this the "Raster Calculator" functions of the same software pack made possible to integrate the grids in the formula and to implement the calculation in GIS format.

By resolving the formula (4) for the precipitations E_{pi} using the map of yearly average precipitations we delivered a map of the basin for the specific areal theoretic hydroenergetic potential. (*Fig. 2.)*

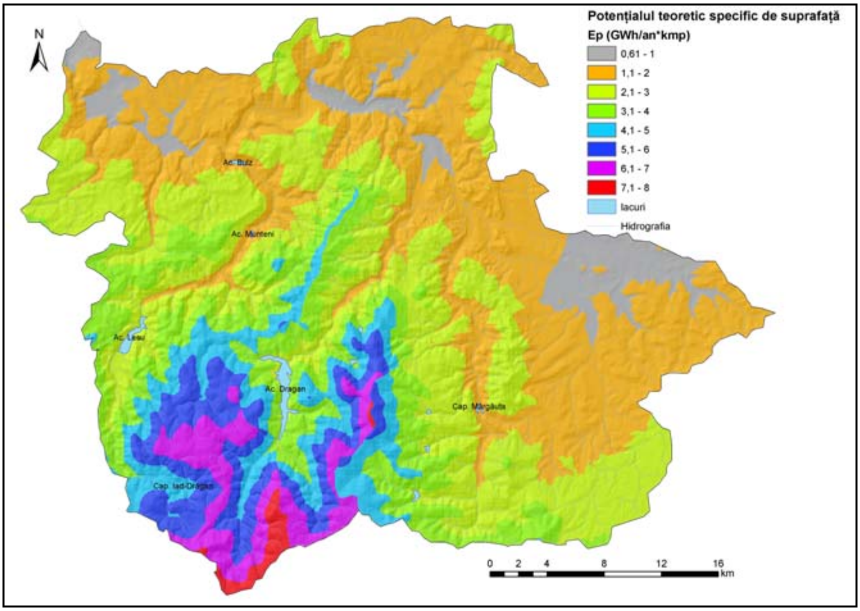


Fig 2. *Theoretic specific hydroenergetical potential map from precipitations of the Crişul Repede river upper basin*

By applying the values of runoff in the formula, like in the case of precipitation, on altitude 50 m strips, we could generate a specific areal theoretic hydroenergetic potential map from runoff (*Fig. 3.)*for the studied area.

The theoretical potential from runoff could be calculated, also with the runoff coefficient (5.):

$$Ep = 2{,}725 \bullet \sigma \bullet P \bullet A \bullet H_m \quad [kWh/an] \tag{5}$$

where, σ is the runoff coefficient calculated from precipitations and runoff, P-is the average precipitations, A is the area and H_m is the head of the water volume.

The biggest problems, regarding the calculation, appear at the values of water volume head, because in a grid environment it is hard to measure the altitudinal difference inside areal grid cells, and to take in account the general slope of the basin. This can be resolved by two methods, taking in account the gross head, from the absolute altitude of surface or by calculating it inside the studied area. In our case we used grid calculator, and extracted the "max" and "min" of every 1 km^2 grid cell which gave us the head of the studied grid cells.

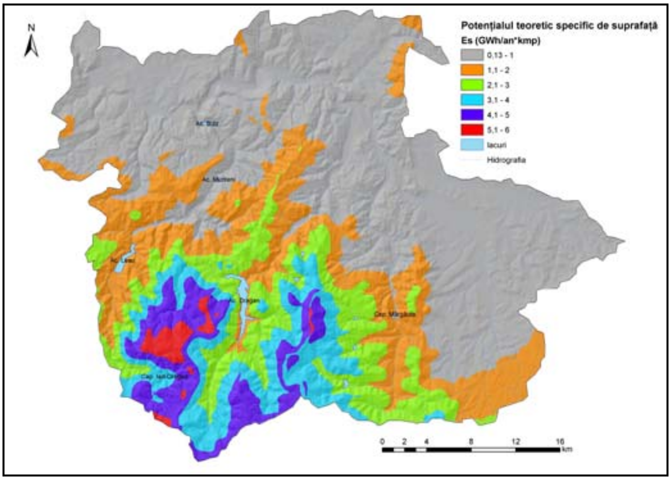


Fig 3. *Theoretic specific hydroenergetical potential map from runoff of the Crişul Repede river upper basin*

4. CONCLUSIONS

The first step towards developing the energy of a stream or river system is to assess the physical power inherent in the relevant river basin. The methodology described is the implementation of a known formula for assessing the hydroenergetical potential, known also as "the elementary surfaces" method, in a modern GIS environment.

The hydroenergetic potential is formed of net head and water volume and so these are the components which basically influence the magnitude of it. Even if the values are mainly theoretical, they represent the basis of hydropower development.

REFERENCES

1. Cogălniceanu, A. (1986), *Bazele tehnice şi economice ale hidroenergiei*, Ed. Tehnică, Bucureşti.
2. Haidu. I., (1991), *Potențialul hidroenergetic al râurilor mici din Grupa Nordică a Carpaților Orientali*, doctorate thesis , Univ. Al. I. Cuza, Iași .
3. Iacob Ersilia (1972), *Potențialul hidroenergetic al râurilor din Munții Apuseni*, Studia Univ. Babeş-Bolyai, Geographia 1/1972, Cluj-Napoca
4. Opaschi M. (2005), *Continuarea valorificării potențialului hidroenergetic al României pe baza experienței dobândite şi dotarea amenajărilor hidroenergetice cu hidrogeneratoare fiabile şi rentabile*, BULETINUL ŞTIINȚIFIC al Universității "POLITEHNICA" din Timişoara, Seria Energetică, TIMIŞOARA, Noiembrie 3-4, 2005
5. Sorocovschi V., Imbroane A. (1992), *Prelucrarea automată a parametrilor necesari în determinarea potențialului energetic liniar şi bazinal*., Studia Univ. Babeş-Bolyai, Geographia XXXVII, 1-2, Cluj-Napoca
6. Vladimirescu I (1984)*, Bazele hidrologiei tehnice*, Ed. Tehnică , Bucureşti
7. *** http://support.esri.com

GIS APPLICATIONS IN BUSINESS ENVIRONMENT

M. Imbroane[1]

ABSTRACT
GIS Applications in Business Environment. A major change in many business organizations is the increasing evidence of a change in our regard to locational decision-making. Many sectors like retail, distribution and marketing have a spatial dimension. At the very core of this information is geographic location, an address or a sales territory. All this information can be displayed and managed interactively on a map. GIS market can help the organization to determine which products and promotions match the lifestyles and buying patterns of the customers.
Keywords: GIS, application, business, sales, strategy

*

1. GIS AND INFORMATION STRATEGY

Making decisions on geography is basic to human thinking. A Geographic Information System (GIS) is a group of procedures (sofware) that provide input, storage and retrival, mapping and spatial analysis for both spatial and attribute data to support the decision-making activities of an organization. We can notice that GIS is not just a technology for data-base management and spatial analysis but a tool for comprehending geography and making intelligent decisions. Viewed from within GIS technology, business geographics is seen as a real success to promote the application of GIS in comercial area. Viewed from a different perspective, the position is less clear. It ofen apears to be the case of GIS in business is used simply to map out or represent spatially referenced data (Birkin et al 1999). At one level it is resonable and should be supported. At another level, it falls somewhat short of what it is termed „inteligent GIS" (Birkin et al 1996). The integration of modeling tools within a GIS environment leads to the creation of decision support system that can adress a much wider range of operations and strategic issues then desktop mapping.

The decision making activities of middle management tend to be described as tactical or semi-structured decisions (Scott - Morton, 1967). More external data may be required to provide information for decision making, like acces to commercially products or census data. For example, in a retail organization, the marketing department searches for a new location for a retail outlet. They first need the base map containg the urban and rural areas, the road network, hydrography. External data from other companies can be used to provide information about competitors and about geodemographics of the proposed catchment area of any new outlet. Most of the current applications of GIS people in marketing functions of companies is to solve problems in the consumer market. Knowing where existing and potential markets are is crucial to any business. Additionally, there are potential gains to be made applying GIS to industrial markets (Grimshaw, 1994).

[1] *„Babeş-Bolyai" University, Faculty of Economics, Cluj-Napoca, Romania.*

2. SPATIAL DATABASE MANAGEMENT SYSTEMS

Geographic databases contain collections of spatial data representing the variety of views for the real world at a specific time. The term spatial refers to the location of objects positioned in geographic space. Spatial objects are representations of the elements of the real world such as rivers, countries, railways, buildings, and shops. The diversity of data that are collected over the same area, often from different sources, imposes a question of how to integrate and to keep them consistent in order to provide correct answers for spatial queries.

The geographic entities or objects in GIS are based on two different types of data: spatial and attribute. Spatial data have two formats: raster and vector. Vector data have a quantitative nature and are used to represent coordinates, lines, areas etc. The two-dimensional vector format has three subtypes: point, line and polygon, named features. The geometric data model is that in which any positional information is recorded. Attributes descriptive, or aspatial data are alphanumeric data related to the graphic entities. They are also called thematic data because they contain themselves a theme of the graphic features. A unique identifier links them. This operation is called geocoding or address matching. The fact is that attributes data can be linked with other tabular data (external) and so the new data can be processed together with the others. This is one of the powerful specific operations in GIS. Spatial data and attribute data can be stored separately or together depending of the database design performed by the GIS proprietary. A geographical database is a set of geometric entities (spatial features) and attributes.

The data stored may be in the form of one or more files, or in the form of database. The difference between a files and a database is semantic and varies somewhat from one discipline to another. For GIS purpose, a file is regarded as a single collection of information that can be stored, whilst a collection of files is regarded as a library. A database comprises one or more files structured in a particular way by a DBMS and accessed through it. Today almost all GIS data is stored in databases. The various methods of data storage differ primarily according to the facilities or operations supported by the DBMS. A recent theoretical study for database management systems (DBMS) was realised by Imbroane Al. and Bucur L. (2007).

3. ARCVIEW GIS SOFTWARE

ArcView is a product of ESRI Enterprise (Environmental Systems Research Institute), world leader in the area. ArcView is a GIS headed desktop that functions on microcomputers standard PC. It has a variety of functions and its simplicity and easiness in usage makes it very productive and obtains results in time, faster than the complete systems. In ArcView, spatial data (maps) is organized in thematic layers such as: point layer (cities, stores, clients), line layer (road network, telephone network), or polygon layer (limits of a city, the area of sales).

The attribute data exists as tables associated with a specific theme. These two types of data are connected in such way that one cannot exist one without the other. The attribute table associated with a theme is a table filled with alphanumerical data that is compulsory and also other arbitrary data that is considered fixed for the period of time being.

When a theme (map) is created the attribute table is also created automatically. The alphanumerical data that will be represented on the map and that is the result of processing from other informational systems will be attached to the attribute table of the theme, so that they can be shown on the map. Excluding the creation of the spatial data base, the most important types of operations of GIS products can be categorized in 4 classes: the data base query, the data integration, procedures of analyze and modeling and data presentation in the spatial data as well as in the attribute data in a very useful manner to the decision factors.

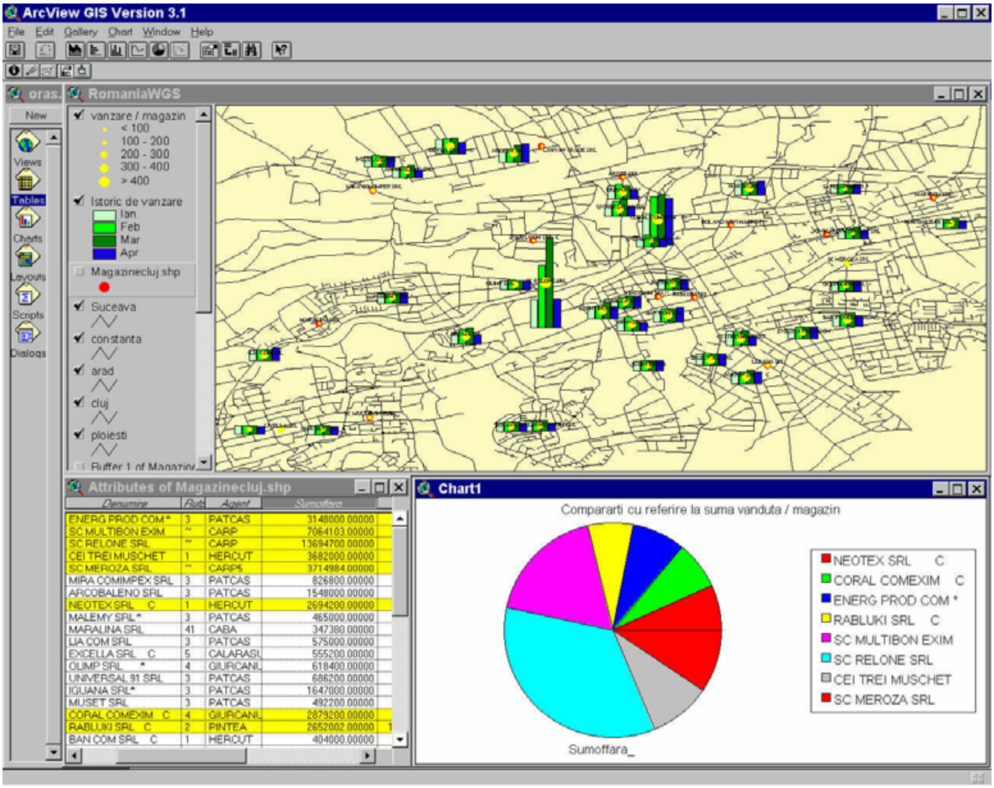


Fig. 1. *ArcView GIS software*

Figure 1 details how the software ArcView works. The spatial layer is key point stores. The table on the left side is called attribute table and contains data (sales) from the company. The software locates the stores on a map and display the sales for months January-April. It can be seen how the sales evolve from one month to another, and one location to another. The same information can be put on a pie chart if the manager chooses to compare different stores with their sales

The program put together information that the company provides, and helps the manager take more precise decisions. An interractive map shows more accurate information and determines the process of decision making using a geographical location.

Decision change from region to region because of different factors, one the most important being the demography. Being able to display this factor, the answer to a low sale in a certain (diffrent) region becomes more clear. Displaying the factors that have a direct impact on the evolutions of the sales such as demography and competition the manager can modify the strategy of implement new ideas.

4. TRACING THE SALES

A manager decides to trace the activity of the company (that produces 3 products) at national level. From the database that is integrated in their own information system he will extract data concerning the sales on an established period of time (a day, a week, a month). These data will be constituted in a file named “vanzari.dbf”. A simple click on the surface of the city will list the corresponding attributes.

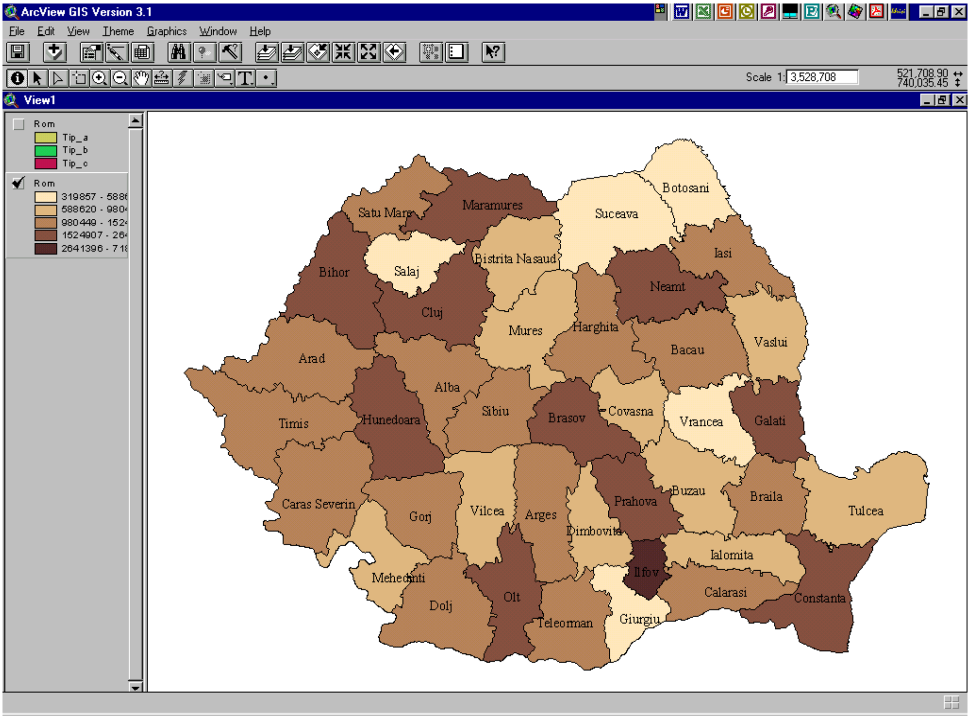


Fig. 2. *Romanian county classification by product sales*

A more complex operation is the classification of the polygons after a specified field A representation on the Romania map with the cities classified after products’ sales The result achieved on the screen can be seen in Fig. 2. The lighter the color gets the smaller the sales become. Seeing all products sales on a map helps the manager identify the regions (locations) where sales are above average, and the zones where the sales of the same product diminish. This piece of information is very relevant because the regions with sales under the average could be studied, a new approach of the product could be implemented.

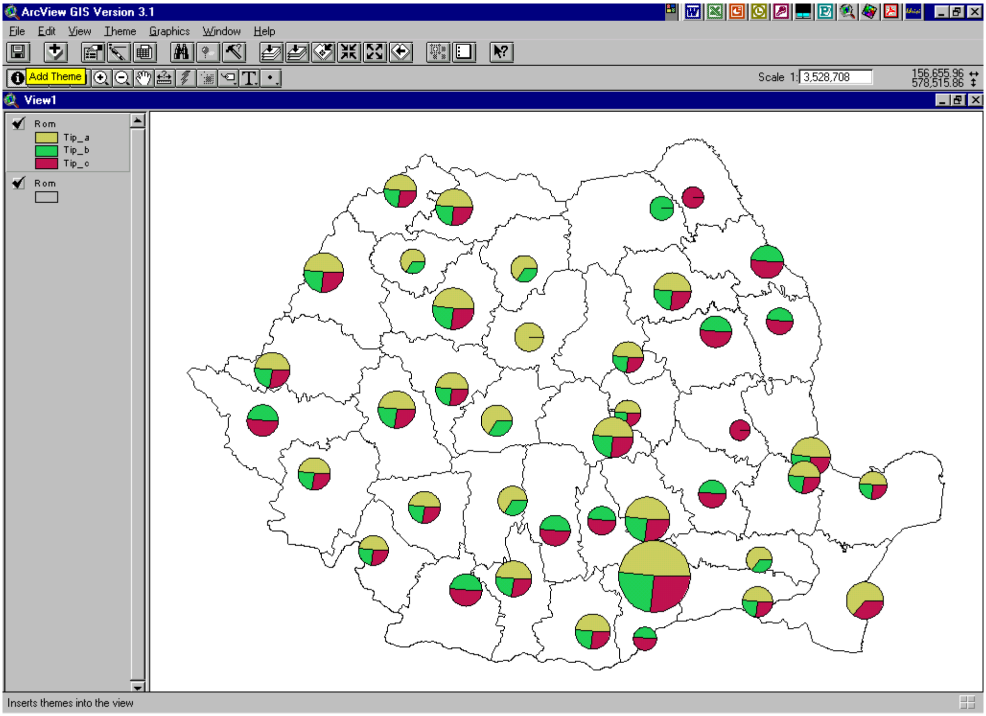


Fig. 3. *Distribution of multiple products from a company*

We specify that the additional table may contain useful data such as stock products or incomes of the company. All these can be visualized on the map (Fig. 3). Fig. 3 shows the distribution of 3 products from the same company. The manager could easily see how the 3 products are sold in different cities. Optional we could display the city names. It can also be displayed various themes simultaneously but this could lead to a difficult legibility of the map. New strategy and research could be done where sales of certain products are very low.

5. CHOOSING THE PROMOTION LOCATION

The strategy of marketing has its key point the client. In business- to- customer marketing and in business- to- business marketing, the understanding of the demographic factor is crucial to understanding the client. The demographic variables like age, income, sex or the numbers of a family are correlated to the products demand in business- to- customer marketing. On the other hand, business- to- business marketing variables like the size of the company, the type of the company, and the profit of the company depend on the demand of the products and services the company needs to sell. With the help of this data the marketing specialists can anticipate and understand the consumer’s needs and so they can personalize their own strategies for certain market segments. GIS becomes an intensification source of satisfaction and a competitive advantage.

In the marketing mix, the promoting strategies refer to all instruments methods and processes through which a firm informs the client about a product or a service. The demography is the element with the greatest influence when it comes to promoting strategies. In any situation connected to the promoting strategy like the direct encounter between the sales representative and client, the understanding of the demographic element is essential to the success of this strategy.

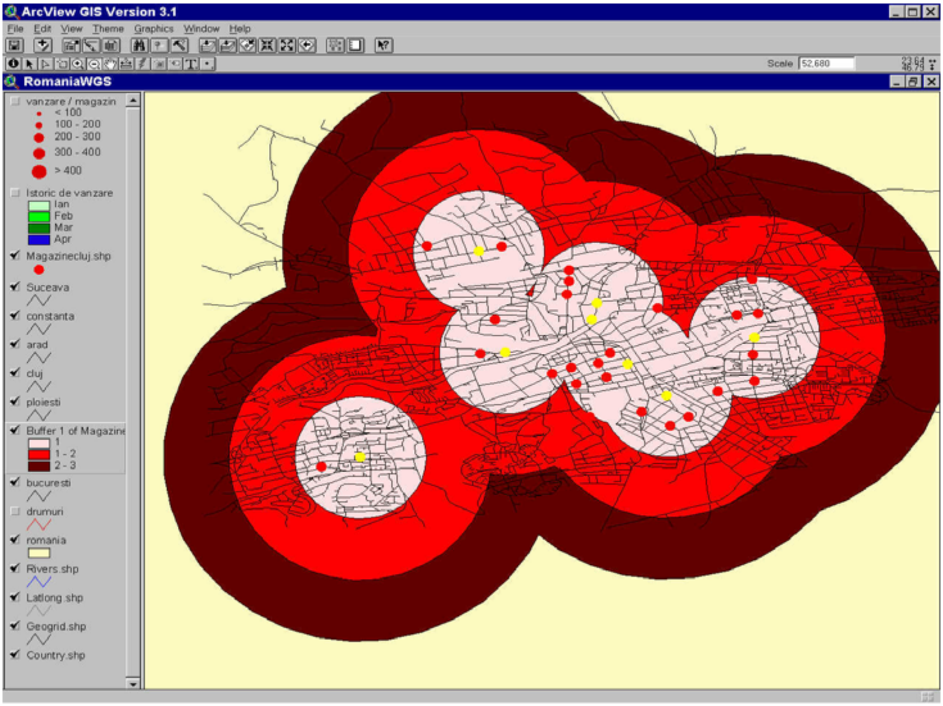


Fig. 4. *Division of market areas by client potential*

In direct sales, the sales representative uses GIS to create a map of the market, dividing it in primary, secondary and tertiary target markets. These are represented with different colors on the map. For the beginning we choose locations for promoting. We observe that through the application of specific functions in GIS called buffers the manager realizes that the primary zone is not compact (Fig. 4). As consequence, the manager decides to change the location so that a whole primary zone is covered. The primary market becomes compact and can be controlled easier (Fig. 5). In this situation the manager expects more clients to visit those locations.

6. CONCLUSIONS

GIS offers a new approach of the market. This represents an advantage for the great companies in what concerns different activities from the marketing mix such as the optimal choice of the location for promoting. Being a complex system, GIS offers another perspective and a different approach for a company situated in a market with continuous fluctuations. It helps in taking the best decisions and the most appropriate decisions, saving time and money, offering a better control on the market in what concerns the clients and the competition.

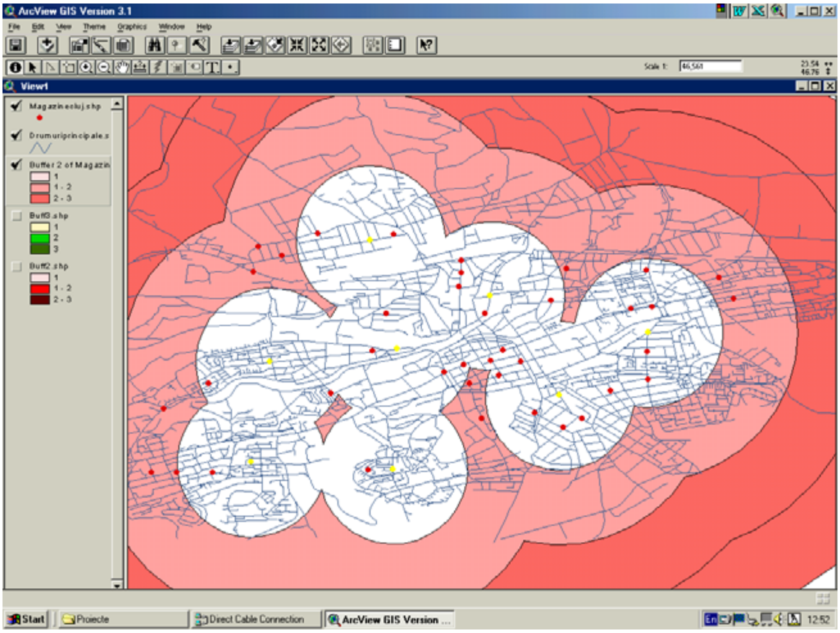


Fig. 5. *Division of market areas by client potential*

REFERENCES

Birkin M., Clarke G.P., Clarke M., Wilson A.G. (1996) – *Intelligent GIS*, Cambridge (UK) Geoinformational International.

Birkin M., Clarke G.P, Clarke M. (1999) – *GIS for business and planning, in Geographical Information Systems, vol. 2*, Eds. P.A. Longley, M.F. Goodchild, D.J. Maguire, D.W. Rhind, John Willey&sons, New York.

Grimshaw D.J. (1994) – *Bringing Geographical Information Systems into Business,* Cambridge (UK) Geoinformational International.

Imbroane Al., Bucur L., (2007), *Database management systems for spatial data structures – an overview*, Geographia Technica no.1, ISSN 1842-5135, Cluj Univerity Press;

Openshaw S. (1995) – *Marketing Spatial Analysis*, in GIS for Business and service Planning, Eds. P. Longley, G. Clarke, Cambridge (UK) Geoinformational International.

Scott-Morton M.S. (1967) – *Decision Support System: An Organizational Perspective*, Addison,-Wesley, Reading, Mass.

***, (1996) – *ArcView GIS*, ESRI user manual.

STUDY ON SOIL EROSION IN THE UPPER MUREŞ BASIN

Zs. Magyari-Sáska[1], I. Haidu[1]

ABSTRACT
The soil erosion process produces harmful effect in a relative short time and the repairing time is much longer. One of the most frequent used method in soil erosion evaluation is USLE. In our study we developed a methodology to calculate and estimate soil loss in the Upper Mureş Basin. Part of this methodology was implemented as a software based on IDRISI Andes Edition, R System and Borland Delphi. Based on this software several studies were made. As a result we could appreciate that the North part and the eastern downhill of the Giurgeu basin are the most vulnerable areas, and the surroundings of several establishments in the Mureş Defile (Stânceni, Lunca Bradului). We also found that orchards are more exposed to soil loss, and after than the mixed agricultural zone, with a much higher standard deviation for the last category.
Keywords: soil erosion, application, RUSLE, Mures Basin

*

1. INTRODUCTION

Soil is an important resource especially for nutrition and woodland husbandry but also for maintaining biological and ecological equilibrium. The soil erosion process produces harmful effect in a relative short time and the repairing time is much longer. Thus it's important to identify the vulnerable areas and take protective measures.
Different meteorological phenomena (wind, rain, freeze-melting processes) have their importance in soil erosion. In this study we present soil erosion due to rainfalls.
There are several methods for estimating soil erosion due to rainfalls (WEPP, PISA, SHETRAN, USLE, etc.). Some of them studies erosion in flow channels while others on the entire surface.

One of the most frequent used method is USLE or its' variants. The original equation for determining soil loss quantity is based on the initiative of Hugh Hammond Bennett in 1929, asking founding from the USA Congress to start researches on soil erosion. The database developed by Bennett was completed and used by Wischmeier, to develop the USLE (Universal Soil Loss Equation) model.

Latter models were developed on this equation: RUSLE, MUSLE and USLE-M. RUSLE is a revised variant of the initial model, correcting some data values in the database, but also changing some methodological aspects. In MUSLE model, the raindrops energy was replaced with de flow energy, permitting the soil erosion study in hydrological basins. USLE-M is a recent development based on USLE, permitting short range time scale study of erosion (ex. for a single heavy rainfall).

In our study we want to develop a methodology to calculate and estimate soil loss in the Upper Mureş Basin, which is the hydrological basin of Mureş form its' rise to Deda.

[1] "Babes-Bolyai" University of Cluj-Napoca, Romania

2. THE USED MODEL

In the original form the soil loss equation has the following format:

$$A = R \cdot K \cdot LS \cdot C \cdot P$$

where A represents the lost soil quantity, R the rainfall erosivity factor, based on rain intensity, K the soil erodability, LS the topographic factor, C the vegetation factor and P the soil protection factor.

The most problematic factor is determining rainfall erosivity, because in Romania rainfall intensity is not recorded in for every 15, 30 minutes, as it's necessary in calculus. Thus different methods are developed to determine R factor in another way. The most convenient method is to calibrate mean annual precipitation for the studied region (Patriche, 2007). The "a" parameter varies from 0.5 to 0.2 (Roose, 1992) in Africa. Van der Knijf (1999) uses 1.3 value for Italy.

$$R = a \cdot \overline{P}$$

The calculation of topographic factor (LS) with its' two components slope length (L) and slope value (S) raised intensive debates. By definition slope length represents the path length of particles until the sedimentation or until they enters in a flow channel. In GIS the maximum flow path is calculated based on upslope area (A_s). In this study the Moore (1993) formulae was used, but localized for Romania with the exponent value of 0.3 (Patriche based on Moțoc, 2007)

$$L = 1.4 \cdot \left(\frac{A_s}{22.13} \right)^{0.3}$$

The slope value calculation has different forms in USLE and RUSLE. In this research The formulae of Moore was used which proved their suitability in Călimani Mountains (Patriche, 2007), where θ represent the slop value in degrees.

$$S = \left(\frac{\sin \Theta}{0.0896} \right)^{1.3}$$

The other two factors: soil erodability (K) and vegetation factor (C) can be determined based on nomenclatures. The soil protection factor (P) is not present in our study, as no specific protections are used in the studied area. This omission can be done with no problem as the three components (R, L and S) represent the potential erosion, while the other three (K, C and P) can have values in the [0,1] interval. The product of them represents a factor which can reduce the potential erosion. Omitting the P factor, in fact it is considered having the value of 1, representing that no protection measures are have been taken.

3. THE DEVELOPED APPLICATION

Based on the well formulated methodology some software has appeared to determine soil loss quantity. Some of them are applications (RUSLE, RUSLE2), while others can be used in on-line mode (http://www.iwr.msu.edu/rusle). These software pieces are especially based on the USA database, thus unusable for other regions. IDRISI software also contains a RUSLE module but the localization of its calculus cannot be done, and the R factor image should be provided.

For this study a new application was developed based on IDRISI Andes Edition, Borland Delphi and the R statistical system, which offers the possibility to enter the calibrated "a" value for R factor. The annual precipitation values are cumulated from National Climatic Data Center. Towards on calculating the soil loss quantity for different years, the application also can calculate the estimated soil loss for a given year based on annual precipitation tendencies.

The key element in R factor calculus is the annual precipitation value. After evaluating several interpolation methods (IDW, Kriging, Spline and multiple regressions) the last one proved to be the best. The suitability evaluation was based on successively eliminating points from the map, and calculating the mean RMS error.

In the multiple regression method the presumption was made, that the 4 most important factors determining precipitation amount could be the geographical position, altitude and aspect. The aspect value was calculated from the DEM. Due to the fact that these values represent a discontinuous space for north direction (0-22.5 and 337.5-360 using 8 cardinal directions), the aspect value range was transformed in the following manner:

- if the aspect value was between 0-22.5, it's new value become 360+old value
- from every aspect value (including the resulted ones) was subtracted 22.5, the final values being between 0-360

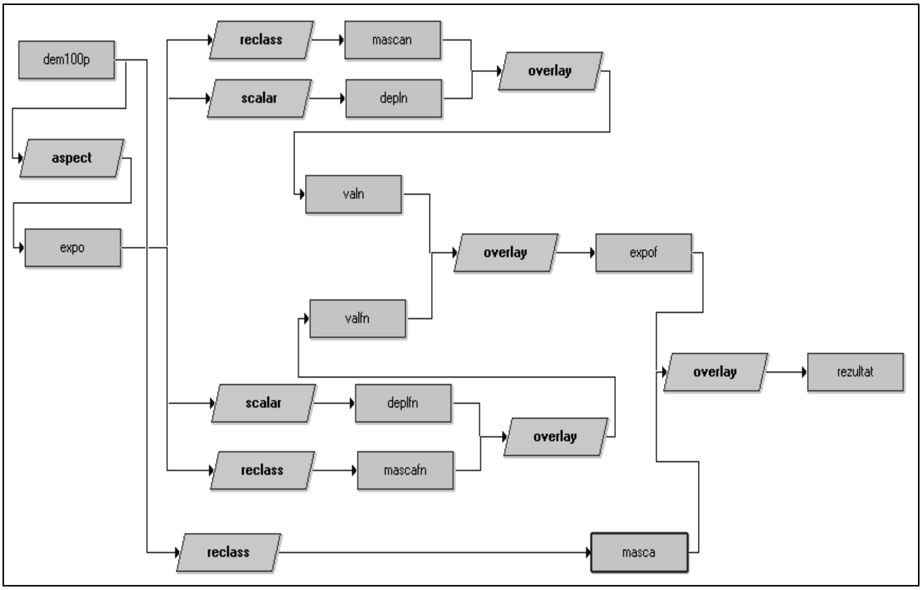


Fig. 1. *Aspect transformation algorithm in IDRISI*

For testing the multiple linear regression model (MLR) the starting model was a modified version of an existing model proposed by Naoum and Tsanis (2003) in which the 4 above mentioned factor is present

$$P = a_1 \cdot px + a_2 \cdot py + a_3 \cdot h + a_4 \cdot ex + a_5 \cdot px^2 + a_6 \cdot py^2 + a_7 \cdot h^2 + a_8 \cdot ex^2 + \\ + a_9 \cdot px \cdot py + a_{10} \cdot px \cdot h + a_{11} \cdot py \cdot h + a_{12}$$

where

P	– precipitation value
a_1 .. a_{12}	– coefficients
px	– x position (Stereo70 – Romanian national system)
py	– y position (Stereo70 – Romanian national system)
h	– altitude
ex	– transformed aspect value

Using the R software a stepwise regression was made in backward direction. The stepwise regression is based on successive term elimination to minimize the overall AIC value.

If for the chosen year there are values in NCDC database these values are used, if not the predicted value is calculated based on annual time series trend. The significance of the trend is also indicated in the developed system.

The software also permits manually introducing precipitation values for measuring points.

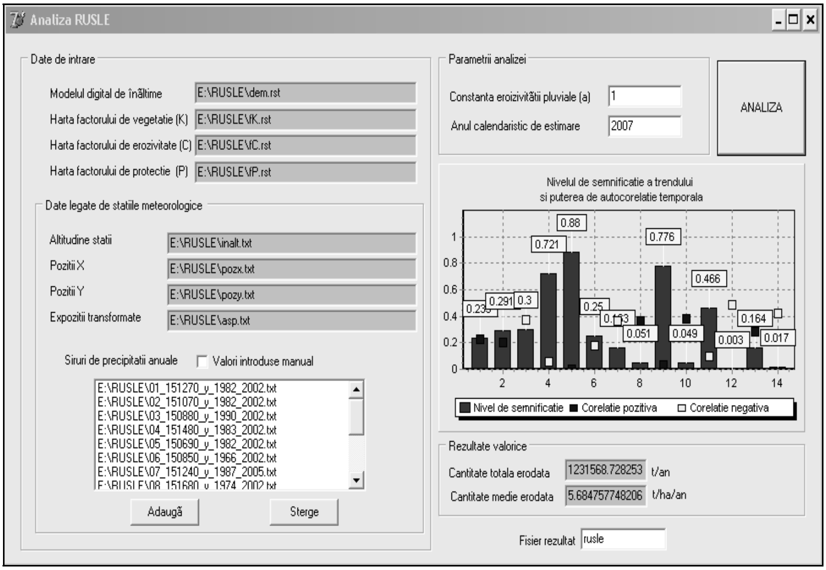


Fig. 2. *The developed application's interface*

4. RESULTS AND CONCLUSIONS

With the developed software several analysis were made. First of all the actual mean soil erosion map was created, based the multiannual mean precipitation value.

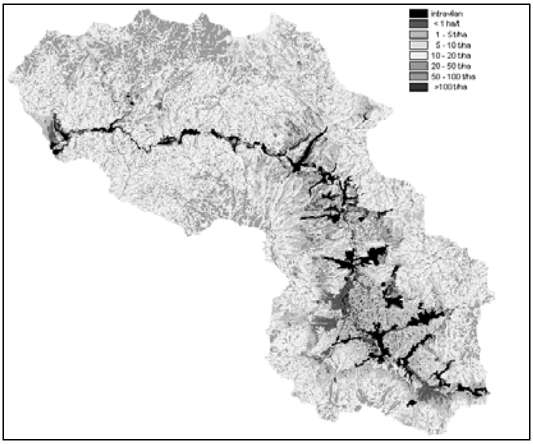


Fig. 3. *Mean soil erosion map*

From the resulted image we could appreciate that the North part and the eastern downhill of the Giurgeu basin are the most vulnerable areas, and the surroundings of several establishments in the Mureş gullet (Stânceni, Lunca Bradului).

To determine the most vulnerable land cover types, based on multiannual rainfall values the Corine Land Cover 2000 database was used to reclassify and summarize the values.

Table 1. *Soil losses for different land cover types*

NO.	LAND COVER TYPE	MEAN SOIL LOSS QUANTITY (T/HA/YEAR)	SOIL LOSS STANDARD DEVIATION (T/HA/YEAR)
1	Tillage	4.9	7.6
2	Orchard	20.4	23.5
3	Pasture	3.2	5.4
4	Mixed agricultural	12.5	20.1
5	Forest	5.1	4.6
6	Bush	4.1	3.7

From table 1 we could appreciate that orchards are more exposed to soil loss, and after than the mixed agricultural zone. The other land cover types, including tillage, pasture and forest have an acceptable mean soil erosion value. But if we consider the standard deviation values, their relative high values indicates, that there are locations in which these values can have also a more significant values. Just forest and bush have a standard deviation below the mean value, representing that these types are most homogenous relative to soil erosion. Considering in percent relative to the mean value the highest standard deviation value appear at mixed agricultural zones, which can also have soil loss over 12t/ha/year.

Table 2. *Mean soil loss for different years for the Upper Mureş Basin*

YEAR	MEAN QUANTITY (T/HA)	YEAR	MEAN QUANTITY (T/HA)	YEAR	MEAN QUANTITY (T/HA)
1990	7.11	2000	3.41	2010	5.46
1991	3.24	2001	2.30	2015	5.65
1992	6.31	2002	4.46	2017	5.80
1993	8.50	2003	6.17	2020	6.07
1994	14.09	2004	5.63	2050	9.49
1995	5.97	2005	5.59		
1996	8.09	2006	5.60		
1997	12.77	2007	5.68		
1998	5.49	2008	5.61		
1999	3.63	2009	5.53		

In further analysis the mean annual soil erosion quantity was calculated based on every year's rainfall value. The estimation of soil loss based on rainfall tendency was also made for a 50 years period. Even if is no clear tendency in the rainfall time series, the frequency analysis methodology couldn't be applied as mean values are used and not extreme values. It should be mentioned that for all calculus the "a" parameter values was 1.

The resulted values form table 2 is not alarming as the soil regeneration value is 3-5t/ha/year, and the dislocated soil particles can be deposited in other parts if they do not enter in a flow channel.

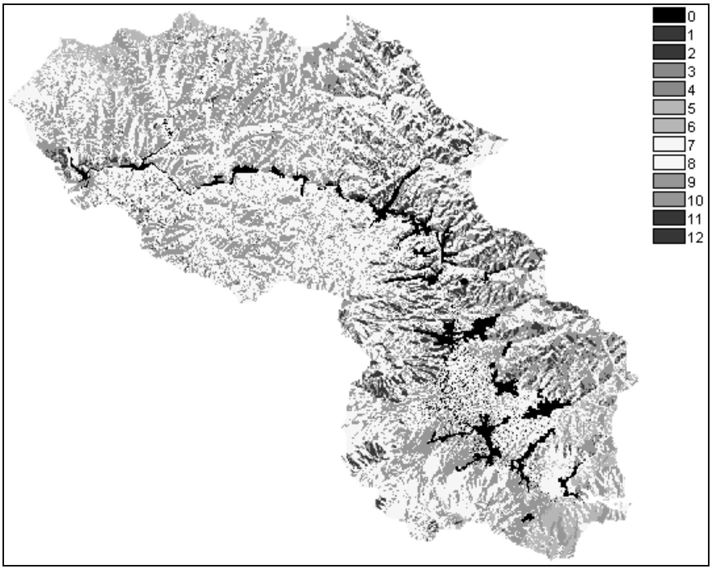


Fig. 4. *Successive soil stress categories (years)*

Due to the fact that we do not have a detailed database on time scale for vegetation changes, the estimations for the future could not be very concluding. But for determining the most vulnerable areas based on rainfall values we could use another method. We could appreciate those areas which suffers intensive or rising soil loss for successive years.

Thus for every successive year form 1990 to 2006 were determined those regions in which soil loss quantity had a rising value, and the summary of these maps were calculated. Even if in this analysis small but rising differences can have higher values than several important risings in other areas, values over 10 in this map represents areas in which the soil suffers continuously rising stress due to erosion.

The cumulated soil loss for the above mentioned period was also determined. Comparing the soil erosion stress map with the multiannual soil erosion map no significant changes could be observed.

The development of such analysis software is valid for the following reasons:

- it's developed for Romania and can be adjusted for the different concrete situations.
- contains the power of two analysis systems (GIS and statistics), offering a uniform user interface and realizing the data interchange between different systems
- speeds up the analysis process, incorporating in one button click more the 70 elementary operations which shouldn't executed manually.

REFERENCES

Moore I.D., Turner A.K., Wilson J.P., Jenson S.K., Band L.E. (1993), *GIS and land-surface-subsurface process modeling.* Enviromental modeling with GIS

Moţoc M., Munteanu S., Băloiu V., Stănescu P., Mihai Gh. (1975), *Eroziunea solului şi metode de combatere,* Editura Ceres, Bucureşti

Patriche C.V., Căpăţână V., Stoica D.L. (2006), *Aspects Regarding Soil Erosion Spatial Modeling Using the USLE /RUSLE within GIS,* Geographia Technica, 2006-2, Cluj University Press, Cluj-Napoca

Stângă I.C., Minea I. (2005), *Vulnerabilitatea la eroziune a unor soluri zonale din Carpaţii Orientali,* Riscuri şi catastrofe, Casa Cărţii de Ştiinţă, Cluj-Napoca

Stone R.P., Hilborn D. (2002), *The Universal Soil Loss Equation (USLE),* Ontario, Canada: Ontario Ministry of Agriculture and Food (OMAFRA).

Van der Knijff, J.M., Jones, R.J.A., Montanarella, L. (1999). *Soil erosion risk assessment in Italy.* European Soil Bureau. EUR 19044 EN

***, *Revised Univrsal Soil Loss Equation, Version 2* http://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm

***, RUSLE – an online soil erosion assessment tool, http://www.iwr.msu.edu/rusle/about.htm

***, The Soil Erosion Website (2004), http://soilerosion.net

PRECIPITATIONS ANALYSIS IN THE NORTH-WEST OF ALGERIA – IMPACT ON THE CEREAL YIELDS

M. Meddi[1], K. Ketrouci[2] et A. Matari[3]

ABSTRACT
We studied the variability of pluviometry in the North West of Algeria. We noticed a fall of the precipitated volumes from decade 80. This decrease is due mainly to the fall of the winter pluviometry. Also, we found a direct relation between the pluviometry and the cereal farming production.
Keywords: precipitation, Algeria, pluviometry, cereal yields

*

1. INTRODUCTION

Algeria and especially the West, knew a several drought periods during this century, the Forties and the Eighties until our days (Matari et al., 1999; Meddi et al. 2000; Meddi et al. 2002; Meddi et al., 2003). Accordingly, we will propose to study the variability of pluviometry and the relation between the latter and the durum wheat outputs in the Algerian North-West.

2. GEOGRAPHICAL SITUATION

The studied zone is located in the West of Algeria (Fig. 1). It includes the basins of Tafna, Macta, basin of the Oran coastal and a part of the Chelif basin. We have selected 23 precipitation stations (observation from 1968 to 1998), Table 1 .

3. PRECIPITATIONS ANALYSIS

Regionalisation

The regionalization study aim is to obtain homogeneous zones inside studied area. Regionalization consists to search the stations which present a similar behavior. With this intention, the A.C.P with Varimax rotation was used. Total information is better distributed between the three principal components. The first component explains 32.5% of the variance. It reveals a homogeneous district covering the North-East of the studied. The second component explains 22.1% of the variance. It highlights a second region, parallel to the first zone starting from Ain Temouchent. The Ghazaout station is the best represented since it has greatest saturation. As for the third component which explains more than 23% of the variance, it represents the stations located at the East of the area. These various results give the possibility to divide our area into three sectors (Fig. 1).

[1] LRERP – Khemis Miliana University – ALGERIA
[2] Mascara University – Algeria
[3] HFR – ORAN - Algeria

Table 1 *Precipitation stations*

Stations	Altitude (m)	Stations	Altitude (m)
Sebdou	925	Sougeur	1120
Saida	804	Mostaganem	141.3
Ferme blanche	20	Ghazaout	80
Fergouge	97	Bakhada barrage	606
Cheurfas	260	Frenda	1035
Oued sarno	431	Oran sania	95
Mascara	600	Ain Temouchent	325
Bouhanifia barrage	295	Hammam bouhdjar	150
Sidi belabbes	486	Relizanne	80

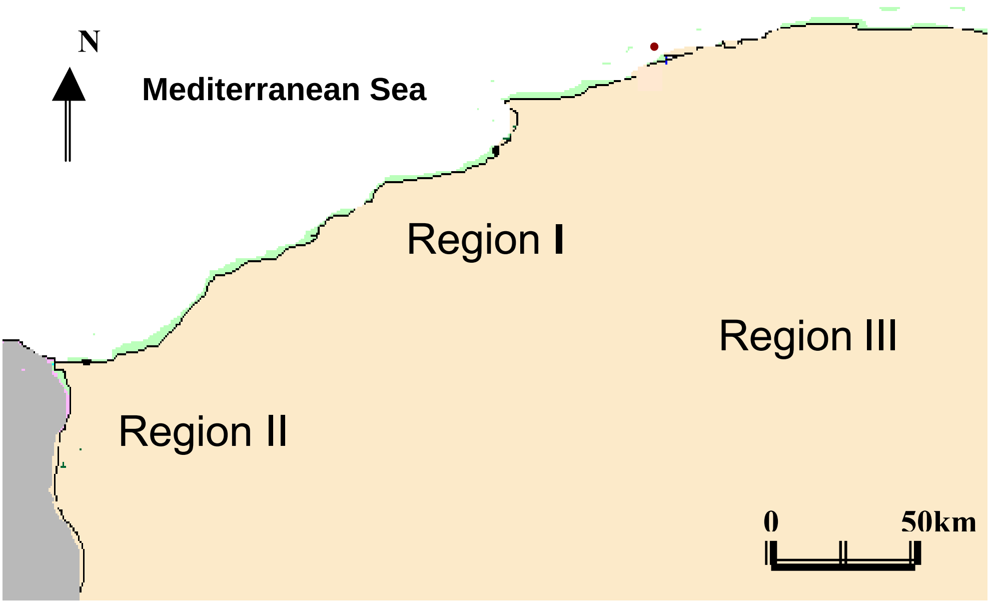


Fig. 1: *Cartography of the three principal components with Varimax rotation.*

Annual precipitation variability

To study the annual variability, we centered our work on three stations which are regarded as standard station; each one described a homogeneous zone (Mascara, Maghnia and Sougeur). These three stations have 48 years of observations (1950-1998).

The ratio between the wettest year and the driest year can be higher than 4 (Tabl. 2); the coefficient of variation represents this variability well and can exceed the 30%. For more detailed analysis, we will characterize the annual variability by the reduced centered variables of the annual rainfall of the three stations. One notices the agreement of the deficits years of the three stations. The pluviometric surpluses correspond to the year 1973-1974 for the Maghnia station, the year 1969-1970 for Sougeur station and 1962-1963 for Mascara station. The maximum deficit over the 48 years of observations corresponds to years 1987/88, 1983/84 and 1981/82 at the stations of Maghnia, Sougueur and Mascara respectively. This analysis confirms the appearance and the persistence of drought during two last decades (Meddi et al., 2000; Meddi et al., 2002; Meddi et al., 2003).

Table 2. *Annual precipitations Analyses on Mascara, Sougeur and Maghnia stations (studied period 1950-1998)*

Station	Maximum	Minimum	Standard deviation	Average	Medium	Coefficient of variation
Sougeur	612.4	140.4	103.4	344.1	337.7	30%
Maghnia	747.7	189.4	135.8	389.3	372.9	34.9%
Mascara	786.02	196.5	134.4	444.6	440.1	30.2%

Monthly variability

We study now the monthly precipitations variability. Indeed, we ask if the reduce of the rainfall is due to a given season, or it concerns all the months. A water deficit will not have the same consequences on agriculture, particularly the cereal yield, according to whether it intervenes at the beginning of the campaign or during the phase of fruit reproduction.

To know if there is a possible relation between the changes in the pluviometric regime of the last decades and the pluviometry reduce of a specific month, we will compare two successive periods of twenty four years: 1950-1951 to 19 73-1974 and 1974-1975 to 1997-1998. The choice of these two periods was made according to the available data. Two statistical parameters were used to carry out this comparison, the average and the median. These two parameters of central tendency are not statistically different in the case of symmetrical distributions. But as several work in this way shows that the monthly distributions are dissymmetrical (Bouacheria, 2000), it appeared judicious for us to consider them both.

The monthly precipitations analysis of the three studied stations shows that the extent of the pluviometry variation is very clear between the two above mentioned periods. The three stations represent a more abundant pluviometry over the first period than the second. This reaffirms the obtained results in previous studies. For the Maghnia station, January and December, as well on the averages as on the medians became less rainy over the second period. On the other hand February became rainier for the second period. For the remaining we noticed a good agreement over the two periods especially April and summer's months. The station of Mascara represents almost the same behavior as

Maghnia, in other words, the pluviometry of January and December became less abundant over the second period. On the other hand, March became most rainy during the two last decades for this station. For the Sougeur station, the difference between the two periods is not clear, but we can also say that January and December represents the rainy months for the first period, and February for the second period.

4. RELATION BETWEEN THE YIELD AND PRECIPITATIONS

The Algerian cereals cultivation whose production varies between 10 and 30 million quintals (Hzmoune.T et al. 2001) seems to be the most vulnerable field, because it is practised on great extents without irrigation. The wheat, basic food of the major part of the Algerian population seems to suffer the greatest damage of the pluviometric deficit of the last decades. It is largely cultivated in Algeria, approximately a million hectares is hallowed to that crops. The principal and direct consequence of the pluviometry reduce is the reduction in the productivity. In dry Mediterranean zone, the water deficit intervenes with more than 50% in the reduction in the outputs. To this end, the analysis of the effect of two last decades in the pluviometric deficit on the wheat outputs will be carried out. The series of output representative of the studied area are those of Mascara (region I), Sidi Bel Abbess and Tlemcen (region II), SAIDA (region III).

Seasonal rainfall

Fig. 2 represents the evolution of the totals seasonal pluviometry of winter and spring and the wheat yields, for the four studied regions. The figures do not make it possible to show a possible relation between rains and output. These results can be influenced by the data of outputs (quality of data), or the yields are not explained only by pluviometry of one season. The total pluviometric taken into account is from September to May. By studying this relation, we noted that there is relation between these two parameters for the four regions. Therefore, the results of this analysis confirm the fall of yields observed by the specialists these last years. For the four studied areas, the points representing the relation output-rain shows that the yields vary in an increasing way with pluviometry.

5. RELATION BETWEEN THE YIELD AND TEMPERATURE

The temperature plays a very important role in the life of the plants; a very significant rise of the temperatures accelerates the evapotranspiration and is generally accompanied by a lack of water, for that, it appeared very interesting to us to study its variation. Due to the lack of data over a long period on the studied zone, the data of only one station were analyzed. The station of Oran Essenia has a long series of measurement (1956-1996).

The chronological representation of the minimal and maximal temperature average over the period (1956-1996), shows the two periods presenting an upward trend. First was observed before the end of decade 50 and the second during the two last decades. Over these two periods, pluviometry was generally weak and lower than the normal.

Poor yield observed these last years is in connection with the downward trend of pluviometry and the upward trend of the temperature. Augmentation in temperature accelerates evapotranspiration, which represent the quantity of consumed water which includes on the one hand the water perspired by the plant, on the other hand a direct evaporation from ground.

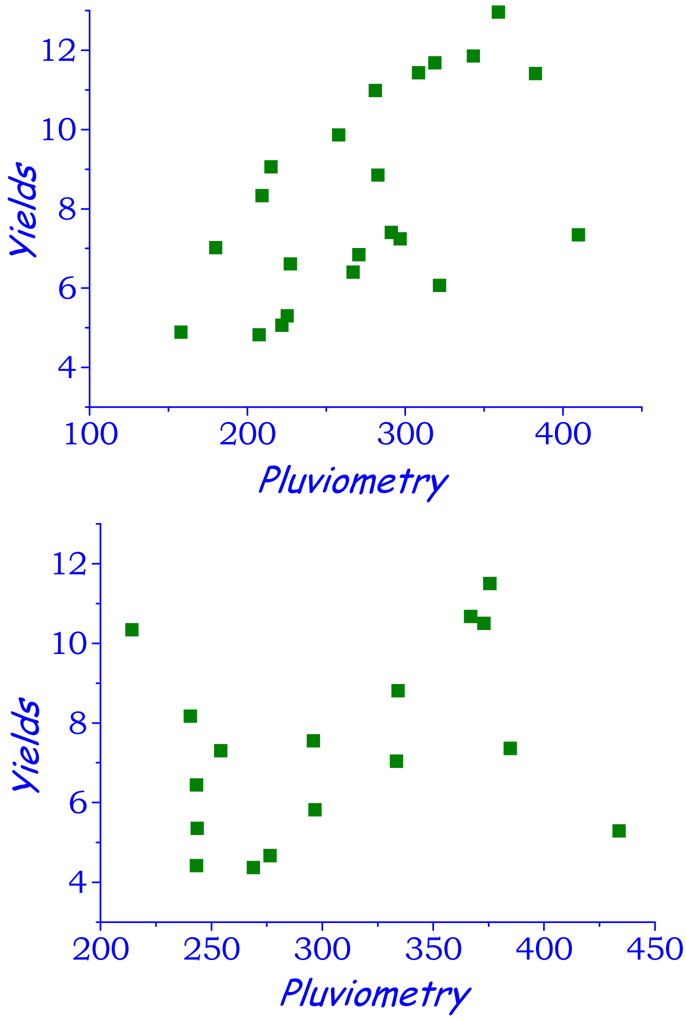


Fig. 2: *Illustration yields and precipitation relation for Sidi Bel Abess and Saida regions*

6. CONCLUSION

The study of the variability of precipitations starting from the reduced centered variables of the annual pluviometry was made on three representative stations (Mascara, Maghnia and Sougeur). This analysis highlighted the succession of two phases, a long rainy episode which covers the years of the fifties until the end of seventies, and in deficit episode, which would have started at the beginning of the Eighties and which persists until our days.

The relation yield-rain confirms the fall of the outputs and shows the existing relationship between precipitation and outputs.

REFERENCES

Bouacheria N. (2000), *Etat de la pluviométrie en période de sécheresse sur quelques stations d'Algérie.* mémoire d'ingéniorat, I.H.F.R, Algérie.

Hazmoune T., Benlaribi M. (2001), *Impact du semis profond sur l'alimentation en eau du blé dur et réalisation des composantes de rendement en zone semi aride.* Séminaire national sur la problématique de l'agriculture des zones arides et de la reconversion, Sidi Bel Abess , 22-24 janvier 2001, pp98,104.

Matari A., Kerrouche M., Bousid H., Douguedroit A., (1999), *Sécheresse dans l'ouest algérien* . Publications de l'association internationale de climatologie , volume 12.

Meddi M., Humbert J (2000), *Variabilité pluviométrique dans l'ouest Algérien durant les cinq dernières décennies.* 13ème colloque de l'Association Internationale de climatologie. 6 au septembre 2000 Nice, France.

Meddi M., Humbert P., Bendjoudi H. (2002), *Evolution du régime pluviométrique du Nord-Ouest de l'Algérie. L'eau dans le bassin méditerranéen.* Ressources et développement durable Monastir, Tunisie, 10-12 octobre 2002.

Meddi M., Humbert P., Bendjoudi H. (2002), *Impact du changement du régime pluviométrique sur les ressources en eau dans le Nord-Ouest de l'Algérie.* Hydrologie des régions méditerranéennes et semi-arides, 1-4 avril 2002, Montpellier, France.

GIS CERTIFICATION: THE AMERICAN EXPERIENCE

M.D. Mihailescu[1]

ABSTRACT
Incontournable pour la définition d'une profession, le processus de certification et les procédures utilisées son souvent débattues passionnément. La certification *SIG* (Systèmes d'informations géographiques) ne fait pas exception à la règle. Afin de définir la profession de ceux qui sont impliqués dans les *SIG*s, plusieurs organisations et associations des Etats Unis ont fait des pas importants dans la direction de la certification *SIG*. Par conséquent, un institut américain indépendant (GIS Certification Institute) a été fondé en 2004. Le but de cet article est de présenter plusieurs aspects liés à la certification *SIG*, tels qu'ils ressortent de l'expérience américaine, afin de les proposer éventuellement comme mode d'action pour d'autres communautés *SIG*. La discussion porte sur les pour et contre d'une telle approche, ainsi que sur les procédures concrètes de certification des professionnels *SIG* par le GISCI.
Keywords : GIS, certification, USA, procedures

*

1. INTRODUCTION

In one of his books on geographic information systems (*GIS)*, Roger Tomlinson wrote that "*a real-world GIS is actually a complex system of interrelated parts, and at the center of this system is a smart person who understands the whole*" (Tomlinson, 2003). The question is how do we identify that person? A quick answer leads us to appeal to *GIS* professionals (*GISP*), that is persons working in *GIS* domain and already certified for their results.

This paper is about these *GISP*s and their certification procedure as resulted from the American experience. Several universities, organizations and associations from USA have made significant steps towards a consistent and viable *GIS* certification procedure, at length founding an independent *GIS* Certification Institute (*GISCI*). Pros and cons on this subject, as well as actual American certification procedures for *GISP*s in terms of *GISCI* are further presented, as an eventual option for other *GIS* communities.

2. ABOUT GIS CERTIFICATION

Certification process and procedures are often hotly debated, and *GIS* certification is no exception. The most frequent questions on the subject denote a poor understanding of the concept. *GIS* certification is often taken for *accreditation*, *qualification* or *licensing*, therefore several clarifications should be provided from the very beginning.

According to the Technical Report 19122, issued by the International Organization for Standardization (ISO, 2004), *GIS* certification is "*a procedure leading to a written testimony of the qualification of an individual's professional competence provided by a range of public, private and professional institutions*". More specific, *GISCI* states that "*certification is a process, often voluntary, by which individuals who have demonstrated a level of expertise in the profession are identified by a third party.*" (GISCI, 2008).

---

[1] *S.c. ARCHDESIGN s.r.l., Cluj-Napoca, Romania*

In short, *GIS* certification offers third party recognition of one's already proven contributions in *GIS* domain. It does neither review an institution (like *accreditation*), nor the graduation of formal university courses (like *qualification*). It does not conform to governmental legislation (like *licensing*). Unquestionable, *GIS* certification is still a debatable subject, far from being standardized or universally agreed upon.

Although the previous definitions are of recent date, the *GIS* certification issue was first debated in USA decades ago. Nancy Obermeyer first wrote about the potential for certification in the *GIS* field (Obermeyer, 1993). In 1997, the Urban and Regional Information Systems Association (*URISA*) from USA created a certification committee to look into the feasibility of creating a certification program. In 2001, this committee developed the present method for certification. In 2004, *GISCI* was founded, being supported by the University Consortium for Geographic Information Science (*UCGIS*), the Association of American Geographers (*AAG*) and the National States Geographic Information Councils (*NSGIC*), all members in *GISCI* board.

In fact, *GIS* certification is constantly in the attention of the American *GIS* specialists, in view of eventually defining a *GIS* profession (Wayne, 2007). According to the definition supplied by D.L.Pugh and cited by Wayne, a "profession" has the following attributes:

- mission
- common language
- specialized training
- culture and lore
- specialized body of knowledge
- formal organizational
- code of ethics
- certification.

Since its foundation, *GISCI* has been undertaking the last three requirements (see sub-chapter 4), while *UCGIS* has already edited the first version of the "Geographic Information Science & Technology Body of Knowledge" (see sub-chapter 5).

Still, according to the official site of the U.S. Department of Labor, no *GIS* profession is listed in the Standard Occupational Classification (*SOC*)! *GIS* "specialists", "analysts", "technicians", "managers" are all titles of possible jobs in listed occupations, such as "Drafters, Engineering Technicians and Mapping Technicians" *SOC* code 17–3000 (U.S. Dept. of Labor, 2008).

The importance of a *GIS* profession definition is also taken into account in the already mentioned *ISO* document, the Technical Report 19122:2004. This document underlines the need to define the boundaries between *GIS* and other related professions, as well as to specify technologies and tasks pertaining to *GIS*.

3. GIS CERTIFICATION: PROS AND CONS

There is a lot of support in favor of *GIS* certification (Harvey, 2003; Huxhold, 2003; Kemp, 2005).

As first proponent of *GIS* certification, *GISCI* outlines the following advantages with respect to this subject:

- the primary beneficiary of professional certification is the public: people deserve assurance that competent and ethical *GIS* professionals are being hired in budget paid jobs
- certification encourages long-term professional development that will help existing professionals maintain currency in *GIS* technology and methods
- Certification ensures ethical behavior by members of the profession and provides a basis for judging the validity of allegations or complaints against *GIS* practitioners.
- assist prospective employers to assess and hire *GIS* professionals (lower risk)
- ensure that those who produce geographic information have a core competency of knowledge;
- assist aspiring *GIS* professionals and professionals outside the *GIS* profession choose their educational opportunities wisely
- Contribute to the development of geographic information science.

Still a lot of questions arise with respect to *GIS* certification, mostly about the utility of such a procedure, the authority of the certification institution, the certification procedure, etc..

The main critics, usually expressed by young *GIS* specialists on *GIS* forums, are related to the portfolio-based certification procedure. On the other hand, experienced *GIS* experts deny the necessity of *GIS* certification, concluding that it is a discriminatory procedure (Cordova, 2005).

The disadvantages of *GIS* certification, in particular the *GISCI* procedure, essentially gravitate around the following issues:

- certification is unproductive, increasing bureaucracy
- skilled employees will be appreciated regardless education or experience, so regardless a *GIS* certification
- there are no measures in place to make sure information is accurate for the portfolio-based certification procedure
- for an exam-based certification procedure, there is no core knowledge agreed upon by all members of *GIS* community.

The majority of *GIS* community supports *GIS* certification rather as a combined portfolio- & exam-based form of checking one's abilities in the domain, being concerned about the very limited knowledge of core *GIS* competences demonstrated by some applicants to *GISCI*. The need to combat professional erosion might impose some form of exam-based certification instead or in addition to a bare portfolio-based certification procedure.

4. THE AMERICAN GIS CERTIFICATION PROCEDURE

Starting 2004, the American *GIS* certification procedure developed by *URISA* has been implemented by *GISCI* as a point-based and self-documented system, quantifying one's achievements in the domain. The system adds objectivity (points) to the subjective (one’s career).

There are 3 achievement categories that are reviewed by *GISCI*:

Educational attainment

- at least bachelor’s degree with some *GIS* courses (or equivalent)
    - credential points

    - course points
    - conference attendance points
    - Professional experience (portfolio)
  - minimum 4 years in *GIS* application or data development (or equivalent)
    - job title and description
    - duration of employment
    - Contributions to the profession
  - at least annual membership and modest participation in a *GIS* professional association (or equivalent)
    - publications at seminars or conferences
    - membership in professional associations
    - awards received
    - Volunteer efforts, etc.

Each category was given a certain number of points, but additional points can be received in any of the three categories, just to achieve the minimum total points established at 150. The educational attainment category requires a minimum of 30 points, for the professional experience at least 60 points are necessary and finally minimum 8 points are required for the professional contributions category. The remaining 52 points can be distributed between the three categories. This allows one to make up for a lack in one category with an excess in another (eg. long on *GIS* experience, short on education).

Until the end of 2008, a so called "Grandfathering" provision allows professionals who have been working with spatial data for many years to have only their professional experience reviewed. They need to have been involved at least (a) 8 years in *GIS* data analysis, system design, programming or (b) at least 13 1/3 years in *GIS* data compilation, teaching or (c) at least 20 years in a *GIS* user position. The minimum total was established at 200 points.

Every 5 years, the certification process has to be renewed, thus keeping the *GISP* in direct and permanent contact with the last achievements in *GIS* domain. The recertification procedure is similar with the initial certification one, but the points are differently awarded to the 3 categories and the total is only 75 points. Comparatively, both certification and re-certification point requirements are listed in Table 1. Less importance is given to education, but more contributions to the profession are expected from already certified *GISPs*.

Table 1. Category points for certification

Category	Points	
	certification	recertification
Educational achievement	10	4
Professional experience	60	50
Contributions to the profession	8	10
Additional points	52	11
Total	150	75

Moreover, a *GISP* has to meet the additional demand of the "*GIS* Code of Ethics" and respect the "Rules of Conduct" appropriate for professional practice in the domain. The importance of this "*GIS* Code of Ethics" is crucial for *GISP*s, providing a basis for evaluating their work from an ethical point of view. The document expounds the main guidelines based on the ethical principle of always treating others with respect and never merely as means to an end. It requires *GISP*s to consider the impact of their actions on other persons. It emphasizes the obligations to other persons, to colleagues and profession, to employers, funders and to society as a whole.

GISCI has already certified over 2000 *GISP*s, about 56% being from the public sector, 38% from the private sector and 6% from academic institutes. Over 90 % of the applicants are from USA and Canada. They have backgrounds in the various disciplines related to *GIS* works, such as: planning, public works engineering, emergency services, resources assessment, community development, transportation, finance, administration.

5. PORTFOLIO- vs. EXAM-BASED GIS CERTIFICATION

The portfolio-based certification procedure has previously been presented, in the chapter about *GISCI* activity.

The exam-based certification procedure should require a document representing a wide-range bibliography for the knowledge checking process. In this respect, a "Geographical Information Science & Technology Body of Knowledge" was edited by *UCGIS* and published September 1, 2006, by *AAG*. It consists of 10 main knowledge areas:

- Analytical Methods
- Conceptual Foundations
- Cartography and Visualization
- Design Aspects
- Data Modeling
- Data Manipulation
- Geocomputation
- Geospatial Data
- GI S&T and Society
- Organizational & Institutional Aspects

Each main knowledge area consists of several curriculum units. In total, there are 73 curriculum units.

It is this "Body of Knowledge" that was selected to be the start point of a future exam-base certification of *GISP*s. For the moment, only 24 core curriculum units were proposed to be considered for *GIS* certification at *GISCI*. However, several questions arise:

- Does this extensive document accurately reflect a *GISP*'s skills?
- Are there additional core units to be added to this "Body of Knowledge", such as surveying, programming skills, GPS, etc.?
- Should *GISCI* require competence in all or only in percent of knowledge units?
- Is it possible to convert the too academic language of this document into a more ordinary language, familiar to most applicants?

Several years will probably be required until an acceptable examination procedure will be finalized, based on the above mentioned body of knowledge. In the meantime, the competency-based certification process, currently in use at *GISCI*, remains a reasonable option for certifying *GIS* professionals.

6. CONCLUSIONS

Several achievements are worthy of note with respect to the American experience on *GIS* profession recognition and consequently on *GIS* certification procedures. The most important one is the foundation of the independent Certification Institute for *GIS* (*GISCI*).

A clear certification procedure, based on competency and portfolio evaluation, has been implemented by *GISCI*. A number of American states (Ohio, California, New Jersey, North Carolina and Oregon) and federal organizations endorse *GISCI* certificates, for:

- defining minimal cognitive standards for *GIS* professionals,
- providing reduced risk for employers hiring personnel for *GIS* jobs,
- promoting a strict adherence to a sensible code of ethics,
- encouraging long term professional development.

At the same time, *GISCI* is recommended by *ESRI*, the most important software company on *GIS* market (ESRI, 2008). Thus, the first 3000 *GISP*s certified by *GISCI* are supported by *ESRI* with free training and materials.

What's next? The idea of an exam-based certification, with a portfolio-based threshold to qualify for the exam seems to represent an alternative to the present American certification procedure. The use of a "*GIS&T* Body of Knowledge" as the recommended content for certification and re-certification programs at *GISCI* is still to be discussed, due to the impediments related to the actual content of this document. Another step forward is the recently launched *GISCI* mentoring program to link students and young professionals up with certified *GISP*s.

From the author's point of view, the recognition of one's achievements in *GIS* domain is also a matter of self pride, a good business card and a plus when starting a new project. On such a tough competitive market as the *GIS* market, being a *GISP* certified or re-certified by *GISCI* draws in certain advantages, but most of all, it brings respect from the other members of the *GIS* community.

REFERENCES

Cordova, H, (2005), *A Critical Perspective on GIS Certification*, http://www.geoplace.com

ESRI (2008), *GIS Education*, http://www.gis.com

GISCI (2008), *What is a GISP?*, http://www.gisci.org/certification_program_description.aspx

Harvey, F.,J., (2003), *The Significance of Public Safety for GIS Professional Licensing and Certification,* URISA Journal, Vol.15, Nr.1

Huxhold, W.E., Craig, W.J., (2003), Certification *and Ethics in the GIS Profession*, URISA Journal, Vol.15, Nr.1

ISO/TR 19122:2004(E), *Geographic Information/geomatics — Qualification and Certification of Personnel,* Technical Report, http://www.isotc211.org

Kemp, Karen, (2003), *Why GIS Professional Certification Matters To All of Us*, Transactions in GIS, Vol.7, Nr.2, pp.159-16

Obermeyer, Nancy J., (1993), *Certifying GIS Professionals: Challenges and Alternatives,* URISA Journal, Vol.5, Nr.1, pp.67-76

Tomlinson, R., (2003) – *Thinking about GIS*, ESRI Press, Redlands, USA, pp.xvii

U.S. Department of Labor, (2008),*Standard Occupational Classification*, http:/www.bls.gov

Wayne, Linda (2007), *The Profession of GIS*, SCARC Conference, Charleston, SC, http://www.scarcgis.org

TOPOGRAPHIC SURVEY: FROM CLASSICAL METHOD TO 3D LASER SCANNING WITH APPLICATION IN CIVIL ENGINEERING

G. Plesu[1], A. Covasnianu[1], I.R. Grigoras[1], B. Benedict[2]

ABSTRACT
This experiment was meant to determine which method is better in the term of fastness, optimization and speed of processing the data. We analyzed a site with both methods: the classical topographical survey and a 3D scanning laser measurement, with a focused idea on to the second technique. The area which we survey lies in the city of Iasi and represents a thermal local power station. We tried to respect the same technical parameters for both techniques. In the end we came to the conclusion that the 3D laser scanning we used matches the application, in this case civil engineering, but, in Romania, the authorities and the legal situation are not yet prepared to accept that.
Keywords: Surveying, techniques, HDS, laser scanning

*

1. INTRODUCTION

Surveying techniques have existed throughout much of recorded history.

Some of the first surveyors came from ancient Egypt where they used various tools including knotted ropes to measure distances for construction work and other applications (e.g. the construction of the Great Pyramid of Giza).

As late as the 1990s the basic tools used in planar surveying were a tape measure for determining shorter distances, a level for determine height or elevation differences, and a theodolite, set on a tripod, with which one can measure angles (horizontal and vertical), combined with triangulation. Starting from a benchmark, a position with known location and elevation, the distance and angles to the unknown point are measured. A more modern instrument is a total station, which is a theodolite with an electronic distance measurement device (EDM) and can also be used for leveling when set to the horizontal plane.

Fig. 1: *Total Station TCR 705*

Fig. 2: *HDS Scanstation*

Topographic surveys can be produced in a variety of scales ranging from 1:50 up to 1:2500. A

[1] *S.C. Habitat Proiect S.A. Iasi, Romania*
[2] *The Interdisciplinary Research Platform in the Field of Archeology - Arheoinvest Iasi, Romania*

network of control points is first established before features. Most commonly a combination of Total Stations, GPS receivers and Digital Levels are used for data capture, the choice being largely dependant on site conditions.

More sophisticated measuring instruments have been devised over the years and in the last few decades two such important instruments created a revolution in the world of geodesy: *The laser range finder* (e.g. HDS[1] Scanstation as shown in Fig. 2) and the *Global Positioning System* (GPS) helped to dramatically improve the accuracy of measurements, ease of use and the overall cost of surveying operations.

2. DATA

The data we processed were from a thermal local power station within Iasi. We use first the classical measurement by total station (Total Station TCR 705) and then the 3D laser scanning from Leica (HDS 3600 Scanstation).

2.1. Short brief of the objective measured with both methods (classic and 3D)

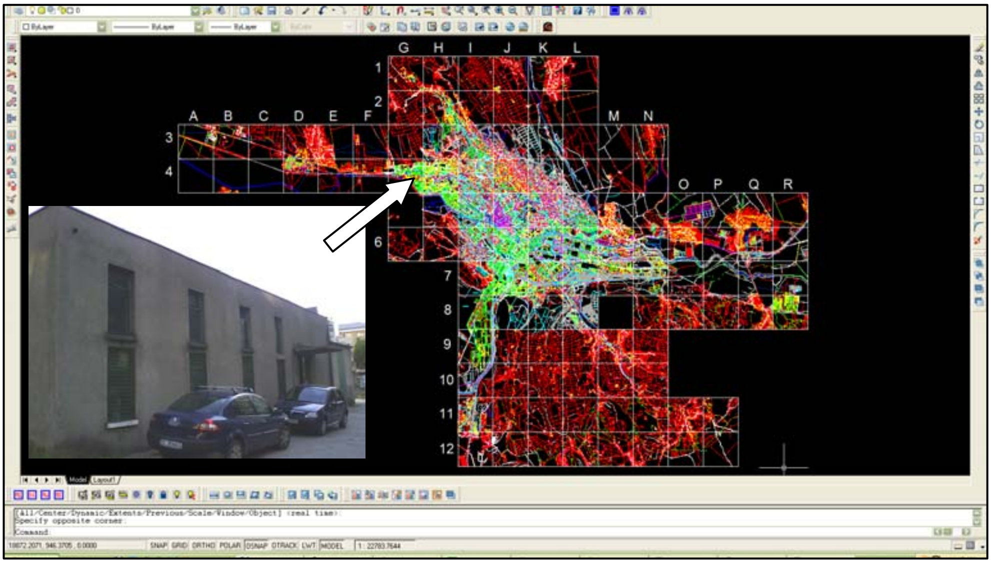


Fig. 3: *Location of the site*

As we can easily observe (Fig. 3), the objective is placed in a quarter within the city of Iasi (Western part). Regarding the parameters of the thermal local power station, this measures 23 m in length, 12 m in width and is 6.5 m high.

For the elaboration of topographical plan the scale of the objective was established at 1:500. This experiment it is part of a bigger project entitled "The modernization of the thermal power plants".

[1] HDS- High-Definition Surveying

In Fig. 4, we represented the same objective as an image obtained from the combination between the point cloud data and the low resolution picture made by HDS's incorporated camera.

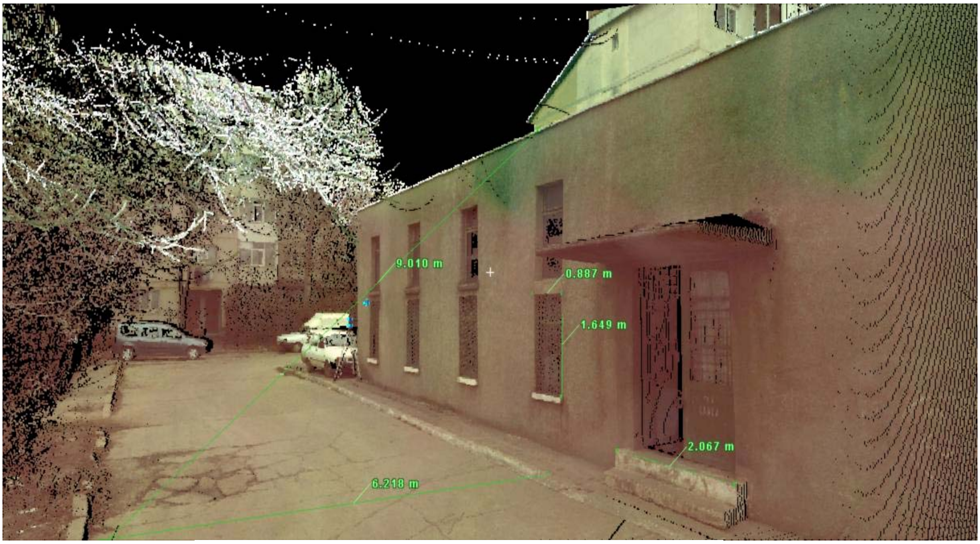


Fig. 4: *HDS representation of the site*

2.2. Steps in the field campaign

2.2.1. Measurement with Total Station TCR 705 - classical method

Since their introduction, total stations have made the technological shift from being optical-mechanical devices to being fully electronic with an onboard computer and software. Modern top-of-the-line total stations no longer require a reflector or prism (used to return the light pulses used for distancing) to return distance measurements, are fully robotic, and can even e-mail point data to the office computer and connect to satellite positioning systems, such as a *Global Positioning System* (GPS). Though GPS systems have increased the speed of surveying, they are still only accurate to about 20 mm.

Fig. 5: *Example from a field campaign*

With a total station one may determine angles and distances from the instrument to points to be surveyed. With the aid of trigonometry and triangulation, the angles and distances may be used to calculate the coordinates of actual positions (X, Y, and Z or northing, easting and elevation) of surveyed points, or the position of the instrument from known points, in absolute terms.

The data may be downloaded from the

theodolite to an external computer and application software will generate a map of the surveyed area.

The steps used in the measurement are:

1. The coordinates of the first point from the station were determined using the backwards-intersection on the triangulation's points bought from A.C.L.R.[1] or staying on a known coordination point and aiming other two points, also bought from A.C.L.R.
2. Was elaborated a polygonal traversing survey with a amount of 87 points per station
3. From the station's points were determined points of detail by the radiation method to whom where obtain the XYZ coordinates (If the surface which needs to be traced isn't nearby, then a polygonal course to the surface will be made).
4. The coordinate system we used was the local Iasi and the reference plan is Black Sea.

2.2.2. Measurement with the 3D Laser scanning HDS Scan Station

The HDS system is composed by a 3D laser scanning, a computer and the scanning software, transfer and processing called Cyclone.

The system captures in 3D the geometry's surfaces of structures through a high precision, speed and safety.

The scanning steps are: head the scanner to the area which we want to be measured, choose the area of measurement and the scanning density.

The complete geometry of the exposed surfaces is captured in minutes as point clouds which can be used immediately. The scanner can be rotate or moved around the objective to capture the entire scene.

Fig. 6: *In the field with Leica HDS ScanStation*

2.3. Processing technique

2.3.1. Total station

After the field campaign, follows the stage of processing technique. This includes downloading and treatment of data. In our case study, using the AutoCAD software, we obtained a final product (a dwg file) and a list of coordinates (a text file). In case needed, we can elaborate the contour lines. The next step is to purchase the supervised plan from A.C.L.R. or the city hall.

2.3.2. HDS Scan Station

After the 3D scanning with the laser technique was obtained a 3D model of the thermal power plant composed of measurable cloud point data. Cyclone software will

[1] A.C.L.R.- Agency of Cadastre and Land Registration

permit the use of the 3D point clouds in a lot of applications, including those who need to be exported to CAD, used in rendering/modeling software AutoDesk VIZ, AutoDesk 3D Studio Max etc., or as meshes for engineering, surveying, construction, architectural and related applications.

3. RESULTS

In the Fig. 7, we represent the land survey of the area with the total station TCR 705, processed in AutoCAD. Next, there are some examples taken from different angles with the objective scanned, visualized in Cyclone software.

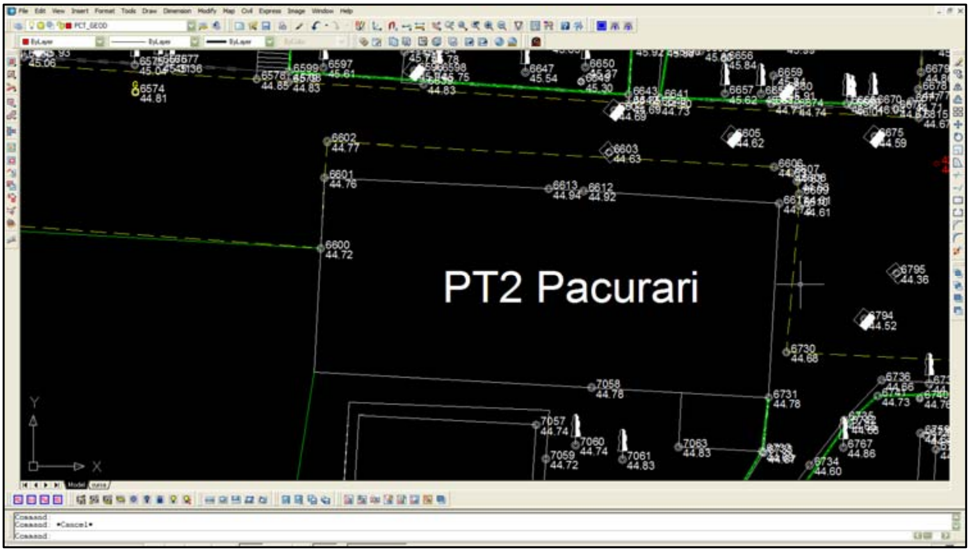


Fig. 7: *Representation of objective in CAD - TCR 705 measurement*

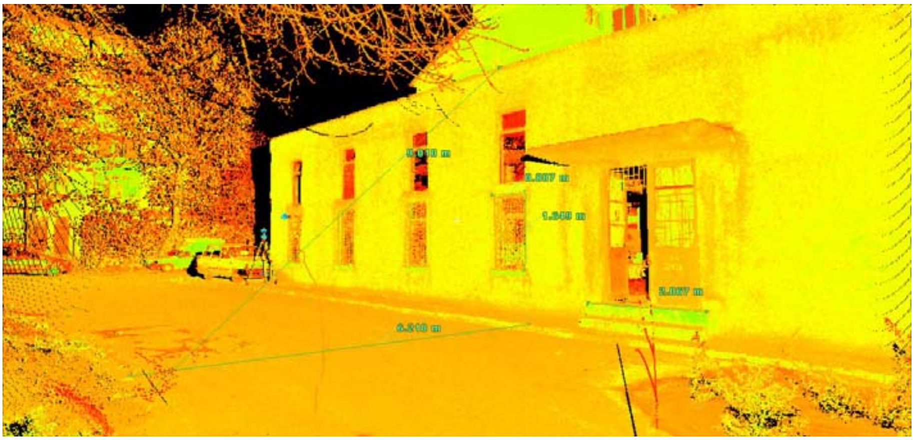


Fig. 8: *Representation of the objective in Cyclone - HDS Scanstation measurement*

Figures no. 8 and 9 represents the objective by the color intensity of the cloud points. We added some extra measurements from software's abilities. Can easily be distinguished the road width, some parameters of the building (the height and the width of the windows, doors, stairs).

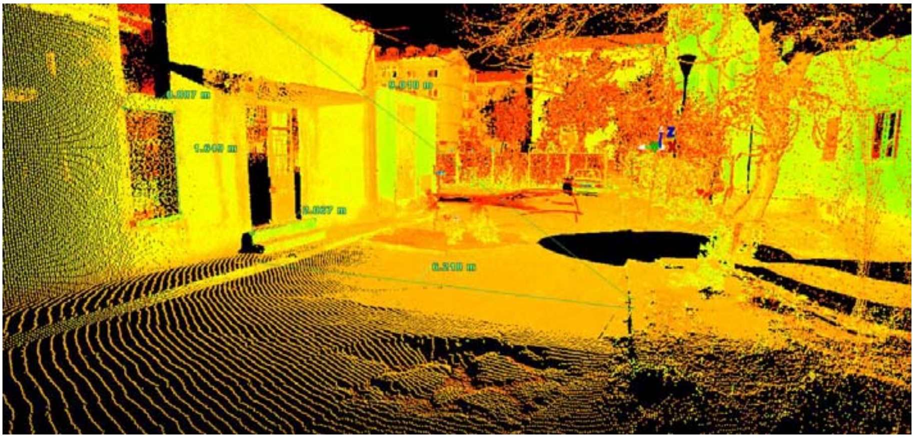


Fig. 9: *Representation of objective in Cyclone - HDS Scanstation measurement (different angle)*

Fig. 10: *Real image of the objective*

In Fig. 10 we have a real photo of the objective measured. With this picture we try to show and expose the accuracy of the Scanstation measurement.

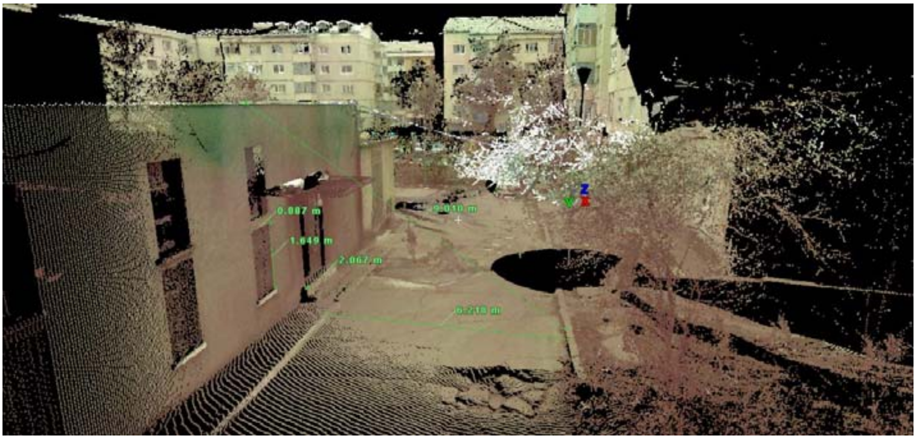


Fig. 11: *General view of the thermal power plant*

In the end, as shown in Fig. 11, a 3D view of the area is represented, obtained by the HDS Scanstation with Cyclone software.

4. CONCLUSIONS

4.1. Advantages and disadvantages of these two methods

First, both methods can be successfully used in different applications, but there are some details which advantages one technique or the other.

For example, TS[1] is limited by line of site, and lighting conditions in the area. All existing systems require the use of a "measuring rod" and sustaining it in a vertical position. The existing systems are also expensive, starting at tens of thousands of dollars per unit, and are used mostly by professional surveyors.

On the other hand, when we speak about HDS Scanstation one of the most important benefits of it is the level of detail which can be obtained. This capability is proven by the SmartScan technology which enables the user to select any area at the needed level of detail.

Instead, the topographical surveys made by total station are agreed by A.L.C.R. Even so, sometimes the risk for the project to be rejected is high, due to the disparities between the real situations expressed by the orthorectified aerial photography.

More, the lower price of the TS measurements, in contrast with the 3D scanning and the existence of a numerously high trained personal, lead to the situation that this method to be accepted and preferred by the authorities and beneficiary.

Advantages of the HDS Scanstation:

- The Virtual Surveyor application can be used for capturing topographical data, with the purpose of generating topographical maps;
- Faster method for the obtaining the needed data;

[1] TS-Total Station

- Creation of a complete database of the scanned objectives
- Possibility of recording data concerning volumes and surfaces. High precision measurements (average error is 4-6 mm at 100 m);
- Points measured can easily be inserted in a local coordinate system (Stereo 70 for Romania) in order to be completely compatible with other projects;
- The unique design with two windows permits the access to a large visualization field (360^o horizontally and 270^o verticaly). A new orientation of the instrument is not necessary;
- The accurate dimensions can be obtained directly from the cloud point data or from the geometrical objects created. Each point has his own coordinates North, East and Elevation which can be coded and processed in order to elaborate plans and sketches.
- Also, in order to obtain a survey or a plan it can be generated orthorectified images or plans.

The laser range finder and the *Global Positioning System* (GPS) helped to dramatically improve the accuracy of measurements, ease of use and the overall cost of surveying operations. Despite these important advances even the most up-to-date surveying systems like the Real-Time-GPS (RTK-GPS) and the "*Total Station*" (TS) still have their limitations

4.2. Future measurements are 3D scanning? Is this method suitable for topographic surveys?

This comparison between measurements was an experiment and should be considered as such. This experiment showed the differences between measurements, but had the same result: to measure a building, e.g. a thermal power plant. The first type of measurement was relatively fast, but the HDS Scanstation 3600 is faster and efficient. The main idea of this experiment was to see if the 3D scanning with this technique is suitable for this type of application. From our point of view we came to the conclusion that 3D scanning is the next step in topographical surveys. But, the future of implementing this technique is in the hands of the authorities. For large scale future projects, with a lot of labor and money involved, this technique would be more efficient if it were tolerated by the authorities

REFERENCES

Băican, V. (2004), *Dictionar de cartografie-topografie,* Editura Tehnopress, Iasi

Old versus new – how a new surveying technology can create instant CAD models – A web article

Pugh, J. C. (1975), *Surveying for Field Scientists*, Methuen, ISBN 0-416-07530-4

http://arheoinvest.uaic.ro/index.htm

http://en.wikipedia.org/wiki/Surveying

http://www.co.lake.il.us/elibrary/publications/planning/pdfs/topos.pdf

http://www.leica-geosystems.com

Leica Cyclone 5.8.1 Technical Specifications

VARIABILITE SPATIOTEMPORELLE DES TEMPERATURES AUX ECHELLES FINES DANS LE VIGNOBLE DE *VINHO VERDE* (PORTUGAL) DANS UN CONTEXTE DE CHANGEMENT CLIMATIQUE*.

Quénol H.[1], Monteiro A.[2], Briche E.[3] et Maciel A.[2]

RÉSUMÉ

Dans la région Do Entre Douro e Minho (Nord Portugal), une étude agrométéorologique est réalisée dans deux terroirs viticoles séparés de quelques dizaines de kilomètres mais dont les caractéristiques topographiques et les cépages sont différents. Pour cela, une étude climatique aux échelles fines permet de comprendre l'influence locale des caractéristiques de la surface (relief, occupation du sol) sur les paramètres météorologiques. Les mesures de températures et l'analyse de l'état physiologique de la vigne effectuées entre février et avril 2003 et 2004 ont mis en évidence une forte variabilité spatio-temporelle du climat d'une part, entre les deux sites et d'autre part, à l'intérieur même des terroirs. Dans un contexte de changement climatique, ce type d'approche climatique aux échelles fines doit être pris en compte afin que le viticulteur puisse s'adapter suffisamment tôt à ce changement attendu.

ABSTRACT

In the Entre Douro e Minho area (North of Portugal), an agroclimatologic study is made in two distant soils of wine of a few kilometers and from which the topographic caracteristics and the variety of vine are different. A climatic study on fine scales is carried out in order to determine the local influence of the surface characteristics on the weather parameters. The temperature measurements and the agronomic analysis carried out between February and April 2003 showed a strong space-time variability of the spring frost risk between the two sites and inside even of the soils. In a context of climate change, this type of climatic study in fine scales must be taken into account to ameliorate simulation and predictions.
Keywords: vignoble, temperatures, variation, echelle, changement climatique

*

1. INTRODUCTION

Les nombreuses interrogations posées par le changement climatique engendrent une multitude de questions sur le fonctionnement des géosystèmes aux échelles locales. Un changement global du climat aura obligatoirement des répercussions sur le climat local et sur l'activité viticole. Dans ce contexte, les impacts attendus d'un éventuel changement climatique posent un certain nombre de questions et l'évaluation du changement climatique à l'échelle du terroir (échelles fines) est donc primordiale dans l'optique de la mise en place d'une politique raisonnée d'adaptation aux modifications du climat.

Actuellement, la communauté scientifique aborde peu l'impact du changement climatique sur la vigne aux échelles fines. Pourtant, en viticulture, la qualité du vin, le choix des cépages ou encore la spécificité des terroirs dépendent de caractéristiques locales

[1] *Laboratoire COSTEL, UMR6554 LETG, Université Rennes 2, Place du recteur Henri le Moal 35043 Rennes Cedex, France.*
[2] *Departamento Geografia, Universidade do Porto, Via Panorâmica, s/nº 4130-564Porto Portugal.*
[3] *PRODIG, Université Paris 7, place Jussieu, 75251 Paris France.*

tels que la topographie (pente, exposition …), la proximité d'une rivière ou d'un plan d'eau qui vont agir localement sur le climat. Un changement global du climat aura obligatoirement des répercussions sur le climat local, sur les caractéristiques du vin et donc des conséquences au niveau économique.

En 2003 et 2004, une expérimentation agroclimatique adaptée aux échelles fines a été réalisée dans le nord-ouest du Portugal, plus précisément dans la « Région Démarquée des vignobles de vinho verde» dans les vignobles de la station expérimentale viticole Amando Galhano à Arcos-de-Valdevez et de Monção-Troviscoso. Cette étude s'inscrit dans la continuité de « l'Atlas agroclimatique de la région do Entre Douro e Minho » réalisé à partir d'un réseau régional de 26 stations météorologiques (Monteiro et al, 2003). Les deux vignobles expérimentaux, distants de quelques dizaines de kilomètres, ont des caractéristiques viti-vinicoles très différentes notamment sur les types de cépages cultivés et la qualité du vin. Le vignoble de Monção-Troviscoso est essentiellement composé du cépage Alvarinho alors que plusieurs tentatives ont montré qu'il était difficile de cultiver ce cépage à Arcos-de-Valdevez car il répond à des caractéristiques topoclimatiques spécifiques.

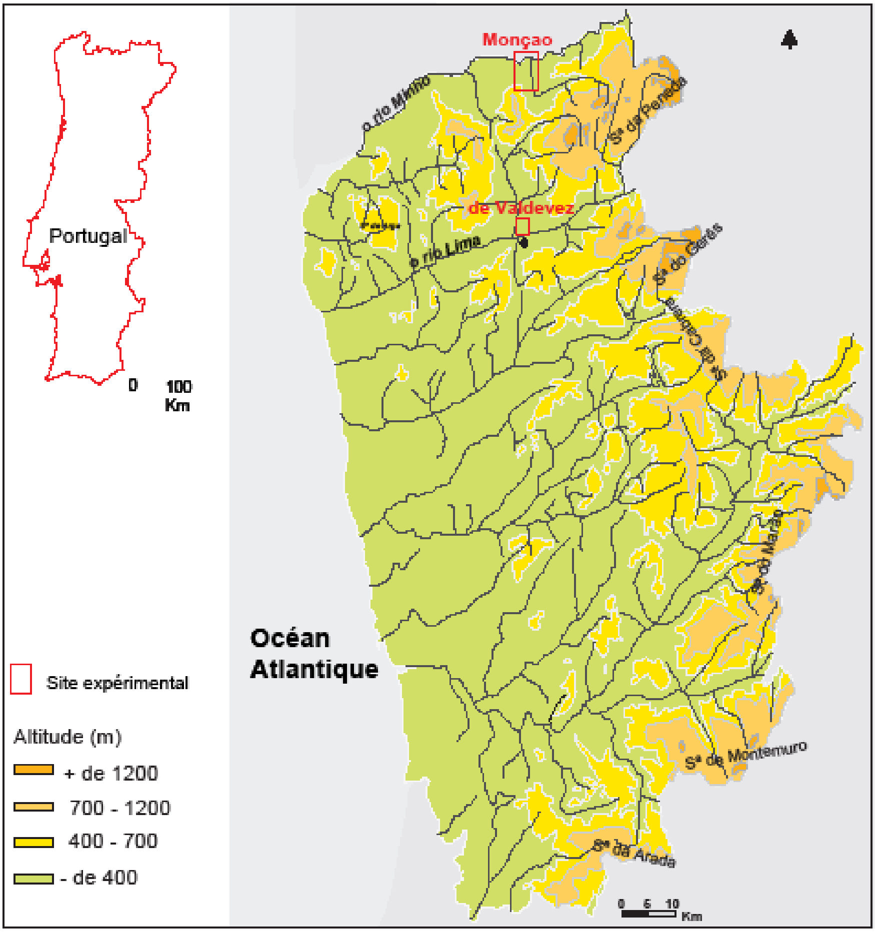
L'objectif de cette étude est de déterminer par l'intermédiaire de mesures météorologiques et d'observations agronomiques, les facteurs responsables de la forte variabilité spatiotemporelle du climat entre ces deux vignobles et également d'expliquer quelles sont les conditions climatiques locales favorables à l'Alvarinho. Dans un contexte de changement climatique, ce type d'approche climatique aux échelles fines doit être pris en compte dans les différents scénarios de l'impact du changement climatique sur la viticulture notamment afin que le viticulteur puisse s'adapter suffisamment tôt à ce changement attendu. Beltrando G. et colab. (2006) fait une simulation du risque gélif dans le vignoble par utilisation des techniques G.I.S.

2. METHODE ET DONNEES

2.1 Sites expérimentaux

L´étude se déroule dans le nord-ouest du Portugal, plus précisément dans la « Région Démarquée des vinhos verdes », qui est limitée au Nord et au Sud par les fleuves Minho et Lima et à l´Est par des montagnes dont l'altitude est supérieure à 1000 mètres. Cet espace (Fig. 1) est caractérisé par un relief accidenté, dont les altitudes croissent au fur et à mesure que l´on s´éloigne de l´océan Atlantique (a Serra da Peneda-Soajo 1416 m). Les fleuves Minho et Lima, d'orientation Ouest-Est se caractérisent par de larges vallées se resserrant progressivement vers l´intérieur du pays (Madureira et al, 2002). Le climat, de type océanique, se traduit par de faibles amplitudes thermiques, une pluviosité relativement importante mais irrégulièrement réparties et une forte sécheresse estivale (Alcoforado, 1982; Daveau, 1988). La présence des reliefs immédiatement à l'Est du littoral limite très rapidement l'influence océanique (ex: diminution de l'action adoucissante des masses d'air) et favorise une forte variabilité spatiale des paramètres climatiques d'où la présence de topo-climats.

Les deux terrains expérimentaux sont distants d'environ 30 km et se situent dans les vallées du Lima (près d'Arcos de Valdevez et de la confluence avec son principal affluent, le Vez) et du Minho (près de Monção et Troviscoso, dans un vallon orienté Sud/Nord) (Fig. 1) Ces deux sites présentent une topographie accidentée et sont peu soumis à l'influence maritime.

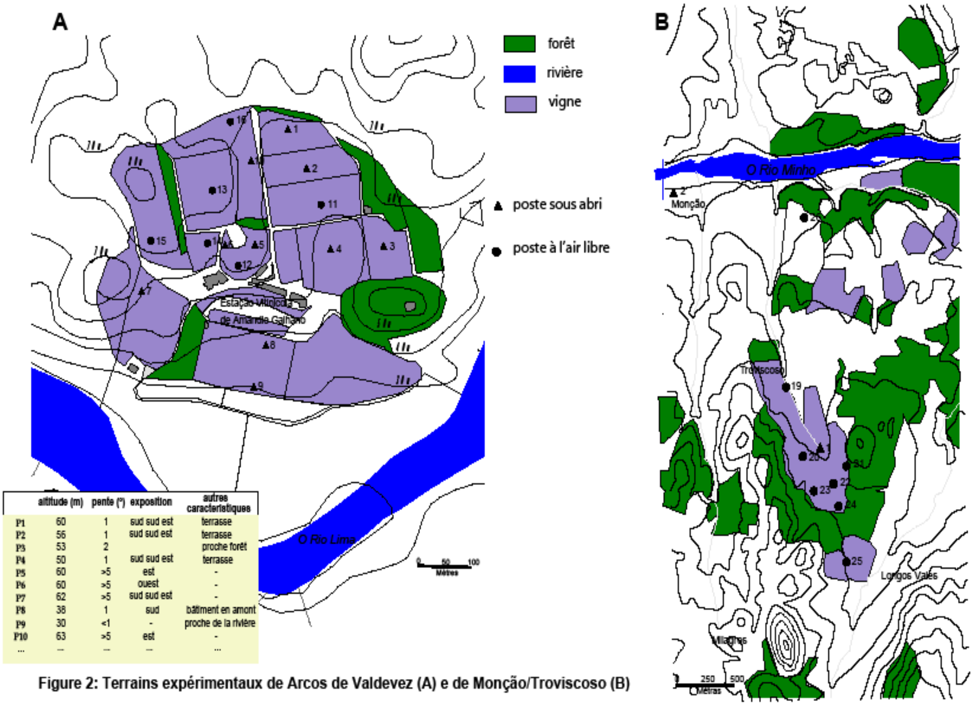


FONTE: Ferreira

Fig. 1 : *Sites expérimentaux dans le nord-est du Portugal*.

Le vignoble d'Arcos de Valdevez se situe sur la station viticole de Amandio Galhano. Le Loureiro (cépage blanc) et le Vinhão (cépage rouge) sont principalement cultivés. Le Loureiro produit des vins de qualité et est cultivé dans l'ensemble de la région, s'adaptant très bien aux conditions littorales. Ce cépage blanc a un débourrement assez précoce - donc sensible au gel printanier - et une maturation moyenne. Le Vinhão est une variété de cépage rouge qui produit le "tinto". Il présente un débourrement tardif et une maturation moyenne. Cette variété a une croissance vigoureuse et génère une production régulière (Monteiro, 2003). La topographie du site se caractérise par une succession de replats subhorizontaux (terrasses) d'orientation Nord-Sud s'élevant à 50-60 m, bordées de mamelons d'altitude maximale de 80 m et aboutissant dans la vallée du Lima (orientation Ouest-Est ; altitude 30m). La pente générale d'orientation Nord-Sud est d'environ 3° (Fig. 2 a).

Le cépage Alvarinho est cultivé dans le vignoble de Monção/Troviscoso. Ce cépage est caractérisé par des vins de très bonne qualité mais exige des conditions pédoclimatiques spécifiques (Garido, 1984). Précoce au débourrement et à la maturation, cette variété est très sensible aux forts refroidissements printaniers et aux amplitudes thermiques diurnes trop importantes. La topographie du site correspond à une vallée d'orientation Sud-Nord rejoignant la vallée du Minho (Est-Ouest). La présence de reliefs relativement hauts (dénivelé important par rapport au fond du vignoble) au sud, à l'ouest et à l'est du site et le resserrement de la vallée au nord, font que la vallée de Troviscoso se situe dans un "cirque". A proximité du fleuve Minho, le terrain est relativement plat avec une pente inférieure à 2° (Fig. 2 b).



	altitude (m)	pente (°)	exposition	autres caractéristiques
P1	60	1	sud sud est	terrasse
P2	56	1	sud sud est	terrasse
P3	53	2		proche forêt
P4	50	1	sud sud est	terrasse
P5	60	>5	est	-
P6	60	>5	ouest	-
P7	62	>5	sud sud est	-
P8	38	1	sud	bâtiment en amont
P9	30	<1	-	proche de la rivière
P10	63	>5	est	-
...	...	...	...	...

Figure 2: Terrains expérimentaux de Arcos de Valdevez (A) e de Monção/Troviscoso (B)

Fig. 2: *Terrains expérimentaux de Arcos de Valdevez (A) e de Monção/Troviscoso (B)*

2.2 Méthode et mesures

Pour définir les spécificités climatiques d'un vignoble, les stations météorologiques des réseaux nationaux sont souvent trop espacées et elles ne permettent pas de mettre en évidence les variations microclimatiques. Un réseau de mesures où les stations sont disposées en fonction des caractéristiques de surface (pente, exposition …) a été mis en place sur le site. Plusieurs types de mesures ont été réalisés sur les deux sites:

- des postes météorologiques fixes (16 postes à Arcos de Valdevez et 2 à Monção/Troviscoso) ont été répartis suivant les caractéristiques topographiques et environnementales des sites. Des thermomètres enregistreurs (type Tiny Talk) sous abri et disposés à 1,50 m de la surface (hauteur moyenne des bourgeons) ont permis d’enregistrer en continu entre février et septembre 2003/2004 (du débourrement à la récolte) la température suivant un pas de temps de 15 minutes. Les températures sous abri obtenues sur les postes fixes ont été analysées en fonction des types de temps (anticyclonique, dépression, état du ciel, force et direction du vent dominant) (Fig. 2) ;

- des mesures dans des situations météorologiques spécifiques (ex : gelées de printemps, canicule de 2003) ont été réalisées. Au cours des nuits gélives printanières de type radiatif (ciel clair, vent faible), les thermomètres enregistreurs ont été installés, à l'air libre afin de mesurer, la température en indice actinothermique (IA), qui est la valeur la plus proche de celle subi par la surface du végétal. Pour mesurer la direction des écoulements gravitaires (faible vitesse < 2 m/s), une girouette en balsa a été employée. Munis de ce capteur ultrasensibles et d'une boussole, des mesures itinérantes tout au long de la nuit ont permis de déterminer l'aérologie nocturne des deux sites en situations gélives (Fig. 2).

La variabilité spatiale des paramètres atmosphériques a été confrontée et validée par l'intermédiaire des données de réponses viticoles et/ou œnologiques: phénologie, taux de sucre, stress hydrique, …

3. RESULTATS

Les relevés thermiques sous abri et en indice actinothermique mettent en évidence une forte variabilité spatio-temporelle sur des espaces relativement restreints. Cette forte variabilité spatiale a un impact sur la vigne: hétérogénéité de la capacité de résistance aux risques liés au climat (gel printanier, stress hydrique …), différences de niveau de croissance de la vigne, importante variabilité des caractéristiques du raisin (taux de sucre …) …

3.1 Une forte variabilité spatio-temporelle des variables climatiques

3.1.1 Températures minimales sous abri

Les températures sous abri enregistrées entre février et avril 2003 montrent une importante variabilité spatiale entre les deux sites expérimentaux mais également entre les différents postes du site d'Arcos-de-Valdevez.

La disparité spatiale des températures est principalement liée aux différences topographiques. Les moyennes des températures minimales journalières entre février et avril 2003 sont nettement plus élevées à Monção/Troviscoso (M1 et M2) qu'à Arcos-de-Valdevez. Pour les mois de mars et avril, l'écart moyen des températures minimales entre le poste n°4 et Troviscoso (conditions topographiques similaires pour les deux postes) varie entre 1 et 2°C. Sur les différents points de mesures répartis sur le site de Arcos-de-Valdevez, les températures les plus basses sont observées sur les postes où la pente est faible ou en fond de vallée. Inversement, les secteurs où le refroidissement nocturne est le moins intense correspondent aux postes où la pente est la plus forte. La répartition spatiale des températures minimales est donc liée à la topographie du site (Fig. 3):

- les valeurs les plus faibles sont observées sur les terrasses ou dans les dépressions, c'est-à-dire les secteurs où l'air froid s'écoulant par gravité est ralenti et stagnant ;
- les valeurs les plus fortes sont enregistrées sur les rangées où la pente est supérieure à 5°; c'est-à-dire les secteurs où l'air froid au niveau du sol est toujours en mouvement.

La variabilité spatiale des températures minimales est la plus forte en situation radiative lorsque le ciel est clair et la vitesse du vent < 2 m/s. L'absence de nébulosité et la faible vitesse du vent favorisent les déperditions énergétiques radiatives et limitent l'homogénéisation des températures par brassage d'air ou par "effet de serre". Ces constatations sont également confirmées entre les sites d'Arcos-de-Valdevez et de

Troviscoso où l'écart thermique atteint 2,5°C (entre le poste n°4 et Troviscoso) lors des situations marquée par un ciel clair et une température de 0,5°C lorsque le ciel est nuageux.

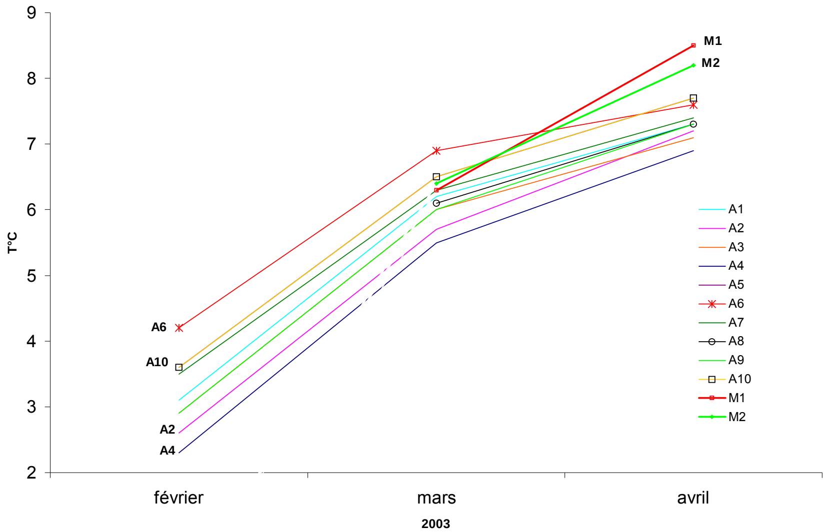


Fig. 3 : *Moyenne des températures minimales sous abri de février à avril 2003.*

3.1.2 Températures maximales sous abri

L'analyse des températures maximales montre également une forte variabilité spatiale entre les deux sites. Celle-ci est toujours provoquée principalement par la topographie (pente et exposition). Contrairement aux minimales, les températures maximales sont plus basses à Monçao/Troviscoso (M1 et M2) qu'à Arcos de Valdevez. Par exemple, en mars et avril 2003, l'écart moyen entre le poste n°4 et Troviscoso varie entre 0,5°C et 1°C. Cet écart est le plus important lorsque le temps est anticyclonique avec un ciel clair.

Sur les différents postes de mesures d'Arcos de Valdevez, les températures les plus élevées sont observées sur les postes exposés vers le sud et où la pente est importante (>5°). Les différences entre les postes sont peu importants en février et en mars, période où l'ensoleillement est encore faible. Par contre, les écarts augmentent à partir d'avril (Fig. 4).

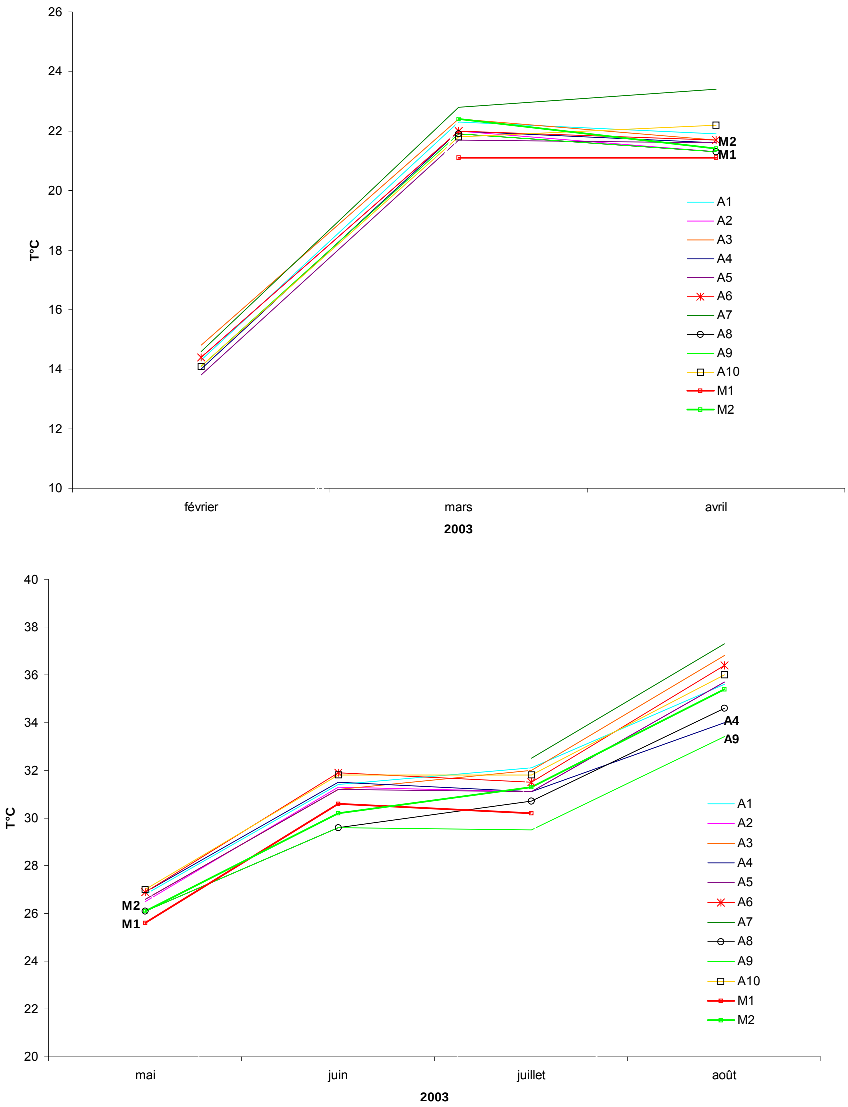


Fig. 4 : *Moyenne des températures maximales sous abri de février à août 2003.*

3.1.3 Températures minimales et aérologie nocturne en situations de gelées printanières

L'aérologie nocturne locale varie suivant la topographie: l'air froid issu des déperditions énergétiques de surface (sol, végétation) s'écoule suivant la direction de la pente et stagne dans les secteurs subhorizontaux ou en amont d'obstacles. La vitesse des écoulements est donc proportionnelle à l'intensité de la pente.

A Arcos-de-Valdevez, l'écoulement principal de direction Nord-Sud correspond à l'exposition générale du site avec comme point bas, la vallée du Rio Lima au sud. L'air froid descend le long des terrasses et aboutit dans le fond de la vallée. A une échelle plus fine, les caractéristiques des écoulements (direction et vitesse) sont conditionnées par la topographie (exposition et pente). On distingue deux types de topographie différentes: les secteurs en terrasses (n°1, 2 et 4) exposées Nord-Sud et de pente < 2° auxquels correspondent des écoulements de vitesse inférieure à 1 m/s et des secteurs d'expositions Est, Sud ou Ouest (n°7, 5 et 10) et de pente toujours supérieure à 5° auxquels correspondent des écoulements supérieurs à 2 m/s (Fig. 5).

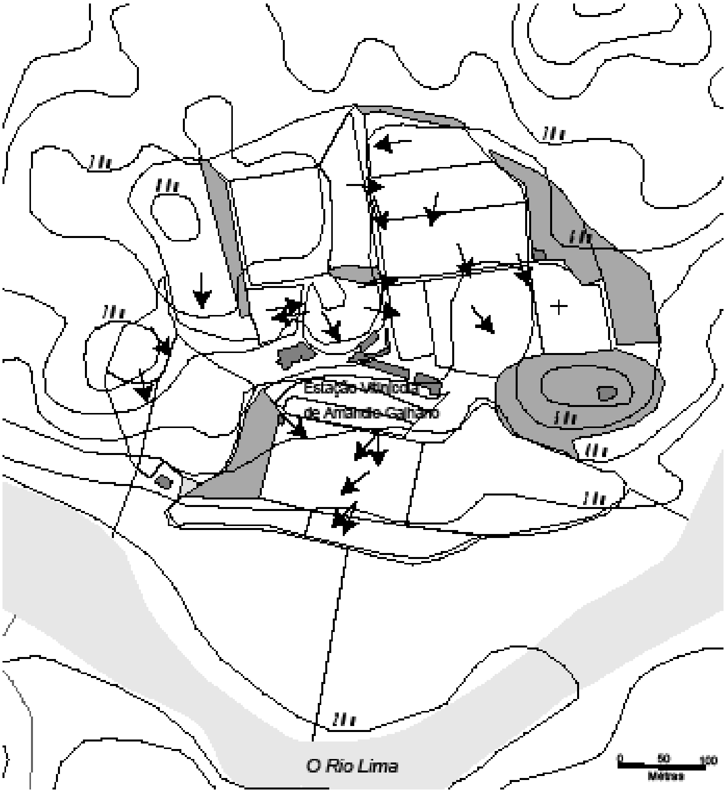


Fig. 5 : *Ecoulements gravitaires nocturnes lors de la nuit radiative du 15 au 16 Février 2003 à Arcos de Valdevez (les flèches indiquent la direction des écoulements).*

A Troviscoso/Monçao, l'écoulement principal de direction Sud-Nord suit la pente générale pour aboutir au niveau de la vallée du Minho. A l'échelle de la vallée de Troviscoso, les écoulements gravitaires proviennent des versants adjacents. La présence de reliefs relativement hauts (dénivelé important jusqu'à 200 m par rapport au fond du vignoble) au sud, à l'ouest et à l'est du site font que les directions sont diverses et surtout que la vitesse est nettement supérieure à celle observée à Arcos-de-Valdevez (> 3 m/s). Au niveau du Minho, une brise de vallée descendante provient de l'Est (Fig.6).

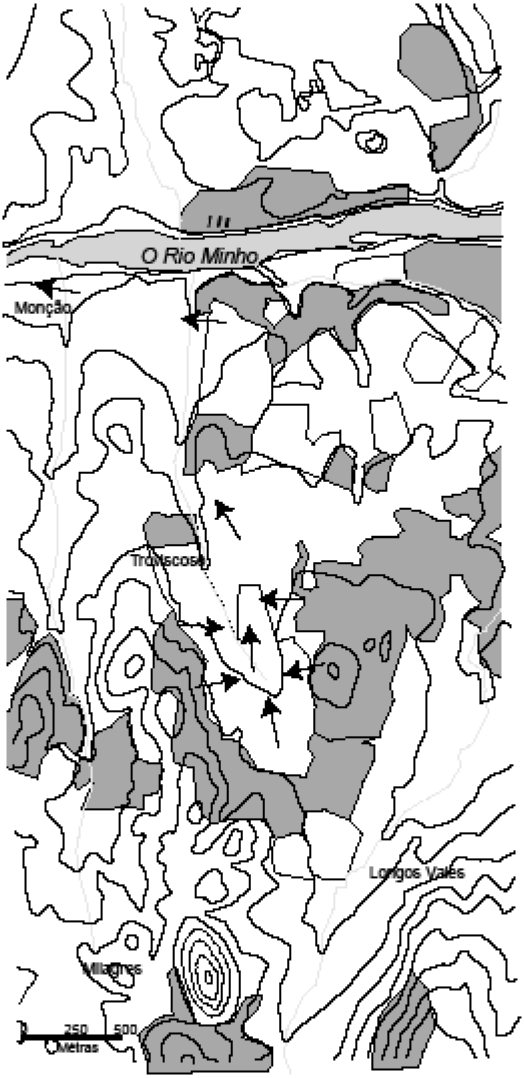


Fig. 6 : *Ecoulements gravitaires nocturnes lors de la nuit radiative du 15 au 16 Février 2003 à Troviscoso/Monçao (les flèches indiquent la direction des écoulements).*

L'évolution des températures en Indice Actinhothermique (IA) est fortement conditionnée par la topographie et correspond aux conclusions tirées des mesures aérologiques. La vitesse des écoulements est proportionnelle à la température. Plus les écoulements gravitaires sont puissants moins le refroidissement nocturne est important.

Sur le site d'Arcos-de-Valdevez, les valeurs minimales de la nuit du 15 au 16 février 2003 sont beaucoup plus basses sur les postes situés en zone d'accumulation d'air froid que sur les secteurs en pente. Le refroidissement nocturne a été le plus froid sur les postes 2, 11 et 4. Il s'agit de terrasses subhorizontales où l'air froid s'écoule très lentement et il a même tendance à stagner. Le resserrement entre la colline et les bâtiments en aval du point n°4 accentue encore plus le blocage de l'air froid et fait que ce secteur est le plus froid du site. Sur les postes où la pente est supérieure à 5° (n°5, 7, 10, etc.) ou sur le sommet de collines (n°13), les températures minimales sont plus élevées de 1,5°C à 2°C. Le point de mesure n°9, situé sur la terrasse proche de la vallée du Lima où le refroidissement est théoriquement le plus fort (accumulation) subit l'influence modératrice de la rivière (forte humidité). Les valeurs minimales sont comparables à celles enregistrées sur un poste en pente (Fig. 7). D'ailleurs, l'influence de la rivière sur le comportement des températures s'observe en fin de nuit avec la présence de brouillard de condensation dans la dépression topographique.

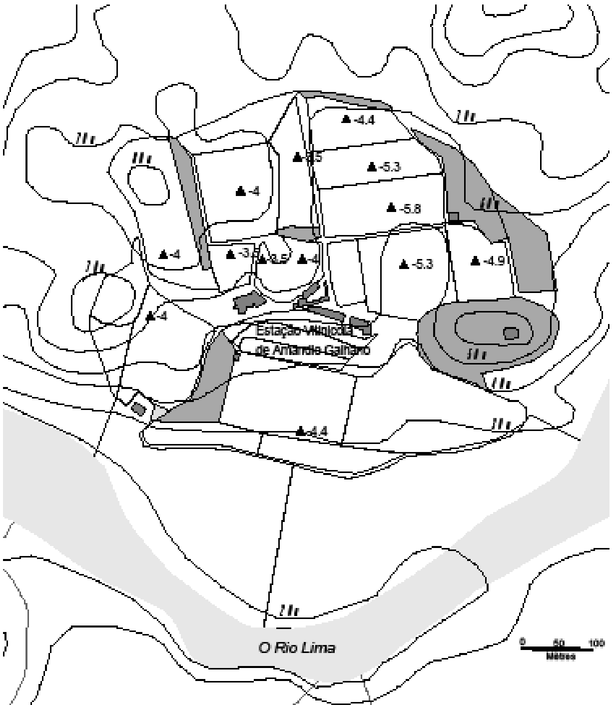


Fig. 7: *Températures minimales en Indice Actinothermique durant la nuit radiative du 15 au 16 février 2003 à Arcos de Valdevez.*

Sur le site de Troviscoso, la variabilité spatiale des températures minimales de la nuit du 15 au 16 février 2003 est moins importante qu'à Arcos-de-Valdevez : dans la vallée de Troviscoso, les valeurs varient peu (entre -0,1°C et -0,6°C) quel que soit la topographie (pente, fond de vallée). A proximité du Minho (-1,4°C), où pourtant la présence de la brise descendante est un facteur favorable pour limiter le refroidissement (brassage de l'air), les données sont plus froides d'environ 1°C (Fig. 8).

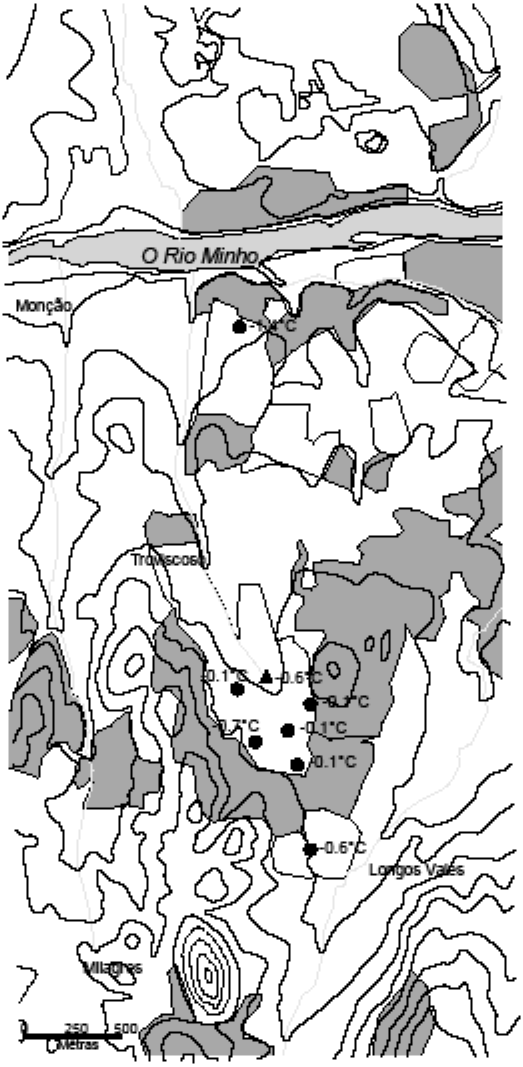


Fig. 8: *Températures minimales en Indice Actinothermique durant la nuit radiative du 15 au 16 février 2003 à Troviscoso/Monçao.*

Par rapport au site d'Arcos-de-Valdevez, les températures sont nettement plus élevées (entre +3,5°C et +6°C) (Fig. 7, Fig. 8). L'aérologie nocturne spécifique au microclimat de la vallée de Troviscoso - espace fermé entouré de reliefs avec fortes pentes - explique ces importants écarts de températures. En situation radiative, les écoulements de pente dont la vitesse mesurée est supérieure à 3 m/s limitent l'intensité du refroidissement nocturne en homogénéisant les températures par brassage de l'air dans les premiers mètres de la couche de surface. Ce microclimat, localisé dans la vallée de Troviscoso, amoindrit la probabilité de risque gélif pour le vignoble d'Alvarinho.

3.1.4 Températures maximales extrêmes

Les températures maximales sous abri en situation de fortes chaleurs (été 2003) ont également une forte variabilité spatiale liée aux caractéristiques et aspérités de la surface. A Arcos de Valdevez, la répartition spatiale des températures maximales du 8 août 2003 montre que les valeurs les plus élevées sont enregistrées dans les secteurs où la pente est la plus forte avec une exposition Sud. Les écarts de plusieurs degrés peuvent atteindre 4°C avec les postes situés dans des secteurs subhorizontaux ou en cuvette (Fig. 9). L'analyse des fréquences des températures maximales durant l'été 2003 confirme l'influence des facteurs topographiques sur la variabilité spatiale des températures à Arcos-de-Valdevez (Fig. 10).

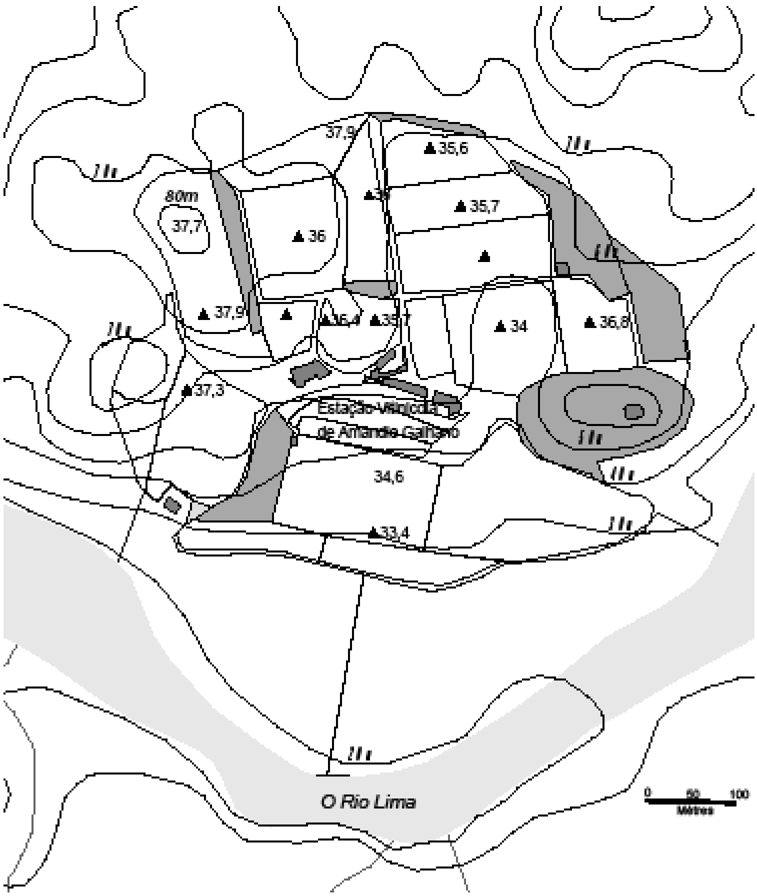


Fig. 9: *Temperatures maximales du 8 aout 2003 à Arcos de Valdevez.*

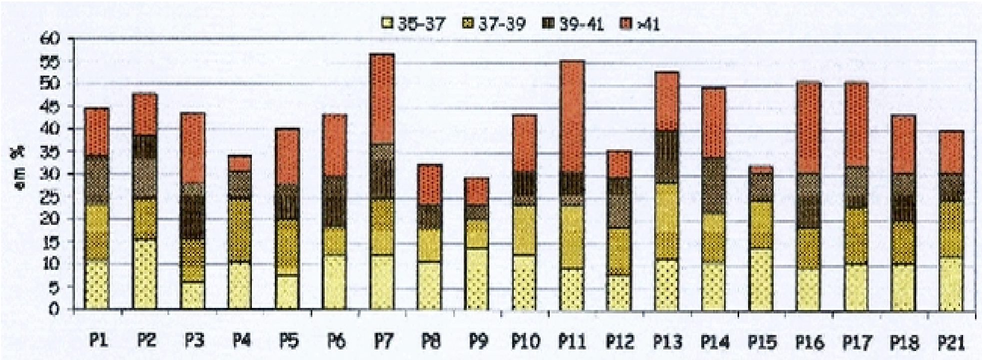


Fig. 10 : *Fréquence des températures maximales de l'été 2003 sur les postes de mesures (%).*

3.2 Conséquences de la variabilité du climat sur la vigne

Parallèlement à l'expérimentation météorologique, un suivi de l'état physiologique de la vigne a été effectué afin d'observer les caractéristiques de la vigne sur l'ensemble des points de mesures.

Durant les printemps 2003 et 2004, le suivi des stades phénologiques a montré une forte disparité entre les postes. Cette importante hétérogénéité spatio-temporelle peut avoir des conséquences sur la capacité des différents cépages à résister au gel printanier. Etant donné que la résistance au gel de la vigne décroît du débourrement à la formation du fruit et que le rythme de croissance varie suivant les cépages - le Loureiro est plus précoce que le Vinhão-, la probabilité du risque gélif varie fortement d'un secteur à un autre, même si les conditions thermiques sont homogènes. Sur le site d'Arcos-de-Valdevez, l'état physiologique de la vigne a été observé du débourrement (stade C-D) au développement des inflorescences (stade G) sur chaque poste de mesures météorologiques (Fig. 11 et 12).

Par exemple, en 2003, le 5 mars, la plupart des points de mesures sont au stade B "bourgeon dans le coton" caractérisant la sortie de dormance. Seuls les postes n°7, 10 (fortes pentes) et 3 sont en début de débourrement. Le 19 mars, la reprise d'activité des bourgeons est générale sur l'ensemble du site. Les postes 10, 3, 8 et 9 sont les plus avancés. Le 21 mars, après deux jours très ensoleillés, le niveau de croissance a évolué sur les points de mesures avec une forte pente. Les postes 1, 2 et 4, situés en terrasses ont un développement plus lent. La vigne est toujours en début de débourrement (C) alors que les ceps des points 7, 8 et 10 ont déjà des feuilles. Cela s'explique d'une part, par les différences de cépages (Vinhão au niveau des points n°1, 2 et 4) et d'autre part, par les caractéristiques topographiques (exposition, pente). Cette variabilité spatiale du niveau de croissance de la vigne est présente jusqu'à la floraison (Fig.12). Les postes expérimentaux où l'aléa est le plus fort (n°1, 2 et 4) correspondent aux cépages les moins vulnérables aux basses températures.

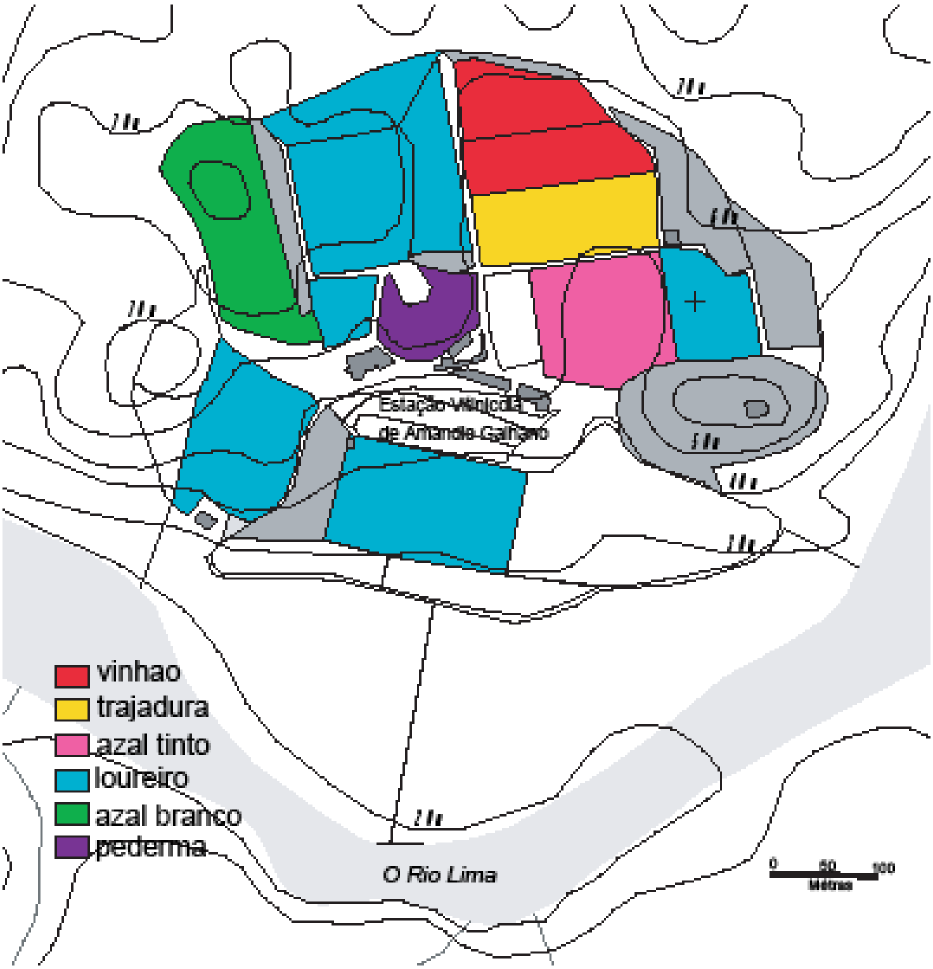


Fig. 11: *Répartition des différents cépages*

Les analyses de teneur en alcool réalisées en septembre 2003 ont montré d'importantes différences liées aux cépages mais également engendrées par la variabilité climatique locale et notamment la température. Par exemple, les parcelles de Loureiro enregistrent des différences de plusieurs degrés sur l'ensemble du site d'Arcos-de-Valdevez (Fig.11 et 13).

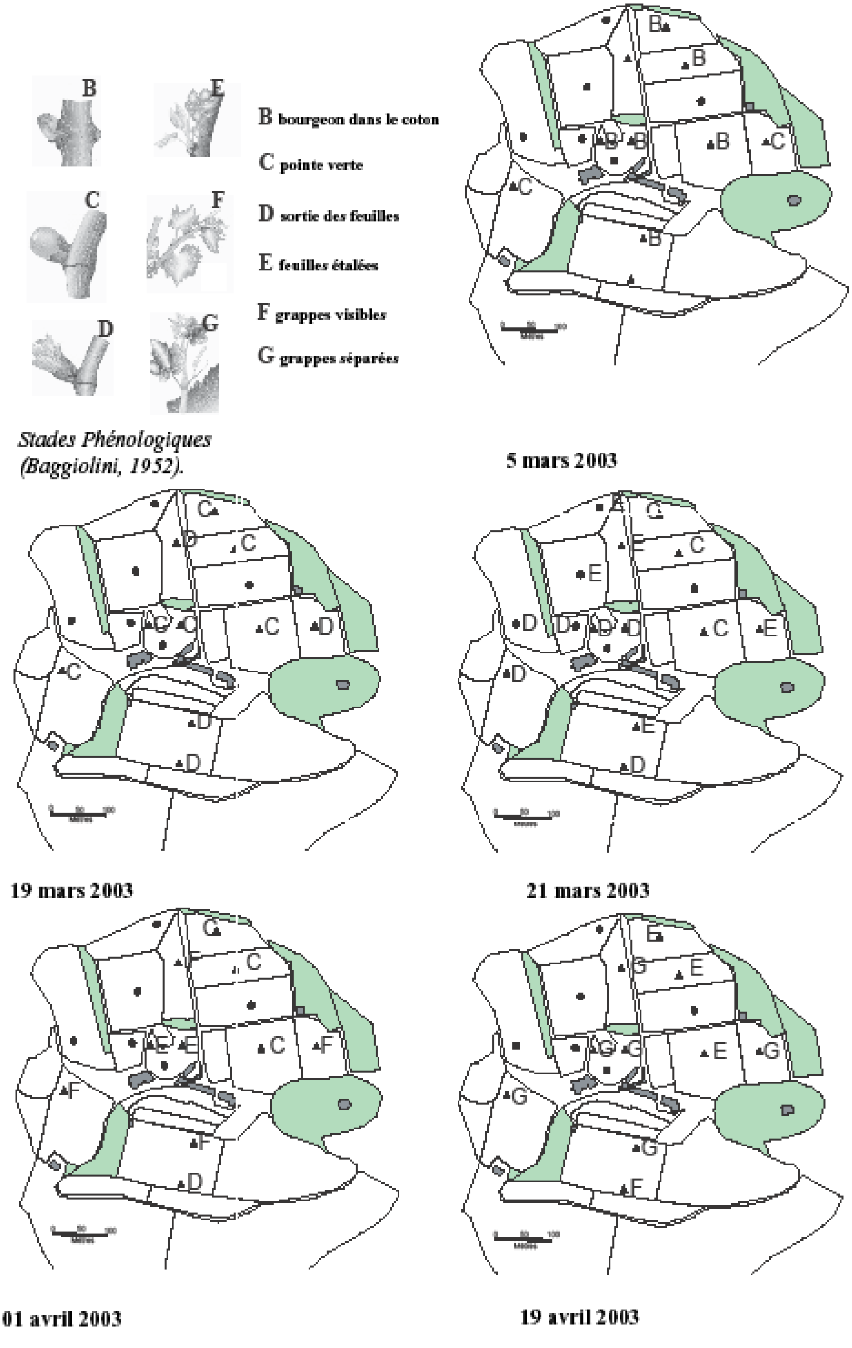


Fig. 12: *Niveau de croissance de la vigne du débourrement à la formation des grappes sur le site d'Arcos-de-Valdevez.*

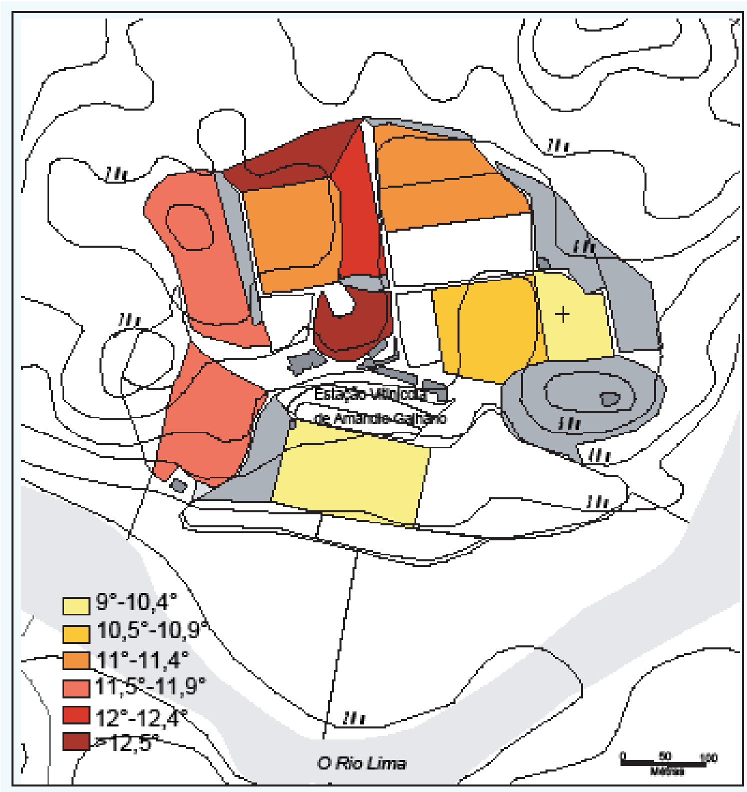


Fig. 13: *Teneur en alcool observée en septembre 2003.*

4. DISCUSSION ET CONCLUSION

Cette étude a permis d'évaluer ainsi l'influence des facteurs locaux sur l'hétérogénéité de la qualité du raisin et du vin observée. Les résultats ont montré une très forte variabilité spatiale des températures notamment en situation de gelées printanières radiatives et lors de la canicule de l'été 2003. Cette forte variabilité spatiale du climat local a eu un impact sur le développement de la vigne et sur la qualité du raisin : forte variabilité spatio-temporelle du niveau de phénologie pour un même cépage ; forte hétérogénéité du niveau de maturité du raisin, …

Les mesures des températures sous abri et en indice actinothermique réalisées au printemps 2003 ont mis en évidence une forte variabilité spatiale sur des espaces relativement restreints: entre les deux sites expérimentaux (distants de quelques kilomètres) et à l'intérieur même du site (quelques mètres).

Le microclimat sur le site d'Arcos-de-Valdevez se définit par une forte variabilité spatiale des températures engendrée par la topographie. Par exemple, les températures nocturnes en situation radiative (ciel clair, vent inférieur à 2 m/s) sont plus faibles sur les terrasses ou dans les secteurs où l'air froid véhiculé par les écoulements gravitaires a tendance à s'accumuler. Par conséquent, au printemps, les vignes situées sur les coteaux enregistrent des températures nocturnes relativement élevées. Ces conditions ont entraîné la plantation de cépages sensibles aux gelées printanières tels que le Loureiro (cultivé sur les coteaux de ce terroir). Sur les terrasses, les températures diurnes et nocturnes sont beaucoup plus basses avec notamment de très faibles valeurs relevées lors de nuits gélives pouvant entraîner la destruction des bourgeons. Mais, dans les secteurs les plus froids, le cépage cultivé est le Vinhão (variété à débourrement tardif est peu sensible au gel printanier). Le microclimat dans la vallée de Troviscoso se caractérise par une variabilité spatiale thermique nettement moins forte que sur le site d'Arcos-de-Valdevez. Les écoulements nocturnes relativement puissants expliquent que le refroidissement nocturne radiatif est peu important. En situation gélive radiative, les températures du site sont homogènes et les écarts avec Arcos-de-Valdevez sont considérables (jusqu'à 7°C). Ce terroir est donc caractérisé par des températures minimales printanières assez élevées. Ces conditions climatiques sont donc très favorables au cépage Alvarinho qui est très sensible au gel et qui ne supporte pas les fortes amplitudes thermiques diurnes. Ce microclimat, très localisé, explique (en partie) la très faible surface où ce cépage est cultivé (quelques exploitations dans la région de Monção et de Melgaço).

L'exemple de la variabilité spatiale des températures nocturnes montre la capacité des viticulteurs à choisir les cépages les plus adaptés afin de limiter au maximum le risque de gel printanier. Dans un contexte de changement climatique, l'étude du climat aux échelles fines paraît indispensable afin que les professionnels viticoles puissent adapter leurs pratiques culturales en fonction d'une nouvelle donne climatique en mettant en œuvre leur savoir-faire (techniques culturales raisonnées, évolution des variétés …). Les différents scénarios climatiques pour le 21ème siècle et les observations actuelles prévoient un réchauffement entre 0,5°C et 2°C pour les cinquante prochaines années (Jones, 2007). L'analyse de la série thermique (Tmin, Tmax et Tmoy) de 1901 à 2005 de la station du réseau météorologique national de Serra do Pilar (Porto) met en évidence une augmentation constante de la température moyenne (Fig. 14). Dans ce contexte de réchauffement et de la forte variabilité spatiale du climat, la mise en place de ce protocole de mesures spécifiques adapté aux échelles fines s'avérera très utile pour affiner les résultats des modèles de circulation générale (MCG) en comblant l'absence de données à ces échelles afin prévoir l'impact du changement climatique à l'échelle d'un terroir.

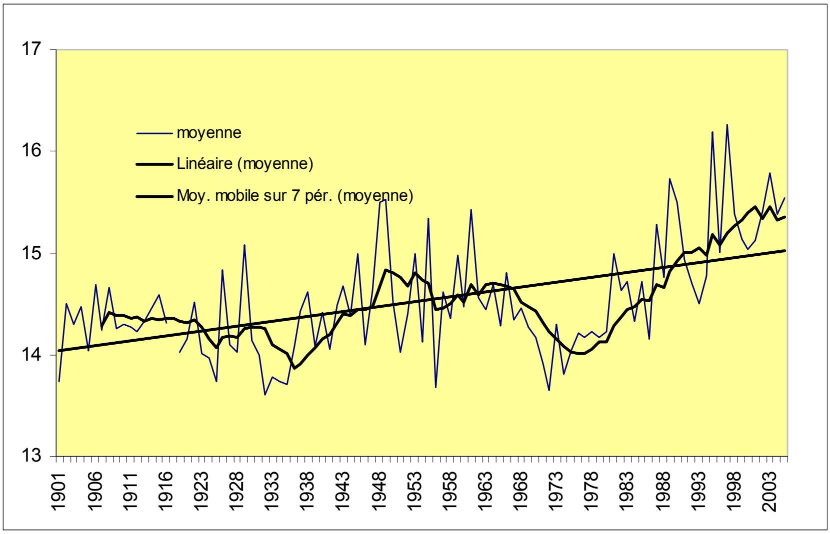


Fig. 14: *Température moyenne annuelle entre 1901 et 2005 à la station météorologique de Serra do Pilar (Porto).*

BIBLIOGRAPHIE

Beltrando G., Bridier S., Quenol H., (2006), *Utilisation des S.I.G pour la spatialisation du risque gélif accru après l'implantation d'un ramblai ferroviaire*, Geographia Technica no.1, ISSN 1842-5135, Cluj Univerity Press

Jones G., (2007), *Climate change : observations, predictions, and impacts for the wine industry.* Colloque international et pluridisciplinaire "Réchauffement climatique, quels impacts probables pour le vignoble ? UNESCO « Vin et culture ».

Monteiro A. et al, (2003) *Atlas agroclimatico do entre Douro e Minho.* Projecto POCTI/GEO/14260/1998. 345p

Madureira H., Monteiro A., Azevedo D., Ramadas I. et Ferreira C., (2002), *Productivité viticole dans le Nord-Ouest du Portugal et Variabilité climatique inter-annuelle.* Association Internationale de Climatologie, vol.14, p.120-126.

Alcoforado M.J.,(1982), *Dominios Bioclimáticos em Portugal, definidos por comparação dos indices de Gaussen e de Emberger*, C.E.G., Lisboa, 31p.

Daveau S., (1988), Geografia de Portugal – *O Ritmo Climático e a Paisagem*, Edições João Sà da Costa, Lisboa.

Garido J., (1984), *Zonagem viticola da Sub-Região de Monção, caso do "Alvarinho".*Diplome Ingénieur de l'université de Vila Real (Portugal), 150p

Quénol H., Monteiro A. et Beltrando G., (2004), *Mesures climatiques aux échelles fines (météorologiques et agronomiques) et variabilité spatiale du gel printanier dans le vignoble de Vinho Verde.* Norois, 193, 117-132.

RISQUE DE POLLUTION DES EAUX SOUTERRAINES PAR LE ZINC ET LE PLOMB EN ZONE SEMI ARIDE. CAS DE LA RN 16 RECOUPANT LA PLAINE D' El Ma El Abiod (TEBESSA) N.E ALGERIEN

A. Rouabhia[1], F. Baali [1], Ch. Fehdi[1], T. Goudjil[2], Dj. Boubaaia[1]

ABSTRACT
Heavy metals are present in all the compartments of the environment, in very small quantities. We are interested here only in lead and zinc, because after the installation of the production facilities on the perimeter of Daïra of EL My El Abiod, the area made very important great strides economic, in particular as regards supply cement portlands near the cement factory, which generated an important road traffic, characterized by the permanent presence on the national road n°16 of weight-heavy vehicles.
Keywords: eaux, souterraines, zinc, plomb, pollution

*

1. INTRODUCTION

Les métaux lourds sont présents dans tous les compartiments de l'environnement, en quantités très faibles. Nous nous intéressons ici uniquement au plomb et au zinc, parce que après l'installation des unités industrielles sur le périmètre de la Daïra d'EL Ma El Abiod, la région a connu un essor économique très important, notamment en matière d'approvisionnement en ciment portlands auprès de la cimenterie, ce qui a engendré un trafic routier important, caractérisé par la permanente présence sur la route nationale n°16 de véhicules poids-lourds.

A cause de cette situation, et parce que la principale ressource en eau souterraine se trouve dans des formations très perméables et naturellement mal protégées, nous avons pensé à une simple étude de type diagnostique, qui a pour intérêt de voir l'état et la situation des eaux souterraines vis-à-vis de la pollution par les métaux lourds (et en particulier la pollution engendrée par le trafic routier).

Pour mettre en évidence cette situation, nous avons utilisé deux campagnes hydrochimiques, la première concerne les résultats d'analyse du Zn et Pb effectués sur l'ensemble des puits de la plaine (campagnes de mars 2003. Lab. E.N. Ferphos). La deuxième campagne a quant à elle été effectuée à l'étranger (Institut de chimie de l'université de Lille) et a été réservée uniquement aux puits situés à proximité de la route nationale 16.

2. MATERIEL ET METHODES

2.1. Situation géographique

La plaine d'El Ma El Abiod est située à 260 km de la mer Méditerranée, à la limite de la frontière Algéro-Tunisienne, elle appartient entièrement au bassin versant saharien et

[1] *Université de Tébessa. Département d'Hydrogéologie. Algérie.*
BP 34-A 12004 Nahda
[2] *Université de Tébessa. Département de Biologie. Algérie.*

fait partie intégrante des hauts plateaux, qui constituent un réseau serré de montagnes de moyenne à forte altitude plus ou moins séparées par des dépressions. La limite Nord de la plaine d'El Ma El Abiod est formée par Dj. Doukkane, Dj. Anoual et Dj. Bouroumane.

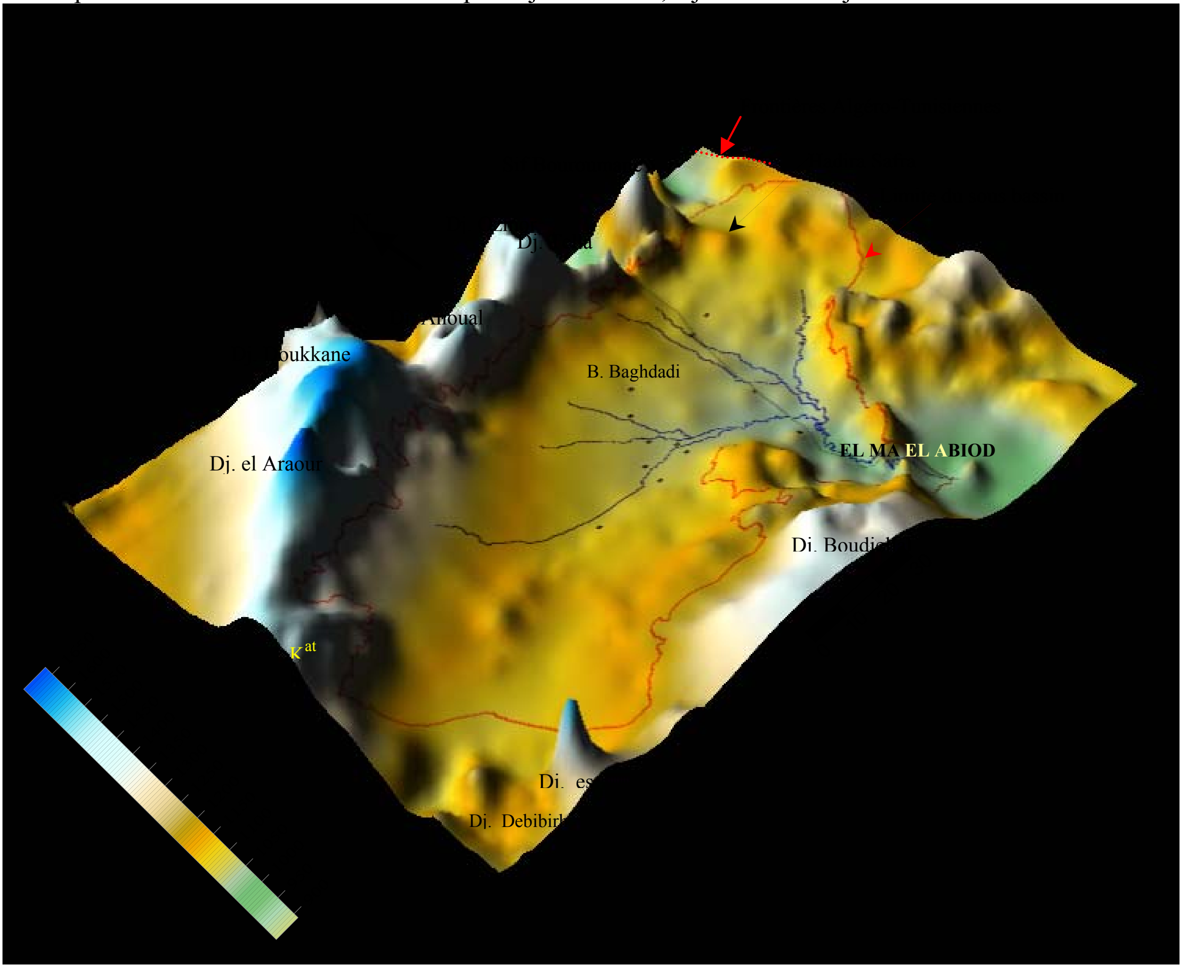


Fig. 1 - *Représentation en 3D, de la plaine d'El Ma El Abiod*

La limite Est de la plaine s'approche du territoire tunisien dans la région de Koudiat sidi salah. A l'Ouest, on trouve la plaine de Chéria, la plus haute des régions du Sud-Est constantinois, vers le sud, on rencontre en limite de zone, la plaine de Telidjen, caractérisée par un faible réseau hydrographique.La limite Sud est constituée par le synclinal de Bir Sbeikia d'age Mio-Quaternaire.

La plaine d'El Ma El Abiod est traversée par la grande voie de communication nord-sud : Tébessa - El Oued et Nord- SE : Tébessa – Bouchebka vers la Tunisie.

2.2. Contexte géologique

La plaine d'El Ma El Abiod n'a pas fait l'objet d'une étude géologique précise, mais elle est intégrée dans un ensemble géologique un peu mieux connu. Seuls ont été réalisés à partir des années 1970, et dans le but de recherche de l'eau et du pétrolier, des forages et une étude géophysique. La région faite partie de l'Atlas Saharien. Elle est limitée par des plis d'axes NE-SW au Nord et au Sud, il s'agit d'un haut plateau où on peut distinguer deux grands ensembles :

- Les affleurements de bordure d'âge Crétacé ;
- Les formations d'âge Miocène et Quaternaire occupant la totalité de la plaine.

La plaine se présente comme une cuvette, dont le substratum crétacé, calcareux et marneux, est séparée du Miocène par des éboulis très perméables.

2.3. Contexte hydrogéologique

La structure générale de la plaine d'El MA EL Abiod montre deux familles d'unités aquifères de profondeurs différentes.

La première, de faible profondeur et très étendue, se rencontre dans les formations alluviales récentes ; constituées d'argiles remaniées avec du sable et des cailloutis.

Localement, une formation de calcaires de faible profondeur (Oglat Chaachaa) été exploitée par deux puits actuellement à sec.

La deuxième se trouve dans les formations miocènes, grès, sables et graviers à plus grandes profondeurs ; elle est exploitée par une dizaine de forage et une centaine de puits. Les deux nappes sont libres, mais la nappe miocène devient légèrement captive plus à l'Est, au niveau du forage AT1.

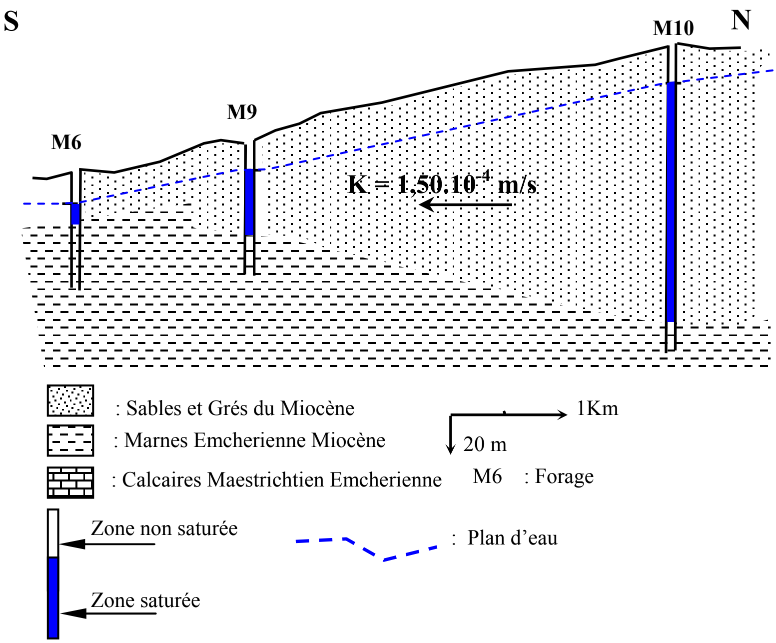


Fig. 2 - *Coupes hydrogéologiques à travers la plaine d'El Ma El Abiod (In Rouabhia 2006)*

2.4. Méthodes de prélèvements et méthodes analytiques

Pour visualiser et examiner l'éventuelle pollution par les deux éléments en question (Plomb et zinc) nous avons cartographié la répartition des deux éléments sur la totalité de la plaine, et sur les rives de la route (puits en rouge).

Les échantillons d'eau prélevée ont été dosés au laboratoire de chimie de l'Université de Lille (France).
Sur le tableau figurent quelques résultats concernant ces deux éléments :

Puits	P2	P4	P5	P7	P8	P9	P11	P12	P15
Zn	0.002	0.426	0.258	0.410	0.150	0.129	0.146	0.545	0.053
Pb	0.025	0.012	0.010	0.009	0.019	0.020	0.032	0.017	0.042

Tabel 01 *-Concentration en plomb et Zinc au point de prélèvement sur les deux cotés de la RN 16*

3. RESULTATS ET DISCUSSION

3.1. CARTOGRAPHIE DES TENEURS EN ZN ET EN PB

A- Répartition du Plomb

Sur l'ensemble de la plaine, Fig.3 les concentrations en plomb, sont élevées au centre et au Nord-Est, cette situation est confirmée par une cartographie de proximité de la source de pollution en cet élément (route nationale N°16) sur laquelle il claire que dans le secteur de M'Taguinaro les échantillons d'eau présentent des teneurs élevées

Par analogie à la répartition du zinc les concentrations en plomb suivent le sens de l'écoulement des eaux souterraines, qui se fait du nord vers le sud. Cette situation est due à la fixation de l'élément par les argiles,

Il semble aussi que ces concentrations ne sont pas dues uniquement à l'intensité du trafic routier en cet endroit mais aussi à l'activité industrielle (la cimenterie d'El Ma El Abiod), ainsi que la géologie.

B- Répartition du Zinc

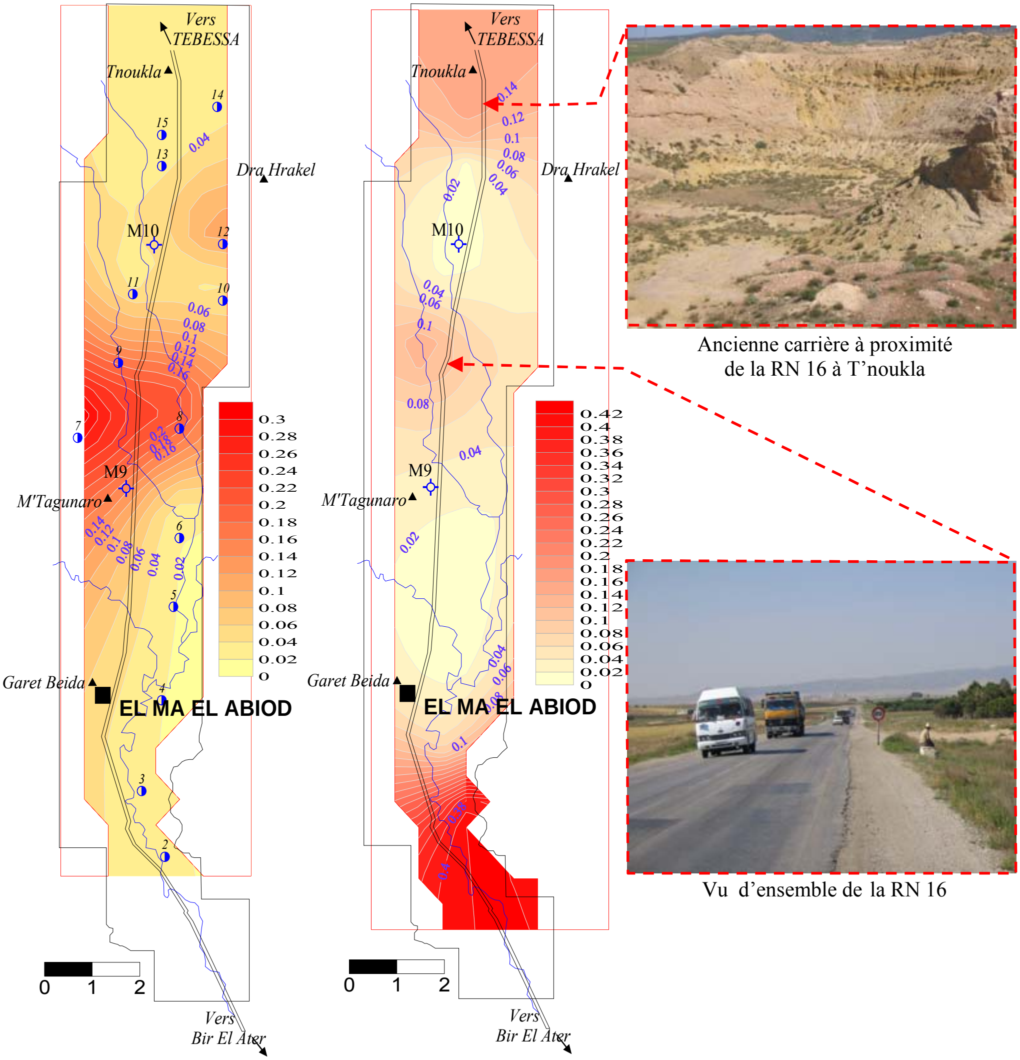
L'examen de la carte de répartition du zinc sur le territoire de la plaine, montre que ce dernier présente un comportement analogue a celui de la Piézométrie c'est-à-dire que les concentrations suivent le sens de l'écoulement, il est claire que ces concentrations commencent forte au nord, et s'affaiblissant au centre pour qu'elle se retrouve en fin en forte dose au sud à l'exutoire.

Cette situation nous a amener a pensé cartographier cet élément de part et d'autre de la route nationale 16, sur 1,5 kilomètre Est et ouest

Les deux cartes globales et parcellaires, présentent le même scénario, les concentrations sont élevées au Nord, au centre et au sud coïncidant avec les zones de recharge de la nappe, parce que en ces endroits la nappe des sables miocène se trouve a quelques mètres de la surface du sol, ce qui facilite donc l'entraînement de ces deux élément vers la zone saturée et puis directement vers la nappe.

L'accumulation des métaux lourds est très inquiétante parce qu'ils ne sont pas biodégradables et les micro-organismes du sous sols n'ont aucun effets sur leur devenir.

Les deux éléments zinc et Plomb présentent la même évolution (Fig.4), également pour ce qui est de la concentration, sauf pour le centre de la plaine, où le Plomb présente des teneurs plus élevées que le zinc, ce qui traduit une deuxième source d'alimentation en cet élément. Cette source peut être la géologie, parce qu'au centre du terrain affleurent des formations calcaires et argileuses.



a- Carte de répartition du Plomb b- Carte de répartition du Zinc

Fig. 3 : *Cartographie du Zinc et du Plomb.*

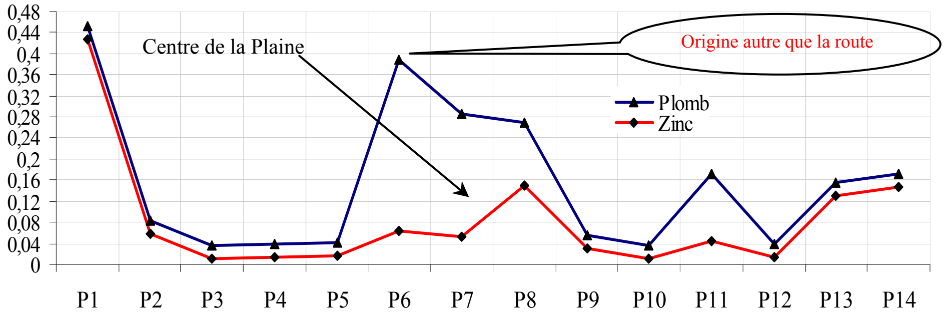


Fig. 4 : *Evolution dans l'espace du Plomb et du Zinc*

4. CONCLUSION

Les eaux de la plaine d'El Ma El Abiod présente une très bonne qualité en terme de potabilité, les teneurs en éléments qui constituent l'objet de la présente étude, sont au-dessous des normes de potabilité, chose qui à l'instant ne présente aucun danger, mais les concentrations enregistrées sont alarmantes, elles constituent en outre un début vers la contamination des eaux de la nappe, en dehors des mesures de protection.

Les éléments de diagnostique, montrent que l'environnement de cette ressource ne permet plus de garantir à l'eau une qualité suffisante, d'ailleurs l'absence de stratégie de protection de cette dernière rend urgent la mise en évidence des causes de pollution par le trafic routier, car il est très probable que dans un avenir proche, on renoncera à l'exploitation de cette ressource a des fins d'eau potable.

5. REMERCIEMENTS

Au Pr. KHERICI N. et Pr. DJABRI L. A toute l'équipe du projet de recherche CNPRU codé G02920070001, car ce travail constitue une partie de celui-ci.

REFERENCES

Djabri L. (1996), *Mécanismes de la pollution et vulnérabilité des eaux de la seybouse. Origines géologiques, industrielles, agricoles et urbaines.* Thèse de Doctorat d'État. Université d'Annaba 280p

Debieche T H. (2002), *Evolution de la qualité des eaux (salinité, azote et métaux lourds) sous l'effet de la pollution saline, agricole et industrielle.* Thèse de doctorat. Univ. De franche comté. 199p.

Rouabhia Aek, Baali F., Kherici N., Djabri l. (2004), *Vulnérabilité et risque de pollution des eaux souterraines de la nappe des sables miocènes de la plaine d'El MA EL Abiod (Algérie),* revue Sécheresse n°4, Vol.15

Rouabhia Aek, Baali F., Kherici N., Djabri l. (2004), *Vulnérabilité et impacts des activités anthropiques sur les eaux souterraines de la région d'El MA EL Abiod*, Revue vecteur environnement, Vol.37, N°3

Rouabhia Abdelkader (2006), *Vulnérabilité et risque de pollution des eaux souterraines de la nappe des sables miocène de la plaine d'El Ma El Abiod. N.E Algérie,* Thèse de doctorat en sciences. Université d'Annaba. 210p.

Rodier J. (1996), *L'analyse de l'eau, eaux naturelles, eaux résiduaires, eau de mer,* 8e édition Dunod, Paris.

Younsi A. (2001), *Méthodologie de mise en évidence des mécanismes de salures des eaux souterraines côtières en zone semi-aride irriguée. Chaouia côtière, Maroc,* Thèse de doctorat d'état. Univ. Chouaib Doukkali. El Jadida Maroc, 18-30

THE ANALYSIS OF THE RURAL TOURISM FROM 2000 – 2006

I. S. Sas[1], L. M. Țiplea[2]

ABSTRACT
In this paper we are trying to discover other "regions", different from the 8 regions of Romania according to NUTS 2. The purpose of the research is to identify classes of counties which present similar demographic characteristics within the group; thus, each county will be framed into a certain class in report with the size of the observed indicators.
Keywords: rural, tourism, countryside, pension, accommodation

*

1. INTRODUCTION

Recently the tourism geography studies became more and more important – Ghereş M. et colab. (2000), Petrea R., Petrea D. (2001), Hapenciuc C.V. (2003), Geamănu C. (2004), Nistoreanu P. (2006), Pop C. (2008). The representative accommodation structures for the rural tourism are the tourist pensions from the countryside, namely the agro tourist pensions. For the 2000 – 2006 period, were used the following time series: the total number of the accommodated tourists in the touristy units from the countryside, the number of the staying overnight and the accommodation capacity in function for the same accommodation structures. The data have been taken from www.insse.ro, from the "Tempo online" data base. Upon these data, a series of indicators were calculated in order to analyze the development of tourism:

- the average staying in the rural tourist pensions
- the tourist density reported to the rural population
- the occupancy degree
- the tourist function
- the accommodation capacity moderation in the countryside from the total accommodation structures

The analysis was made in the 2000 – 2006 interval, each of the indicators being annually calculated. For an analysis in progress, it was calculated the evolution of each indicator in 2006 in comparison with the year 2002, but also the evolution of the number of tourists from the countryside in the same period of time. We have chosen the year 2002 as a reference year due to the fact that for the years 2000 and 2001, the available data were insufficient.

2. METHODOLOGY

Taking into account that in this study there are some dependence ties between the used variables, applying the analysis of the main components, we capture the information through a small number of factors, which are independent.

---

1 „Babeş-Bolyai" University, Faculty of Economics and Business Administration, Cluj-Napoca, Romania.
2 „Babeş-Bolyai" University, Faculty of Economics and Business Administration, Cluj-Napoca, Romania.

The following stages of the research (cluster analysis) will be based on this reduce number of factors, which explain well enough the analyzed phenomenon.

The purpose of the research is to identify classes of counties which present similar demographic characteristics within the group; thus, each county will be framed into a certain class in report with the size of the observed indicators. The description of the characteristics of the groups and the counties framing into classes has a great importance towards the implementation of the adequate programs and policies for the development of the rural tourism.

3. RESULTS

The data base was made with the help of the information given by the Tempo data base of the National Institute of Statistics. It also contains other indicators calculated on the initial data. All the variables make reference to the countryside. The 41 counties from the data base have 20 variables representing their demographic characteristics (population density, birth rate, death rate, divorce rate, nuptial rate, etc.), the urbanization degree (road density, number of tourist agencies), but also the elements of the tourist offers (tourist number, accommodation capacity, number of staying overnight, average staying, occupation degree, tourist function, etc.). The demographic indicators and those which make reference to the tourist offer were calculated as the evolution of the 2006 in comparison to 2002.

The concepts used are in concordance with the stipulations of the World Organization of Tourism. The data was processed with the help of the SPSS 15.0 statistics software, after they were previously standardized because they had different measure units.

The analysis of the main components reduced the number of the initial variables to 3 factors, for which the loss of the information is of 30%. The retain information represents 69.95% of the total information, being considered sufficiently for the retaining of those three factors.

Table 1 Retained information

COMPONENT	INITIAL EIGENVALUES			EXTRACTION SUMS OF SQUARED LOADINGS		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	4.395	36.628	36.628	4.395	36.628	36.628
2	2.256	18.800	55.428	2.256	18.800	55.428
3	1.744	14.530	69.958	1.744	14.530	69.958
4	1.046	8.718	78.676			
5	.802	6.684	85.359			
6	.704	5.868	91.227			
7	.504	4.198	95.425			
8	.395	3.288	98.713			
9	.135	1.125	99.838			
10	.013	.112	99.950			
11	.006	.049	99.999			
12	.000	.001	100.000			

Extraction Method: Principal Component Analysis.

Each variable is found on one of the three factors.

During the analysis different factors were eliminated which were not representative from the statistic point of view (insignificant correlations with the other indicators (information taken over from the correlation matrix), information too little extracted (information taken over from communalities), small correlations with extracted factors (information taken over from the component matrix), KMO test and Bartlet's sphericity test were not passed).

For the other 12 remaining variables, the information extracted from each one overreach 50%, and the correlations with the extracted factors are significant.

Table 2 The correlation coefficients between the initial variables and factors

	EXTRACTED FACTORS		
	1	2	3
General population density evolution (%)-2006/2002	-.084	.602	.345
Natality rate evolution (%)-2006/2002	-.058	-.408	-.303
Internal migration in countryside environment-2006	.003	.814	.127
Medium net income-2006	.210	.602	.228
Number of agencies-2006	.116	.346	
Tourist number evolution (%)-2006/2002		-.025	.092
Accomodation capacity evolution (%)-2006/2002		-.039	-.140
Staying overnights evolution (%)-2006/2002		-.352	.491
Tourist density evolution raported to countryside population (%)-2006/2002		-.025	.082
Tourist function evolution (%)-2006/2002		-.039	-.149
Degree of occupation evolution (%)-2006/2002	-.414	-.386	
Average staying in the countryside (%)-2006/2002	-.165	-.552	

The first factor makes reference to the number of tourists from the countryside (Romanian and foreigners), the accommodation capacity and the number of staying overnight. Also, upon this factor we find the tourist density in rapport to the countryside population, and respectively the tourist function (the number of the accommodation places reported to 100 persons from the countryside).

The second factor groups demographic indicators: the overall density of population, birth rate, the internal migration balance, and the net medium nominal wage. The birth rate is conversely correlated with factor 2 because this is decreasing in the analyzed period.

Upon *the third factor* we find the number of tourist agencies, the degree of occupation of the tourist accommodation units and average staying.

From the following classification resulted nine groups, two of them containing one county, Cluj and respectively Sibiu, which have no resemblance with the other 39 counties from the analyzed characteristics point of view (see Annex 1 Dendogram).

Table 3 Group composition

GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
Bacău Braşov Prahova Vrancea	Alba Bihor Bistriţa-Năsăud Dolj Maramureş Satu-Mare Tulcea	Harghita Iaşi	Argeş Buzău Neamț Suceava	Brăila Caraş-Severin Călărași Galați Giurgiu Gorj Hunedoara Ialomița Mehedinți Olt Sălaj Teleorman Vaslui
GROUP 6	GROUP 7	GROUP 8	GROUP 9	
Arad Constanța Ilfov Mureş Timiş	Covasna Dâmbovița Vâlcea	Cluj	Sibiu	

The 9 groups were validated upon the ANOVA analysis

Table 4 ANOVA analysis

		SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.
REGR factor score 1 for analysis 1	Between Groups	37.578	8	4.697	62.066	.000
	Within Groups	2.422	32	.076		
	Total	40.000	40			
REGR factor score 2 for analysis 1	Between Groups	32.600	8	4.075	17.620	.000
	Within Groups	7.400	32	.231		
	Total	40.000	40			
REGR factor score 3 for analysis 1	Between Groups	34.491	8	4.311	25.044	.000
	Within Groups	5.509	32	.172		
	Total	40.000	40			

The above table shows that each of the 3 factors is significant in group distribution (sig.=0.000), the variation within the group is small, and that between the groups is large.

To describe the groups meant to make a reversion to the initial variables and to keep those variables which were significant (ANOVA analysis). As a result of this analysis the following variables were excluded:

- The evolution of the rural population (%) – 2006/2002
- The evolution of the birth rate in the countryside (%) – 2006/2002
- The evolution of the death rate in the countryside (%) – 2006/2002
- The evolution of the nuptial rate in the countryside (%) – 2006/2002
- The evolution of the divorce rate in the countryside (%) – 2006/2002
- The life expectancy rate in the countryside - 2006
- The public roads density (km/km^2) – 2006

It is noticed that the excluded variables are approximately the same as those from the analysis of the main components. There are 2 small differences: the birth rate was eliminated because it was insignificant in the counties distribution into groups and the infantile death rate and the international migration balance were kept, the latter ones having a high level of significance (sig.=0.017, respectively 0.009).

Group 1 is made of only 4 counties (Bacau, Brasov, Prahova si Vrancea). Characterizing the composition of this group we can say that the population density in these counties has dropped in average with 0.7% in 2006 comparing to 2002. The internal migration balance in the countryside, in 2006, was positive recording a value of 909 persons, a higher value being recorded in the counties from group 7. Similar to the other groups, the international migration balance was negative in 2006, recording a rather high value (445 persons). Unfortunately, those who migrate are the young people hoping at a bigger income and thus at a way of life close to that from the Occident. Regarding the wage, there aren't great differences between groups, the recorded value for the 4 counties from group 1 being in average of 226.98 lei. Between 2002 – 2006, an increase of the living standards was recorded in these counties, a fact shown in the reduction of the infantile death rate with

20%. In the case of the number of the tourist agencies, group 1 stands well: 19 agencies, in average in 2006. In the year 2006, compared to 2002, the capacity of accommodation in the countryside increased in average with 65%. Taking in account that Brasov and Prahova are in this group, this increase has little significance. In Bacau and Vrancea the increase of the number of the accommodation places was insignificant in the 2002 – 2006 period, but it is compensated by the increase of the other two counties which have a high tourist potential and well capitalized. Due to the multiplication of the number of accommodation places, the number of tourists also increased and that of the staying overnight in the accommodation units from the countryside increased with 88.8% in average. Due to the increasing number of tourists (the population from the countryside has reduced a little) also the evolution of the *tourist density in rapport with the population* indicator is the same: an increase of 88% in average. The increase of the number of accommodation places led to an increase of the *tourist function* indicator with 65%. This increase is not very big, the number of accommodation places reported to the countryside population being rather small. Regarding the *occupancy degree*, this has increased very little: only with 16%. Although the number of the tourists increased, the growth of the occupancy degree of the rural accommodation facilities was counteracted by the growth of the rural accommodation capacity. The average staying was almost constant, the people spending as much time in 2006 as in 2002 in their countryside holidays.

Group 2 includes 7 counties, being one of the most populated groups (see Table no.15 Group composition). The international migration balance is much smaller than that of the counties from group 1, the difference between the arrived persons and the departed ones outside the frontiers being of 197. Having in mind that this group has 7 counties, with a rather numerous population, the impact is not that great. Regarding the number of accommodation places from the countryside, this almost tripled in 2002 – 2006 period, leading to a triple number of tourists. Considering that Maramures is a component of this group, this growth is not surprising. It is well known the rural tourist potential of this county. *The tourist density in rapport with the population* and *the tourist function* had the same evolution: they tripled in 2006 as in 2002. *The occupation degree* significantly increased comparing to that recorded in the first group: approximately 47%. Also, the *average staying* recorded an average increase of 12.7%.

Group 3 has in its composition only 2 counties: Harghita and Iasi. What differentiates them from the rest of the groups is the number of accommodation places that decreased in average with 30% in 2006 as in 2002, and implicitly the evolution of *the tourist function* indicator was a descendent one. Even if the accommodation places haven't multiplied in the analyzed period of time, the number of tourists increased in average with 64%, which led to a doubling of the staying overnight and a tripling of the *occupancy degree* indicator. A growth in the accommodation capacity is not necessarily needed, being also sufficient a better financial administration of the existent accommodation units, a better usage and an intensely promotion of these.

Group 4, the same as group 1 has also 4 counties: Arges, Buzau, Neamt and Suceava. Concordant to group 1 is also the internal migration balance from the countryside: the average number of persons who settles in the countryside is with 706 bigger than that of those who leave towards the city. What differentiates them from the other groups is the much reduced number of tourism agencies, this group recording an average of 7 agencies/county. Although the number of institutions which have to promote the area is reduced, the number of tourists increased four times in 2006 as in 2002. The other indicators had in average the same evolution, excepting the *occupancy degree*, which decreased with 7%, as a result of an accentuate growth of the number of accommodation places, comparing with the number of staying overnight. Furthermore, it had reduced the duration of the average staying in these counties with approximately 15% in 2006 as in 2002.

Group 5 is the most numerous, having 13 counties (see Table no.15 Group composition). The internal migration balance in the countryside is negatively, only that the recorded value is bigger (25 persons) than in the previous group. What differentiates them from the other counties from other groups is the medium net wage, the recorded value in this group is smaller than that recorded in any other 9 groups (231.498 lei/employee). An element which indicates a rather low life standard is the infantile death rate, which has grown in average with 18 percents in 2006 compared to 2002, while in all the other counties it has reduced. Regarding the number of tourists, the accommodation capacity and the number of staying overnight, these have tripled in 2006 as in 2002.

Group 6 is made of 6 counties (see Table no.15 Group composition). In these counties the density of population stayed constant in 2002 – 2006, being the only group with such an evolution. Although the rural internal migration balance has the higher value: 1932 persons, the inhabitants of these counties preferring the quieter life from the countryside. The infantile death rate recorded o drop with approximately 30% in 2006 as in 2002, which indicates a good health system. Having in mind that this group is in the close proximity of Bucharest, and also 2 counties in the west, explains this fact. What differentiates them from the early analyzed groups is the number of the tourism agencies. In 2006 were in average 38 tourist agencies per county, this value being surpass only by Cluj.

Group 7 is made of 3 counties: Covasna, Dambovita and Valcea. In these counties the number of staying overnight considerably increased, in 2006 being recorded a value five times bigger than in 2002. This growth led to a doubling of the occupation degree indicator, due to slow increase of the number of the accommodation places than that of the staying overnight. Also, these counties record the biggest growth og the average staying: approximately 67.7%.

Group 8 has in its composition only the county of Cluj which has no resemblance with any other analyzed counties from all indicators taken into account point of view. Although the city of Cluj Napoca is an important industrial poll, the rural internal migration balance is a positive one, having a rather high value. The average net wage recorded in this county has the higher value: 247.56 lei/employee. The infatile death rate recorded the biggest drop: over 50% in 2006 as in 2002. Also, this county has the most tourist agencies (not less than 69), proving a great interest for the development of tourism. The number of tourists has the greatest value, 7 times greater in 2006 than in 2002, leading to a likewise increase of the tourist density reported to the population. Also the number of staying overnight considerably increased in 2002 – 2006, this multiplying with 8, and leading to a doubling of occupation degree of the tourist and agrotourist pensions.

Group 9 is also a one county group: Sibiu. The average net wage is pretty high, recording a very close value to that from Cluj. Although the number of tourist agencies is very low (only 9 agencies), the number of tourists considerably increased, the recorded value being 6 times greater than that recorded in 2002; the same evolution has the tourist density in the countryside. The accommodation capacity has the greatest increase in Sibiu (the number of accommodation places is 7 times greater than in 2002), which leads to an ascendent evolution of the *tourist function* indicator, but also to a drop of the occupation degree, the number of staying overnight increasing slower than that of the accommodation places.

4. CONCLUSIONS

Applying the PCA, combined with cluster analyses, it can be observed that the counties would form other "regions". Another conclusion would be that the rural tourism and the agro tourism, especially, are not yet developed, even though our country has a grate potential.

REFERENCES

Geamănu, C., (2004), *Eficienţa în turism,* Ed. Universitaria, Craiova 2004

Ghereş, M., Culda, S., (2000), *Turism rural,* Ed. Risoprint, Cluj-Napoca 2000

Hapenciuc, C. V., (2003), *Cercetarea statistică în turism,* Ed. Didactică şi Pedagogică, Bucureşti 2003

Nistoreanu, P., (2006), *Ecoturism şi turism rural,* Ed. ASE, Bucureşti 2006

Petcu, N., (2000), *Statistică în turism-teorie şi aplicaţii,* Ed. Albastră, Cluj-Napoca 2000

Petrea ,R., Petrea, D., (2001), *Turism rural,* Ed. Presa Universitară Clujeană 2001

Pop C., (2008), *The spatial distribution of touristic resources in the Sălaj County*, Geographia Technica no.1, ISSN 1842-5135, Cluj Univerity Press;

Programul Naţional de Dezvoltare Rurală 2007-2013, februarie 2008

Programul Operaţional Regional 2007-2013, iunie 2007

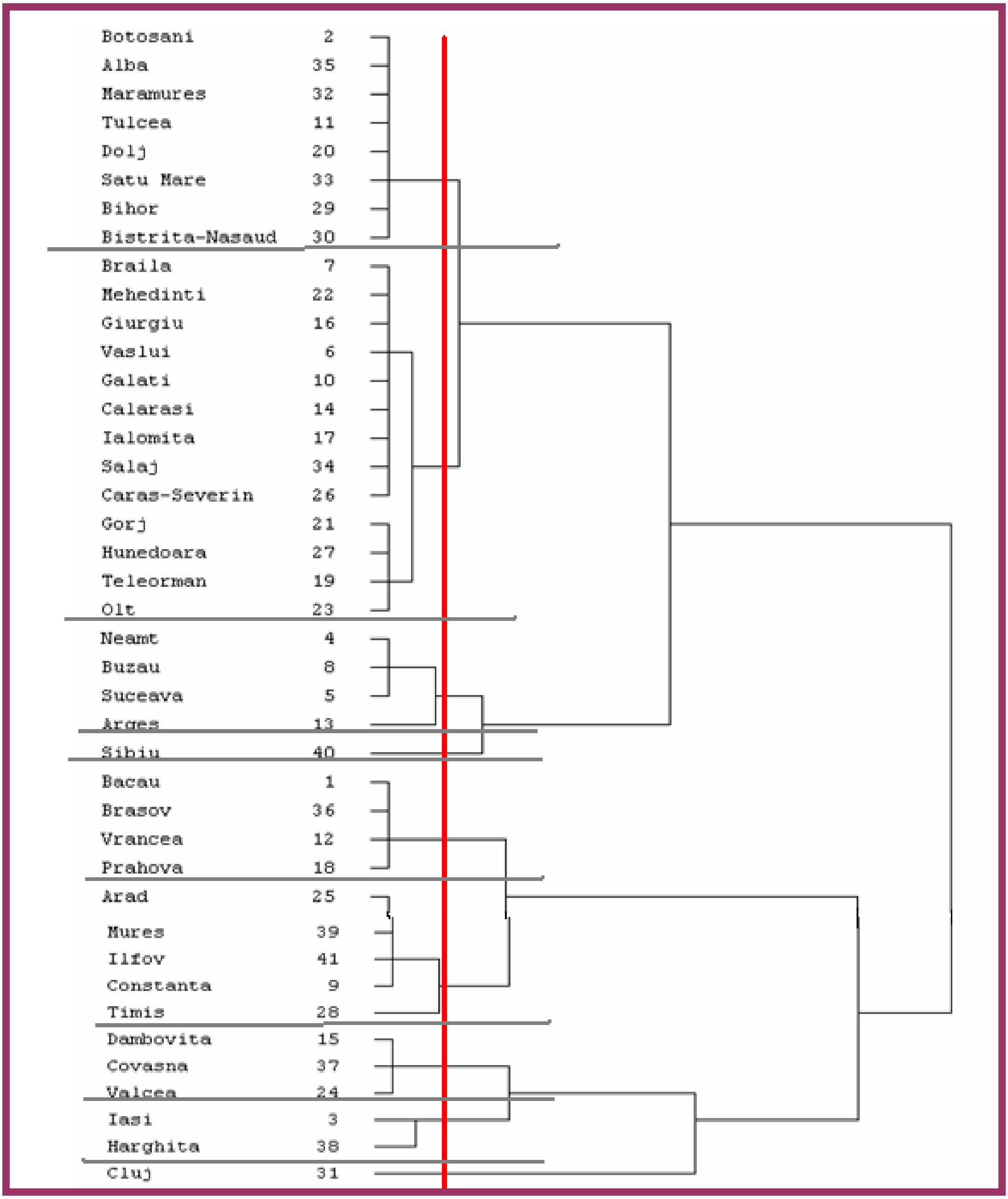
Tourism 2020 Vision, Organizaţia Mondială a Turismului

Tourism Market Trends 2006 Edition, Organizaţia Mondială a Turismului

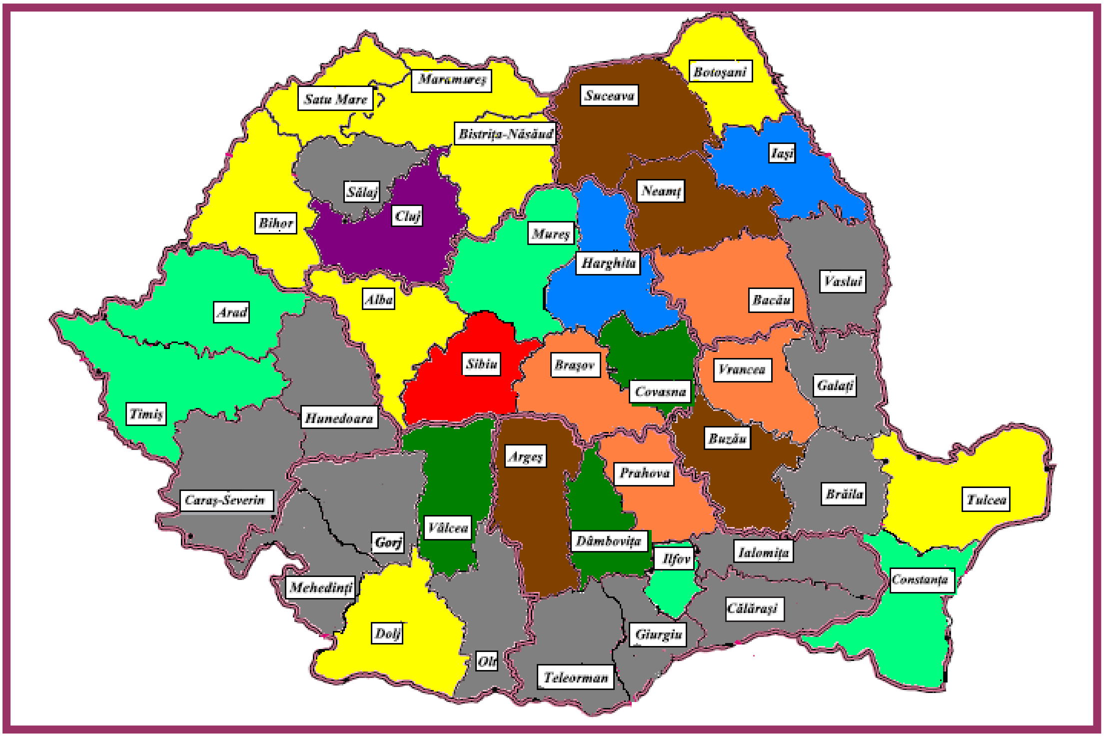
Tourism, conservations and farmers, LISTRA team, Germania, ianuarie 1998

ANNEXES

Annex 1 Dendogram



Annex 2 Map


Maramureş
Satu Mare
Botoşani
Suceava
Bistriţa-Năsăud
Iaşi
Sălaj
Neamţ
Cluj
Bihor
Mureş
Harghita
Vaslui
Alba
Bacău
Arad
Sibiu
Braşov
Covasna
Vrancea
Galaţi
Timiş
Hunedoara
Buzău
Argeş
Prahova
Caraş-Severin
Brăila
Tulcea
Vâlcea
Gorj
Dâmboviţa
Ilfov
Ialomiţa
Constanţa
Mehedinţi
Călăraşi
Dolj
Giurgiu
Olt
Teleorman

CAPPARAIS SCABRIDA (CAPPARACEAE) (SAPOTE) WOODLAND CHARACTERIZATION IN NORTHERN PERU

Bernardo Sepúlveda[1], Glenda Mendieta[1], Michael Morgan[2], Pedro Tume[3]

ABSTRACT
Capparis scabrida (sapote) grows in arid conditions, in the tropics of South America. To characterize a sapote woodland located near of the town El Tabanco (Piura, Peru) in the study area the trees were georeferenced, measured with a telemeter, and a scaled map was designed. From the map the perimeter, area, trees density and the trees cover was calculate. The Sechura desert in Piura Region is between 6º and 7º S, at 30 to 90 masl. In the woodland the biodiversity included C. *scabrida* as dominant, *Prosopis pallida* and *C. ovalifolia*, with no special plant associations. *Tiquilia dichotoma* was the only herbaceous plant. The landscape is rugged with high dunes. The vegetation is sparse and scattered. Sapote is able to retain dunes, and there was beekeeping activity. The sapote is overexploited for firewood, charcoal and for wood craft and colour ceramics production; the foliage and fruits are food for goats. The woodland covered 3.3 ha with sapote trees in a irregular grouped pattern, with density of $5.4x10^{-4}$ trees m^{-2} and covering 2.2% of the total area. There were no seedlings or saplings in this area. The sapote dry forest needed urgent conservation.
Keywords: woodland, vegetation, desertification, trees

*

1. INTRODUCTION

The *Capparis scabrida* woodland is a formation of woody plants adapted to arid conditions, unique to the tropics of South America. (Bracko and Zaruchi, 1996; Torres 2005; Vilela, 1988). *Capparis scabrida* inhabit in dry forest of northern Peru and central and southern Ecuador (0 to 2,500 m high); reported in 40% of the tropical dry forest area (2,165,820.41 ha) (Gentry, 1995,1996; Bracko and Zaruchi, 1996; Jørgensen and León, 1999).

Capparis scabrida grows linked to the presence of relatively high underground water, but non in salitrous areas. It has a good root development (80 m deep) and ability to capture moisture from the fog. They increase the humidity of the surrounding soil and air, allowing other species to grow nearby. The trees slow the advances of dunes by acting as a windbreak and physical barrier (Rodríguez et al., 1996, 2007; Mostacero et al., 2002; Pennington et al., 2004). This specie generates microenvironments giving welfare of animals by mitigating heat (Nolte, 1980), and its flowers have melliferous potential (Rodriguez et al., 1996; Mostacero et al., 2002).

Capparis scabrida is subjected to excessive human pressure, which affects the phenological development of the individual trees and the regenerative capacity of the woodland (Sepúlveda et al., 2008 in edition). It is irrationally and excessively harvested,

[1] *Departamento de Ciencias Biológicas, Facultad de Ciencias, Universidad Nacional de Piura, Piura, Peru.*
[2] *School of Forest Resources and Conservation, University of Florida, USA.*
[3] *Departamento de Ingeniería Civil, Facultad de Ingeniería, Universidad Católica de la Santísima Concepción, PO. Box 297, Concepción, Chile.*

because it is one of the few lumber providing species growing in the Sechura desert; this specie has not been subject to studies of sustainable timber, no timber product extraction or about management systems (Mostacedo and Fredericksen, 2000).

In the Sechura desert there is no a permanent herbaceous stratus; so livestock feeds too on *C.scabrida* basically by transhumance; but this system is not sustainable in the short term (Rodriguez et al., 2007; Nolte, 1991). Then residents derivates to excessive logging and selling of firewood, generating desertification (Uhlenbrock and Rodriguez, 2005).

The plants of the tropical dry forest protect the soil against erosion and direct solar radiation, preserving a proportion of humidity in the soil; the uncontrolled use of natural resources in arid areas negatively affects the structure of vegetation, with loss of forest cover, and induces the desertification process (INRENA, 1998; Torres, 2005; OITT, 2006). This increased the effects produced by droughts, overgrazing, the agriculture, and it increases with the human population (CIPCA, 2002, Abule et al., 2005, Katjiua and Ward, 2007, Hanafi and Jauffret, 2008).

The species of *Capparis* are considered critically endangered, and need urgent conservation (Ferreyra 1977, CDC-UNALM 1991, 1992; Rodríguez et al., 2007). In northern Peru monitoring and evaluation of desertification is insufficient; there is no systematic follow-up and sustained about the changes in forests, erosion and uses soil and water, nor to the impacts of other phenomena (INRENA, personal communication, 2005). A sapote woodland located near the village of El Tabanco appears to be much different than other normal *C. scabrida* woodlands, in this work the basic features of this woodland will be determined.

2. METHODS.

The study area and verification of climatic data.

The woodland studied is located near the rural settlement of El Tabanco, at km 953 of Piura to Chiclayo road, in the administrative Region of Piura, it is located in the north-west coast of Perú (3º to 7º S). Although the climatic characteristics of this desert are known some of these characteristics were verified in climatic records and publications. Some uses of local natural resources by the human population and characteristics of the place were recorded.

Map of the woodland.

For this work, a compass and other field equipment were used. The distribution of *C. scabrida* individuals, their density and the area of woodland were determined. First, the magnetic course of a Piura-Chiclayo road section just in front of the village El Tabanco was determined. In this area, the road is perfectly straight. A fixed point beside the road and in line with the first visible *C. scabrida* tree of the woodland was set as external reference. From this reference point the magnetic course of the first tree and the straight line distance to the tree were determined, records were taken in absolute angle (0 to 360º), and each tree was marked with a number. From a tree, the course and distance to the next tree were recorded into a table. These data were used to design a scale map of the woodland. On the other hand, using a telemeter (designed, manufactured and calibrated by the working group), the height and diameter for each tree crown was determined. These data were incorporated into the scale representation.

On the map, the outer edges of the tree crowns more outside in the study area were joined with straight lines to calculate the perimeter and the area of study. With these data the trees density, and the area occupied by trees were calculated in to the woodland.

3. RESULTS.

3.1. Characteristics of the study area

Within the Region of Piura is located the Sechura desert, it is ranges between the elevations of 30 to 90 m alt. and is and located between 6º and 7º S. The northern part of the Sechura desert has an annual temperature of 26ºC, and an average of annual rain fall of 50 mm concentrated in the summer months (January to March), with temperature average between 20 to 24ºC. The winter is hot and dry, with temperature of 28ºC and the maximum average exceeds 35ºC. Some climatic data were published in Rodriguez et al (1995)

Fig. 1. *Tree of Capparis scabrida and details of the flower and fruit.*

In the studied woodland the predominant specie was *Capparis scabrida* (Fig. 1). The woodland (sapotal) near El Tabanco grows in sandy soils. The landscape is very rugged with high dunes. The existing vegetation is sparse and scattered (Fig. 2). In a number of cases the trees were half buried by the dunes, showing only the crown; the trunk and lower main branches were under the sand. This species is able to retain dunes (Fig. 3).

The nearest source of surface water is located approximately 6 Km far to NW from El Tabanco, but sometimes there are small and fleeting lagoons near this place, product of the summer rains, but they are already dry in September.

Fig. 2. *Open view of the sampling area. The terrain is very irregular, with big dunes and scattered vegetation.*

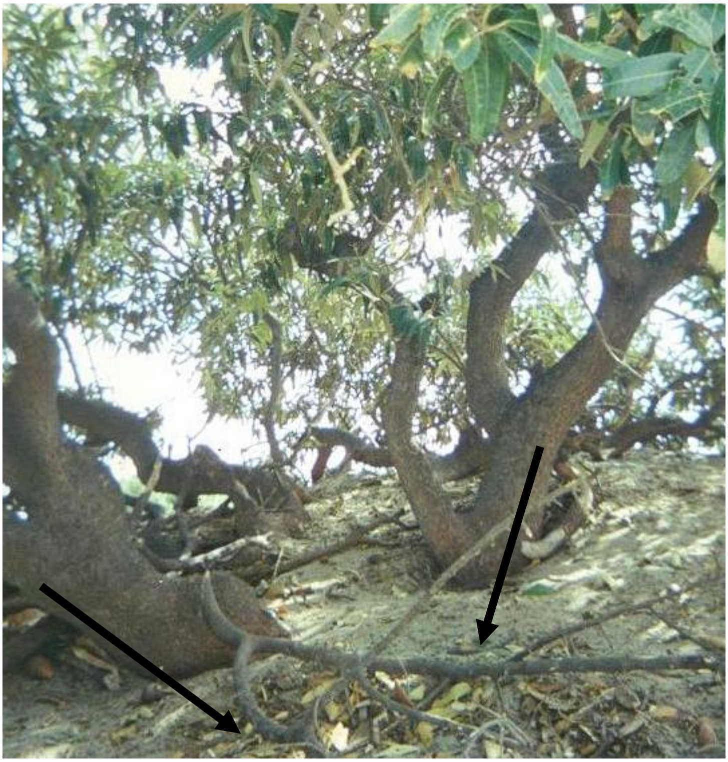


Fig. 3. *Tree of Capparis scabrida. The arrows show the main branches of a large tree, the trunk was covered by the dune*

Fig. 4. *Some comon uses of Capparis scabrida, as firewood (A) and source of crude production of honey (B, C. ovalilfolia).*

3.2. Uses of the trees

The human population, local and in nearby cities, overexploit this forest resource. For example, livestock raisers depend on the foliage and fruits of *C. scabrida* as food for a large population of goats. While the fruit of *C. scabrida* is edible to humans and has an agreeable flavour (tested by the working group), it is not consumed by people.

Sapote is a very attractive species to bees and beekeepers. In Fig. 4A apiaries can be seen near *Capparis ovalifolia*. At least three insect species use the flowers including one bee, it were not identified.

One of the main uses of *C. scabrida* is as firewood (Fig. 4B). A special use of the *C. scabrida* leaves is to give an apparently special black colour to ceramics.

3.3. Structure and some characteristics of the *C. scabrida* woodland.

The woodland near of El Tabanco covers 3.3 ha (Fig. 1); the density of *C. scabrida* trees was $5.4x10^{-4}$ trees m^{-2}, and the tree crowns covered 2.2% of the total area. The plant biodiversity is very low; the dominant species was C. *scabrida*; other species were *Prosopis pallida* (algarrobo) and *C. ovalifolia*. These two last species were not botanically associated with *C. scabrida*, *P. pallida* grew independently and *C. ovalifolia* sometimes grew in patches and alone. The only herbaceous specie was *Tiquilia dichotoma* (manito de ratón, hand of mouse). No other species were found associated with *C. scabrida* in a distinct pattern.

The *C. scabrida* trees were grouped in a very irregular pattern (E<1, Clark and Evans test). There were no obvious reasons to explain this pattern. Only some very old trees with big crowns could be considered nucleus of dispersion. These can be seen on the map (Fig. 5) as the biggest circles. They had crown diameters of 13 m and were 15 m height. There were no seedlings, saplings or younger adult trees under the oldest trees; neither just outside of their crowns nor alone in open desert. A group of firmly established trees that form a U in the map was a group of middle aged trees on the summit of a high dune far from the normal route used by shepherds to graze their goats.

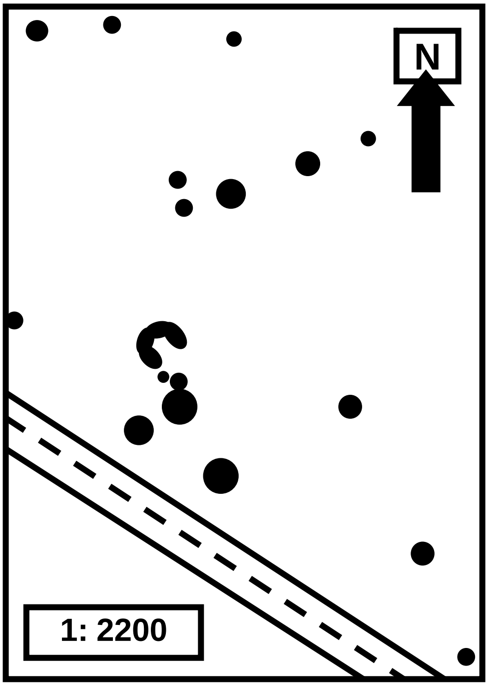


Fig. 5. *Distribution of C. scabrida trees in the studied woodland in El Tabanco, Piura (Perú). Circles represent the trees with its proportional diameter.*

The *C. scabrida* trees were grouped in a very irregular pattern (E<1, Clark and Evans test). There were no obvious reasons to explain this pattern. Only some very old trees with big crowns could be considered nucleus of dispersion. These can be seen on the map (Fig 1) as the biggest circles. They had crown diameters of 13 m and were 15 m height. There were no seedlings, saplings or younger adult trees under the oldest trees; neither just outside of their crowns nor alone in open desert. A group of firmly established trees that form a U in the map was a group of middle aged trees on the summit of a high dune far from the normal route used by shepherds to graze their goats.

4. DISCUSSION

The studied woodland, although the trees were widely scattered, is a subtropical dry forest, but whose coverage is affected by the pressure exerted by the adjacent human population and indirectly by demand for wood and compounded by the closeness to the rural town. These pressures affect the ability of sapote to natural regeneration (Sepulveda et al. 2008, in edition). The evaluation of woodland was done with simple tools. The telemeter was designed, built and calibrated in the university as part of an implementation of country techniques; the measurements were accurate more than 97%, depending on the adequate training of observers. The use of the compass provided very precise measures to determine the position of the trees. The measurement of the entire area was very fast (approximately two mornings). Move data to a map scale allowed calculate absolute data (density, grouping, etc.) from a wide area. The same method was used in other jobs in areas of mayor density of trees with the same advantages.

The soil and climatic conditions do not allow in Piura the existence of a perennial herbaceous layer for the sustainable development of animal husbandry, so the shrub and tree strata of the forest become important for this activity. This system is not sustainable in the short term nor there is a management plan, it is rather predation. It seems obvious that because the little money that is obtained and the lack of options in this system, people should get more resources from the forest, and the natural resources of the dry forests are overexploited by human activities as overgrazing, firewood, charcoal and others, generating desertification; view similar to that of Uhlenbrock and Rodriguez (2005) in relation to the problem of *Prosopis* spp. According to these authors, *Capparis angulata*, and *C. ovalifolia*, are in third and eighth place in the over-exploitation to be used as food for goats in Piura (Nolte, 1980).

The problem of desertification requires periodic assessment of the condition of forests. But in this area there is not sustained and systematic monitoring of changes in forests, erosion, soil and water uses, nor for the impacts of various phenomena; also it was mentioned the need for more investment in desertification control (INRENA, Personal communication, 2004).

In the woodland, *C. scabrida* produce micro environments under its crown; giving an environmental service, lessen the intensity of the heat simply by his shadow, maintaining a moisture content in soil, space and minimum conditions for the maintenance of others species, including for the working group.

The natural populations of *C. scabrida* have decreased significantly (Shimada, 1994; Fernandez and Rodriguez, 2002). This is a slow growth specie and the viability of seeds and their germination percentage decreases drastically in time, be regarded as short shelf life or recalcitrant and high susceptibility to attack by termites (Chaman et al., 1988; Lopez et al., 1988; Rodriguez & Matias, 1989; Paredes, 1993) and beetles of the Anobiidae family (Sepúlveda et al. 2008, in edition). This species is important because it grows in all types of soils, except in salitrous, and is associated to underground water (Rodríguez et al., 2007), the water is sucked up very close to the ground, creating a chances of getting even small water wells, as was observed in country. Moreover, from apiaries near of groups of *C. scabrida* and *C. ovalifolia* a significant quantity of honey of excellent quality was obtained, this information is confirmed in literature (Rodriguez et al., 1996; Mostacero et al., 2002). In spite of the antecedents in this very open woodland the very low humidity in soil, the high temperatures, the loosing of trees and overgrazing, perhaps can explain why in the studied woodland there were not young trees or seedlings.

It was important that in the study area the ground was very irregular, while in normal *C. scabrida* forests practically there are no dunes and the soil is very stable, The sapote, *C. scabrida*, can form natural barriers to stop the advance of dunes, it is confirmed by other authors (Hocquenghem, 1999; Tarazona, 1999). A similar specie, *C. spinosa* grows on arid terraces in the south of the Sinai desert and shows a correspondence between vegetation and soil factors (Monier et al., 2003). In the El Chaco desert (Córdoba, Argentina), *C. atamisquea* colonizes microsites and could be an important regeneration mechanism for the forests of this zone (Páez and Marco, 2000).

5. CONCLUSIONS

It's very necessary to study *C. scabrida*, and other species from woodlands in order to insist in well defining their role within the tropical dry forest ecosystem. Plant species adapted to the desert are important as natural resources to combat desertification and because they are part of the very sensible trophic chain of tropical dry forests. Is possible to recuperate or restore tropical dry forests and woodland, such as the studied one, with production of seedlings, plantation and promotion of natural regeneration. Another option is to create commercial plantations of fast and managed growing trees for materials such as firewood and poles near the communities that use the forest. This would decrease the pressure upon the natural tropical dry resources.

6. ACKNOLEDGEMENTS

This work was carried out in the Universidad Nacional de Piura, Piura (Peru), and financed by internal project. The preparation of this paper was supported by the Office of Research and Graduate Studies of the Universidad Católica de la Santísima Concepción (Chile).

REFERENCES

Abule, E., Snyman H.A., Smit, G.N., (2005), *Comparisons of pastoralists perceptions about rangeland resource utilisation in the Middle Awash Valley of Ethiopia.*, J Environ Manag 75(1): 21-35.

Bracko L., Zarucchi, J., (1996), *Catalogue of the flowering plants and Gymospermae of Perú.* Monogr. Syst. Bot. Missouri Botanical Garden Press 45: pp.1286.

CDC-UNALM, (1991), *Plan director del Sistema Nacional de Unidades reconservación (SINUC), una aproximación desde la diversidad biológica* (Propuesta del CDC-UNALM). Centro de Datos para la Conservación (CDC) – Universidad Nacional Agraria La Molina (UNALM), La Molina, Lima (Peru), (153 pp.).

CDC-UNALM, (1992), *Lista de la flora en áreas manejadas del bosque seco del noroeste. In Estado de conservación de la diversidad natural de la región noroeste del Perú*. Universidad Nacional de La Molina (UNALM), La Molina, Lima (Perú), (pp. 181-198). Available in http://www.nmnh.si.edu/botany/projects/cpd/sa/sa41.htm December 2006.

Chaman, M., López, E., Alvítez, E., (1988), *Crecimiento de Capparis angulata Ruiz & Pav. (sapote) durante el primer año de vida en condicione de laboratorio.* Available in Libro de Resúmenes IV Congreso Nacional de Botánica, 11-15 Octobre 1988, Trujillo, Peru, (pp. 119).

CIPCA, (2002), *Proyecto descentralización y desarrollo regional en Piura. Análisis de variables, subsistema medio natural.* Gobierno de Navarra-Centro de Investigación y Promoción del Campesinado (CIPCA), Piura (Perú). Available in www.cipca.pe, 2008

Fernández, A., Rodríguez, E., (2002), *Etnobotánica del "sapote"(Capparis scabrida H.B.K.) y del "guayabito del inca" (Capparis avicennifolia H.B.K.).* In Abstract book of IX Congreso Nacional de Botánica, 17-22 June 2002, Iquitos, Perú, pp. 177.

Ferreyra, R., (1977), *Endangered species and plant communities in Andean and coastal Peru.* In Prance, G.T. and Elias, T.S. (eds), Extinction is forever: threatened and endangered species of plants in the Americas and their significance in ecosystems today and in the future. New York Botanical Garden, Bronx, pp. 150-157.

Gentry, A.H., (1995), *Diversity and floristic composition of neotropical dry forests. In Bullock, S.H.,* Medina, E. and Mooney, H.A. (eds), Tropical deciduous forest ecosystems. Cambridge University Press, Cambridge, U.K. pp. 146-194.

Gentry, A., (1996), *To the families and genera of woody plants of Northwest southamerica.* Univ. de Chicago Press, Usa. 895 pp.

Hanafi, A., Jauffret, S., (2008), *Are long-term vegetation dynamics useful in monitoring and assessing desertification processes in the arid steppe, southern Tunisia*. J Arid Environ 72(4): 285-582.

Hocquenghem, A.M., (1999), *Una historia del bosque seco. En: Bosques secos y desertificación* . Memories of the Seminario Internacional Proyecto Algarrobo, Instituto Nacional de recursos Naturales (INRENA). Ed. Didi de Arteta., Lambayeque, Peru, pp 231 – 254.

Inrena, (1998), *Bosques secos y desertificación.* Memories of the Seminario internacional Proyecto Algarrobo. Instituto Nacional de Recursos Naturales (INRENA). Lima (Perú), pp 231 – 254.

Jørgensen, P.M., León-Yanez, S., (eds.), (1999), *Catalogue of the vascular plants of Ecuador.* Monogr. Syst. Bot. Missouri Bot. Garden. Vol 75.

Katjiua, M., Ward, D., (2007), *Pastoralists' perceptions and realities of vegetation change and browse consumption in the northern Kalahari,* Namibia. J Arid Environ, 69(4): *716-730***.**

López, E., Chaman, M, Alvítez, E., (1988), *Potencial germinativo de Capparis angulata Ruiz & Pav. (sapote).* In Book of abstracts of the IV Congreso Nacional de Botánica, 11-15 October 1988, Trujillo, Perú, pp. 118.

Monier M., El-Ghani, A., Amer, W.M., **(**2003), *Soil vegetation relationships in a coastal desert plain of southern Sinai, Egypt.* J Arid Environ, 55(4): 607-628.

Mostacedo B., Fredericksen, T., (2000), *Estado de regeneración de especies forestales importantes en Bolivia: Evaluación y Recomendaciones.* Contrato USAID, Chemonics Internacional, Objetivo estratégico del medio ambiente (USAID/Bolivia), 28 pp.

Mostacero, J., Mejía, F., Gamarra, O., (2002), *Taxonomía de las Fanerógamas útiles del Perú. Vol. I.* Edit. Normas Legales SAC. CONCYTEC. Trujillo, Peru.

Nolte, E., (1980), *Relación Cabra–Monte.* Departamento de Producción Animal, Programa Académico de Zootecnia, Universidad Nacional Agraria La Molina. Peru.

Nolte, E., (1991), *Investigación sobre forrajeras xerofíticas y capricultura (1984-1989).* Project: "Sistemas de producción caprina", Centro Internacional de Investigaciones Para el Desarrollo (CIID)–(INIAA). Peru.

OITT (Organización Internacional de las Maderas Tropicales), (2006), *Prevención, manejo de incendios forestales e impactos ambientales en la cuenca baja y media del río Piura, Peru,* 54 pp. Available in: http://www.itto.or.jp/live/Live_Server/ 1633/TS-2006-03.doc.

Páez, S.A., Marco, D.E., (2000), *Seedling habitat structure in dry Chaco forest (Argentina).* J Arid Environ, 46(1): 57-68.

Pennington, T. D., Reynel, C., Daza, A., (2004), *Illustraded guide to the Trees of Peru.* Published by D. Hunt, The Manse, Chapel Lane, Milborne Port Sherbone, DT9 5DL, England.

Rodríguez, E., Matías, M., (1989), *Evaluación de la viabilidad de semillas de sapote (Capparis angulata Ruiz & Pav.) en condiciones de laboratorio.* In Book of Abstracts of the V Congreso de Jóvenes Científicos, August 2-5, 989. Lima, Perú, pp. 23.

Rodríguez, E., Mora, M., Aguilar, W., (1996), *Inventario Florístico de El Algarrobal de Moro (Provincia de Chepén, Departamento de La Libertad, Perú) y su importancia económica.* Rebiol, 16(1 y 2): 57-65.

Rodríguez, R., Mabres, A., Luckmann, B., Evans, M., Masiokas, M., Ektved, T.M., (2005), *"El Niño" events recorded in dry-forest species of the lowlands of northwest Perú.* Dendrochronology, 22, 181-186.

Rodríguez, E., Bussmann, R.W., Arroyo, S.J., López, S.E., Briceño J., (2007), *Capparis scabrida (Capparaceae) a species from Peru and Ecuador in urgent need of conservation plans.* Arnaldoa 14(2): 269-282. Available at http://www.scielo.org.pe/scielo May 2008.

Shimada, I., (1994), *La producción de cerámica en Mórrope, Perú: Productividad, especialización y espacio vistos como recursos.* In Tecnología y organización de la producción de cerámica prehispánica en los Andes. I. Shimada (Ed), Pontificia Universidad Católica del Perú, Fondo Editorial, Lima, pp. 295-319.

Tarazona, R., (1999), *Variabilidad de los bosques secos en la costa norte del Perú. En: Bosques secos y desertificación.* Memories of the Seminario Internacional Proyecto Algarrobo, Instituto Nacional de Recursos Naturales. Ed. Didi de Arteta., Lambayeque, Perú. pp 297-307.

Torres, F., (2005), *Desertificación por minería metálica en páramos y bosques de niebla de nacientes de cuencas en el norte del Perú.* Zonas Áridas (Peru) Nº 9.

Uhlenbrock, M., Rodríguez, A., (2005), *Evaluación de la productividad primaria neta arbórea potencial y la arquitectura vegetal para una mejor producción caprina en el departamento de Piura*. Zonas Áridas Nº 9: 184-211.

Vilela, P.J., (1988), *Ensayos experimentales para optimizar el uso del recurso hídrico en la zona árida costera del Perú.* Informe técnico, Instituto Nacional de Investigación Agraria (INIAA), Peru, 37 pp.