# BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI

**Tomul LV (LIX)**

**Fasc. 1**

**HIDROTEHNICĂ**

**2009**

**BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI**
PUBLISHED BY
**„GHEORGHE ASACHI" TECHNICAL UNIVERSITY OF IAŞI**
Editorial Office: Bd. D. Mangeron 63, 700050, Iaşi, ROMANIA
Tel. 40-232-278683; Fax: 40-232 237666; e-mail: polytech@mail.tuiasi.ro

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BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LV (LIX), Fasc. 1 2009

# HIDROTEHNICĂ

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BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
BULLETIN OF THE POLYTECHNIC INSTITUTE OF IAŞI
Tomul LV (LIX), Fasc. 1 2009

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# USING GIS TO DETERMINE THE FAILURE RISK IN THE WATER SUPLY NETWORK. THE CASE STUDY OF A SQUARE FROM BAIA MARE CITY

BY

**IULIUS EDUARD KELLER, *IONEL HAIDU and **ŞTEFAN BILAŞCO**

**Abstract:** The water supply system is subjected to different flows varying within very large limits, the nature of these flows running through the pipes and fittings of the system are great diversity. The different situations the system is submitted, cause a number of disturbances, which can turn into serious failures if they are amplified.

By integrating graphic and alphanumeric data, the GIS turns into a computerised system for automatic elaboration of maps or diagrams, a general-purpose computerised graphic system, as well as a system that can store, process, combine and analyse data and information on the water systems, it can produce new added-value information. Thus, we can obtain information on the areas at risk of failure in the water supply systems and the flooded areas**.** After having carried out such interrogations and analysis and having presented the results to the decision-makers, more efficient planning and reduced planning costs can be achieved for the maintenance works, repairs and replacement in the water supply systems.

**Key words:** water network, model simulation, GIS.

## 1. Introduction

The GIS system can be considered as an *information management system or as a support for the decision-making system.* GIS provides the possibility *to entry, to maintain and especially to interpret and to analyse rapidly and efficiently the data regarding the water and sewerage systems.*

The GIS processing results are not only much more effective in the information process – decision-making, production, inventory – where they are used, but also they entirely change our perception with respect to the surrounding reality: they provide a quicker and better understanding of the facts and phenomena we analyse and act on.

According to the studies that had been carried out, more than 80% of the data used by the water and sewerage companies have a geographical reference, thus the GIS support is necessary for the efficient development of the activities and for the informational flow fluidisation. Considering the importance of the geographical data in the work of these companies, the GIS applications have a great contribution to the optimisation of the informational flows. Currently, the focus is on the interoperability of the GIS systems, and several efficient functions are integrated with the existing solutions provided by the authorities. *Moreover, the integration of GIS solutions with other systems can provide an exhaustive image on the management process efficiency.* More and more lapped models, (mathematic model – geographic information system) have the tendency to absorb the specific forecast and simulation systems (*simulation models for the flows in the water and sewerage systems*, underground water flow simulation models, etc.).

*The Geographic Information Systems together with hydraulic modelling of sewerage systems simulate critical situations that could take to failures or to their inadequate operation***.** Moreover, the Geographic Information Systems together with the hydraulic modelling of the water supply networks, correlated with a *SCADA* system (*Supervisory Control and Data Acquisition*), can be used for the automation and supervision of the complex water supply networks.

The data base applications are also an important factor in the generation of GIS solutions as they are the element that defines the performance level of these implementations.

*As compared with other European countries, Romania is currently far behind with respect to the information summarization and access to information. The creation of a geographical information system implies exactly the access to diverse and updated information. The settlement of these disparities is part of Romania's efforts to integrate in the Euro-Atlantic structures.* (Bălteanu D., 2002)

## 2. General Causes of Failures in the City of Baia Mare

The analysis of the causes that produce the failures is of utmost importance in determining the measures to be taken. These causes are multiple and they occur in different life cycle stages, being of a great diversity, depending on the material the pipes are made of, on the calculation, execution and technical exploitation conditions, on their age, on the flows they are submitted to during their life cycle.

It would be a mistake to consider that any loss of water is caused by execution faults or that any loss would turn into a fatality that cannot be solved. Researches that had been carried out showed multiple causes of the failures, and the measures taken allowed the limitation of the water losses. The measures to be taken cover the whole life cycle of the systems, from the layout phase, the execution phase and a special attention is paid to the system using phase which represents the longest of the life cycle.

Knowing the causes is crucial in order to be able to take the right correction measures for the remediation of the failures. Sometimes these causes are obvious, thus the measures can be taken immediately; this situation is generally characteristic to failures. But there are also situations when the causes of serious failures or breakdowns that produced great losses of water cannot be easily identified, either because of the complexity of their effects or because of the engineers lack of experience or even because of the length of time necessary for the searches that need to be carried out for an adequate determination of the causes.

During the past 10 years, in the city of Baia Mare significant changes were done concerning the supply of water based on categories of consumers, especially as a result of the decrease in the water demand in the eastern and western industrial areas (these areas have their own adequate transport networks) and the increase of the demand in the residential areas where the number of constructions is very high and the supply systems are overflowed considering their optimum transport capacity, this taking to the under-dimensioning and the decrease of the pressure level. *This capacity transfer from a section to another within the system caused the modification of the hydraulic level (speed, pressure, running way), the pipes being submitted to a heavy exploitation level in the residential areas.*

In the layout phase of the transport pipes, supply and connecting pipes, the properties of the drinking water supplied by the Water plant and those of the land where they were to be situated were not taken into consideration. The study prepared by the Institute for Research and Environmental Engineering emphasises the *dealkalinization aggressiveness towards the concrete and the heavy aggressiveness towards the metals. In order to cut the execution costs, the anticorrosive protection was neglected.*

These two causes determined a life cycle *of at most 7-8 years* for the pipes (especially those made after 1980), afterwards those made of steel and asbestos-cement need expensive maintenance because of the frequent cracks and bursts.

*Failures also occur due to the old age of the pipes in some cases, due to the inadequate quality of the metallic pipes, due to the poor quality in the installation works and to the anticorrosive protection of the pipes against the heavy aggressiveness of the soil, etc.*

## 3. Impact Caused by Failures in the City of Baia Mare

### 3.1. Technical and Cost Impact

The multiple failures of the pipes cause financial difficulties for the company. Basically, the Department for repairs and maintenance and most of the available technical equipment deal only with the keeping the supply system operational.

*The repair works at the pipes* include the following operations: the emptying of the valve manholes, manipulating the valves so as to seal the damaged section, cutting out the asphalt layer, breaking the concrete, digging, draining out the water in the cut, replacing the damaged section, refilling and valve adjustment, restoration of the asphalt layer. All the aforementioned *repair works cost 5-10 times more than the building of a new pipe.*

### 3.2. Social Impact

The frequent failures in the pipes and the repairs of the fire cocks and of the valves *cause water interruption to consumers in large areas.* Due to the difficult turning off of the water (key valve that cannot be turned off tightly anymore, needing the doubling of several sections), due to the difficult digging in the asphalt and concrete, to the inadequate equipment and poor organisation in some cases, *the repair time takes up to 5-12 hours.*

Since the washing and the disinfection of the pipes after repairing are not possible, the water supplied in the first hours after the restart *has high turbidity and it is slurry; thus the discontent consumers* often complain and refuse to pay the entire amount of the bill.

*The water interruptions cause problems in the activity of several trade companies,* especially those at the ground-floor of the residential blocks, where they do not have the possibility to store water in their own tanks, which causes production loss (at the backer's, at pizza places, in restaurants, etc.) or the interruption of the service (at the barber's, at the beauty shop, for drink batching devices etc.)

### 3.3. Environmental Impact

*The repair works at the pipes damage the roads,* because of the excavation works and of the water and sludge leakages. *In other cases, the green areas, the natural surroundings, the scrubs and the trees are damaged.* Efforts are made to rehabilitate the damaged areas, but there are still dissatisfactions of the Municipality, as well as of the citizens due to the multiple works of the type.

During the works in the inhabited areas, *the equipment used cause air and noise pollution, this creating discomfort for the inhabitants in the area.*

## 4. Failure Risk in the Study Area

The study area is one part of the Garii neighbourhood in the city of Baia Mare, Maramureş county. It is located in the south-east part of the city of Baia Mare and it covers an area of approximately 25 ha. It is bordered in the north part by Traian Blvd., in the east part by Gării Blvd., in the south part by the Vlad Ţepeş street and in the west part by the Republicii Blvd.

For the study area, I captured and integrated several types of data regarding the locations, forms, relations (spatial or geographic data) and descriptive figures (attribute-type or alphanumeric data) of objects or geographic elements in one logical data model. Having this logical data model together with the GIS system, I made fast spatial enquiries, which can be expensive and long lasting if using other methods.

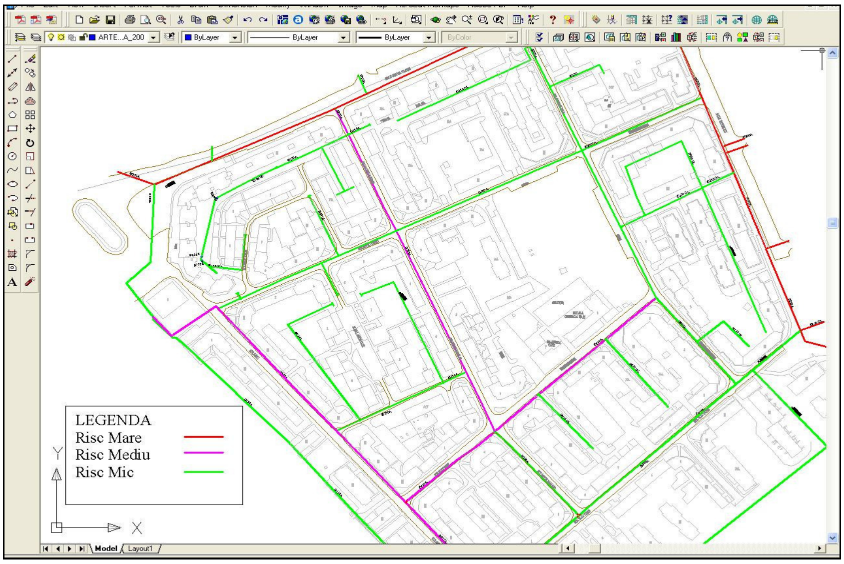


Fig. 1 – Map showing the failure risks in the study area.

In order to identify and locate the risk of flaws and failures, I considered the year of installation of the pipe sections, the material of the pipes, and the number of flaws/or failures in the study area.

I divided the risks of flaws and/or failures in the water supply system into three main categories, as follows:

*High Risk* – asbestos-cement pipes with more than 5 failures

*Average Risk* – asbestos-cement pipes with 3-5 failures

*Small Risk* – asbestos-cement pipes with less than 3 failures

The map showing the failure risks in the study area is presented in Fig.1.

It was also found that the failures in the city of Baia Mare with the most serious consequences on the population an don the neighbouring areas occur with *asbestos cement* pipes having the *longest diameter* where the occurrence of such failure is sudden, with massive *fractures of material*, and the repair works on the water pipe failure takes a long time due to the fact that the damaged section must be replaced; thus *there are long lasting water supply failures for the connected consumers.* Fig. 2 presents the results obtained in graphic format.

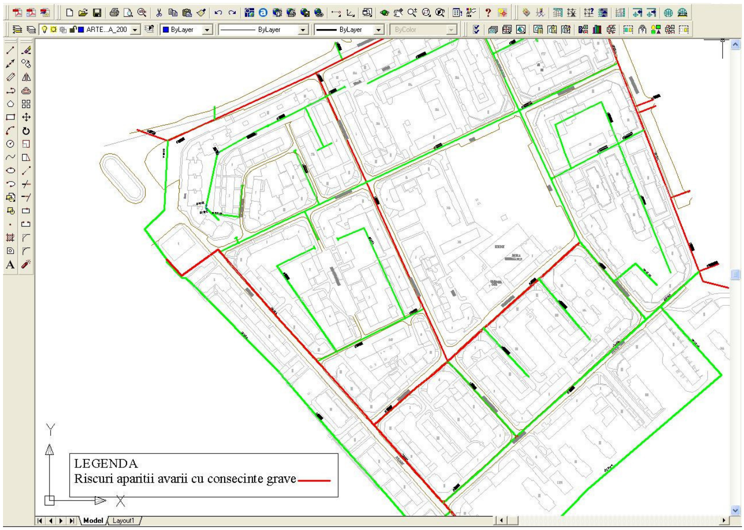


Fig. 2 - Identification and location of the pipe sections where there is risk of failures which would have serious consequences on the neighboring areas.

After carrying out such analyses and enquiries and presenting the results to the decision makers, better planning can be made with reduced costs for planning the water supply system maintenance, repair and replacement works.

## 5. Determination of the Flooded Areas

Some water pipe sections have a higher frequency of failures (more than 3/km) indicating a higher rate of wear. The high rates of pipe failures have a negative impact on the water supply services as far as the financial efficiency is concerned (the repair costs and those related to leakages) and with respect to the provided services (risk of contamination and of temporary water supply failure). Moreover, due to the fact that only 50% of the sector gates are not operational, the possibility to isolate the pipe sections for repair works is limited.

### 5.1. Determination of the Intensity-Duration-Frequency Curves

In order to establish the rain frequency, as well as to determine the IDF family curves (Intensity-Duration-Frequency), I used the records regarding the rains fallen in the city of Baia Mare during 32 years (1975-2006).

The frequency is represented by the average recurrence period T of the phenomenon, T being the number of years for which the rain quantity is equal or more frequent than the given value.

The frequency is also expressed in terms of overflow probability p given by the formula $p=p(h \geq h_1) = \int f(h)\,dh$, where f(h) is the distribution curve of the annual maximum rain quantity.

After the selection of the annual maximum values for each given time period d (min) and the alignment of each calendar row obtained this way, a Gumbel probability density function is matched for each empiric curve corresponding to the duration d:

$$f(x) = \frac{1}{\alpha}\exp\left[-\frac{x-u}{\alpha} - \exp\left(-\frac{x-u}{\alpha}\right)\right] \quad (1)$$

The Gumbel function parameters ($u$ and $\alpha$) were estimated using the maximum likelihood method.

Table 1 presents the results of the intensity frequency analysis and of the rain duration in Baia Mare (1975-2006). The table includes the intensity and the duration of the rains calculated according to the Gumbel distribution for different recurrence periods (T).

**Table 1**

*Results of the Intensity Frequency Analysis and of the Rainfall Duration Baia Mare (1975-2006)*

| | T=1000 | T=200 | T=100 | T=50 | T=20 | T=10 | T=5 | T=2 |
|---|---|---|---|---|---|---|---|---|
| I= 15min | 0.687 | 0.55 | 0.49 | 0.431 | 0.351 | 0.29 | 0.226 | 0.129 |
| | 22.6 | 20.7 | 19.9 | 19 | 17.9 | 17.1 | 16.2 | 14.8 |
| I= 30min | 0.518 | 0.417 | 0.373 | 0.329 | 0.271 | 0.226 | 0.178 | 0.107 |
| | 37.3 | 35.4 | 34.6 | 33.8 | 32.7 | 31.9 | 31 | 29.7 |
| I= 45min | 0.249 | 0.203 | 0.183 | 0.163 | 0.136 | 0.115 | 0.093 | 0.061 |
| | 67.3 | 61.5 | 59.1 | 56.6 | 53.3 | 50.7 | 48.1 | 44.1 |

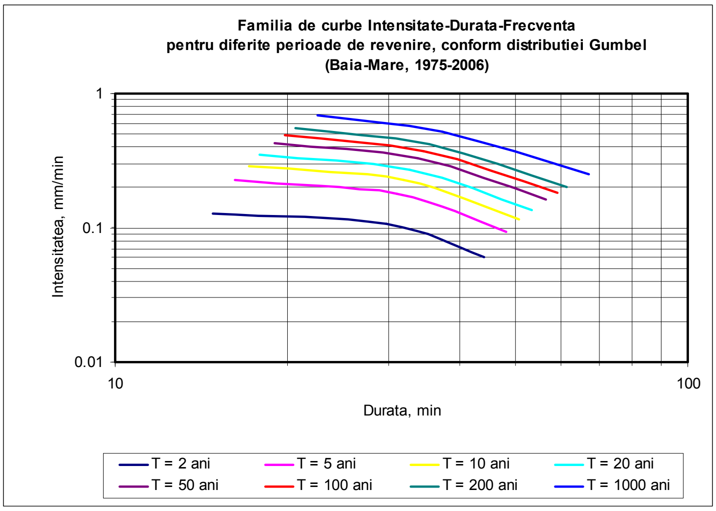


Fig. 4 - IDF family curve for different reoccurrence periods (Baia Mare 1975-2006).

The rainfall intensity depends both on its frequency (probability) and on its duration and this expressed by a bidimensional function known by the name of Intensity – Duration – Frequency (IDF). The intensity according to the rainfall duration at different occurrence frequencies is represented as a series of decreasing parallel curves. The rainfall intensity decreases by their duration and increases by T.

Fig. 4 presents the IDF family curves for different reoccurrence periods, in conformity with the Gumbel distribution for the city of Baia Mare.

The maximum flow rate in the urbanized areas occur shortly after the starting moment of the rainfall with large quantities of water fallen in small time sequences, lasting tens of minutes or a few hours.

### 5.2. Presentation of Results

In order to determine the flooded areas in the study area, 3 scenarios of failure in the water systems were simulated, on pipe sections with average and high risk of failure, as follows:

- failure on the pipe section (D=300 mm), situated on Traian Blvd. (Fig. 5)
- failure on the pipe section (D=300 mm), situated on Matei Basarab street
- failure on the pipe section (D=300 mm), situated on Vlad Ţepeş street

These scenarios were also represented by three rainfalls with different intensity, duration and recurrence periods, as shown in Table 1, by extracting the values from the Intensity-Duration-Frequency curve graphic, for different recurrence periods, considering the hypothesis that only 30% of the meteoric water are discharged in the outfalls.

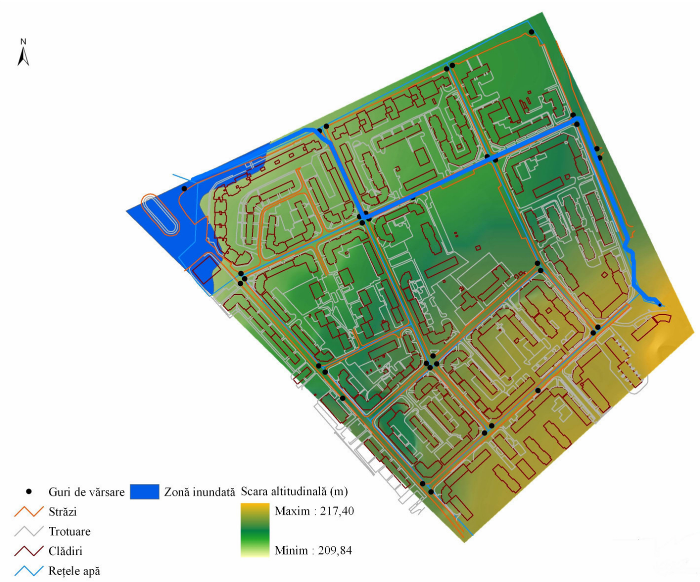


Fig. 5 - Failure occurred in a pipe section on Traian Blvd.

## 6. Conclusions

This paper includes documentations and studies with respect to the use of the GIS technology for the assessment and simulation of the water flow in risk cases for a study area in the city of Baia Mare. This avant-garde field of study, which opens and creates new perspectives for the development and assertion of the specialists in water systems, has outstanding implications in the analysis and decision-making process for planning the works related to the maintenance, repair and replacement of water systems, and implicitly substantial cost savings.

Based on these desiderata, from the very beginning it was necessary to carry out thorough documentations and research on the studies, methods, tools and technologies that form the fundamentals of the water flow assessment and simulation in risk situations.

*Received: February 08, 2009*

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### GIS PENTRU DETERMINAREA RISCURILOR DE AVARIE A REȚELELOR DE ALIMENATRE CU APĂ. STUDIU DE CAZ PENTRU UN CVARTAL DIN MUNICIPIUL BAIA MARE

(Rezumat)

Rețelele de distribuție sunt supuse unor solicitări care variază în limite foarte largi, însăși natura solicitărilor la care sunt supuse tuburile şi armăturile din care sunt

alcătuite reţelele fiind de mare diversitate. Ca urmare a acestor multiple condiţii în care sunt obligate să lucreze reţelele, ele suferă numeroase defecţiuni, care atunci când se amplifică pot deveni adevărate avarii.

Prin integrarea datelor de tip grafic şi alfanumeric, GIS-ul devine nu numai un sistem computerizat pentru producţia automatizată de hărţi sau diagrame, ori un sistem de grafică computerizată de uz general ci şi un sistem care poate stoca, procesa, combina şi analiza date şi informaţii despre reţelele de apă, putând produce noi informaţii, cu valoare adăugată. Astfel putem obţine informaţii asupra zonelor de risc de avarie a reţelelor de apă.

După realizarea unor astfel de interogări şi analize şi prezentarea rezultatelor factorilor de decizie, se pot întocmi planificări mai bune şi reducerea costurilor de planificare a lucrărilor de întreţinere, reparaţii şi înlocuire a reţelelor de alimentare cu apă.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LV (LIX), Fasc. 1, 2009
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HIDROTEHNICĂ

# GIS - TEHNOLOGY IN AGROCLIMATIC RESOURSES ESTIMATION IN REPUBLIC OF MOLDOVA

BY

**MARIA NEDEALCOV**

**Abstract:** It was possible to evaluate heat and humidification resources with different pretability grade of agricultural development on Republic of Moldova's territory thanks to Geographical Informational Systems as a research instrument. Similar investigations can be elaborated basing on elaboration certain estimation criteria of climate's pretability grade for cultural plants while taking into account their concrete biological particularities.

**Key words:** model, climate, cartographical modeling, GIS.

## 1. Introduction

Actual climate changes force humankind to undertake certain measures in order to adapt to them in all branches of human activities, not excluding that of agricultural development. Taking into account Republic of Moldova's agricultural orientation, the estimation of agroclimatical resources in the context of actual modifications of regional climate is a matter of great importance.

Moreover previous evaluations included in Agroclimatical Resources [1] do not cover recent period, and agroclimatical indexes that were used for the basis of agroclimatic regionalization (reflecting heat, humidification and wintering conditions) were as follows: active temperatures sums, Seleaninov hydrothermic coefficient and air temperature's absolute minimum. The possibilities offered by GIS technologies allow expanding the whole specter of agroclimatical indexes thus contributing to specification of spatial distribution areas for heat and humidification resources.

## 2. Materials and Methods

Actual investigations are based on climate's pretability grade estimation for agriculture's development using the system of grading that supposes a complex study of a great variety of agroclimatic indexes [2]. According to this qualificatory, the highest grades („4”) are obtained by the most optimal agroclimatic conditions. The most non-pretable climatic resources for certain cultural plants development are graded with lowest points („1”). Thus, according to this system agroclimatic resources are grouped as follows:

- optimal (3,5-4,0)
- favorable (2,9-3,4)
- pretable (2,3-2,8)
- less pretable (1,7-2,2)
- non pretable (1-1,6)

Assuming a climatic favorability grade for certain cultural plants cultivation, we have elaborated estimation criteria for landscape's climatic conditions from Republic of Moldova (Table1) that reflect *heat resources* adequately (frost period duration, non-frost period duration, active temperature's sums (T>10C), number of days with T>5C), *humidification resources* (atmospheric precipitations' annual sums, atmospheric precipitations' sums in warm year's period, atmospheric precipitations' sums in cold year's period, Seleaninov's hydrothermic coefficient), and also *wintering conditions* (snow cover maximum height, 10% assurance of year's absolute minimum).

**Table 1**

*Agroclimatical Resources Estimation's Criteria for Republic of Moldova*

| bal | Min abs | pp anuale (mm) | Suma pp perioada caldă (mm) | Suma pp perioada rece (mm) | CHT | Durata perioadei cu îngheț (zile) | Durata perioadei fără înget (zile) | Inălțimea stratului de zăpadă | Suma t>10°C | Nr. de zile cu t>5°C |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -28 – -26<br>-26 - -24<br>-24 - -22 | 450-500 | 350-400 | 85-95 | | 90-95<br>85-90<br>80-85 | 270-175<br>275-280 | 9-11 | 2800-2900 | 220-225 |
| 2 | -22 - -20<br>-20 - -18 | 500-550 | 400-450 | 95-105 | 0,7-0,9 | 75-80<br>65-70 | 280-285<br>285-290 | 11-13<br>13-15 | 2900-3100 | 225-230 |
| 3 | -18 - -16<br>-16 - -14 | 550-650 | 450-600 | 105-115 | 0,9-1,1 | 65-70 | 290-295<br>295-300 | 15-17<br>17-19 | 3100-3200 | 230-235<br>235-240 |
| 4 | -14 - -12<br>-12 - -10 | > 650 | > 600 | 135-145<br>145-155 | 1,1-1,8/ | 60-65 | 300-305 | 19-21<br>21-23 | > 3200 | 240-245<br>245-250 |

On the basis of multiple analysis the equations of regression were obtained, which together with Relief's Numeric Model were used as a basis for above mentioned agroclimatical indexes' cartographical modeling. Thus, we elaborated 10 digital maps that were overlaid with the layer of geographical regions and subregions, elaborated by collaborators of Landscapology Laboratory from IEG, and this allowed indentifying agroclimatical resources with different grade of pretability for agriculture's development in physico-geographical regions (Table2).

**Table 2**
Climate's Pretability Grade's Estimation in Physico- Geographical Regions (Republic of Moldova)

Regiuni fizico-geografice

| | | | pp anuale | pp perioada caldă | pp perioada rece | CHT | Perioada cu îngheț | Perioada fără îngheț | Asigurarea cu 10% a min abs | Înălțimea stratului de zăpadă | Suma t >101$^0$C | Nr. de zile cu T>5$^0$C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Podişul Moldovei de Nord | A1 | 3,5 | 3,0 | 3,4 | 4,0 | 1,0 | 1,0 | 1,0 | 3,8 | 1,0 | 1,4 | 2,3 |
| 2 | Podişul Nistrului | A2 | 3,9 | 3,0 | 3,6 | 4,0 | 1,0 | 1,0 | 1,5 | 4,0 | 1,3 | 1,6 | 2,5 |
| 3 | Cîmpia Prutului de Mijloc | A3 | 3,2 | 2,8 | 3,3 | 3,9 | 1,5 | 2,0 | 1,3 | 3,7 | 1,9 | 2,5 | 2,6 |
| 4 | Cîmpia Cuboltei Inferioare | B1 | 2,5 | 2,8 | 2,7 | 3,9 | 1,5 | 2,5 | 1,2 | 3,0 | 1,5 | 1,9 | 2,4 |
| 5 | Dealurile Ciulucurilor | B2 | 2,8 | 2,9 | 2,9 | 3,9 | 1,8 | 3,0 | 1,6 | 2,9 | 2,0 | 2,4 | 2,6 |
| 6 | Podişul Rîbniței | C1 | 3,0 | 3,0 | 3,0 | 3,8 | 1,5 | 1,5 | 1,5 | 3,7 | 2,0 | 2,5 | 2,6 |
| 7 | Podişul Codrilor de Vest | D1 | 4,0 | 4,0 | 4,0 | 4,0 | 2,0 | 2,0 | 2,8 | 3,9 | 2,3 | 2,8 | 3,2 |
| 8 | Podişul Codrilor de Nord | D2 | 3,9 | 3,9 | 3,9 | 4,0 | 2,2 | 2,4 | 1,9 | 3,8 | 2,4 | 2,7 | 3,1 |
| 9 | Podişul Codrilor de Est | D3 | 3,9 | 3,9 | 3,8 | 4,0 | 2,6 | 2,5 | 2,7 | 3,9 | 2,5 | 2,9 | 3,3 |
| 10 | Podişul Codrilor de Sud | D4 | 3,8 | 3,9 | 3,8 | 4,0 | 2,8 | 2,9 | 3,0 | 3,9 | 3,0 | 3,0 | 3,4 |
| 11 | Depresiunea Săratei | E1 | 2,2 | 2,2 | 2,7 | 2,5 | 3,5 | 3,0 | 3,4 | 2,5 | 3,5 | 3,2 | 2,9 |
| 12 | Colinele Tigheciului | E2 | 2,3 | 2,8 | 2,8 | 2,9 | 3,7 | 3,5 | 3,8 | 2,4 | 3,7 | 3,6 | 3,2 |
| 13 | Cîmpia Bîcului Inferior | E3 | 2,3 | 2,8 | 2,8 | 2,9 | 3,3 | 3,0 | 3,2 | 2,4 | 3,4 | 3,0 | 2,9 |
| 14 | Cîmpia Cogîlnicului de Mijloc | E4 | 2,4 | 2,9 | 2,8 | 3,5 | 3,2 | 3,1 | 3,0 | 2,6 | 3,3 | 3,0 | 3,0 |
| 15 | Cîmpia Hadjiderului Superior | F1 | 2,0 | 2,0 | 2,4 | 2,0 | 3,5 | 3,5 | 3,0 | 2,5 | 3,7 | 3,0 | 2,8 |
| 16 | Cîmpia Cahulului | F2 | 1,8 | 1,8 | 2,3 | 2,8 | 4,0 | 3,8 | 4,0 | 2,0 | 4,0 | 4,0 | 3,1 |
| 17 | Cîmpia Ialpugului | F3 | 2,0 | 2,0 | 2,3 | 2,6 | 3,8 | 3,4 | 3,8 | 2,4 | 3,8 | 3,8 | 3,0 |
| 18 | Cîmpia Nistrului Inferior | G1 | 1,5 | 1,5 | 1,5 | 1,5 | 3,5 | 3,5 | 2,9 | 1,8 | 3,5 | 3,0 | 2,0 |

## 3. Obtained Results

Thus, on the basis of digital maps that reflect humidification resources we state that on Republic's territory annual sums of atmospherical precipitations varies from 450-500 mm (graded by 1 point according to their pretability grade) to more than 650mm (graded by 4 points – the highest grade according to their pretability). Atmospherical precipitation's sums in the warm year's period vary from 350-400 mm (getting 1 point according to their pretability grade) to more than 600 mm (getting 4 points according to their pretability grade); atmospherical precipitation's sums in the cold year's period vary from 85-95 mm to 135mm and are being graded by the same grading system as shown above. Aridity grade estimation from the humidification resources' point of view throughout the year were executed using Seleaninov's hydrothermic coefficient which varies from 0,7-0,9 (getting qualificatory 2) to 1,8 (with qualificatory 4). Snow cover's height optimal for multiannual cultures' wintering on Republic's territory is 19-21cm (Fig.1).

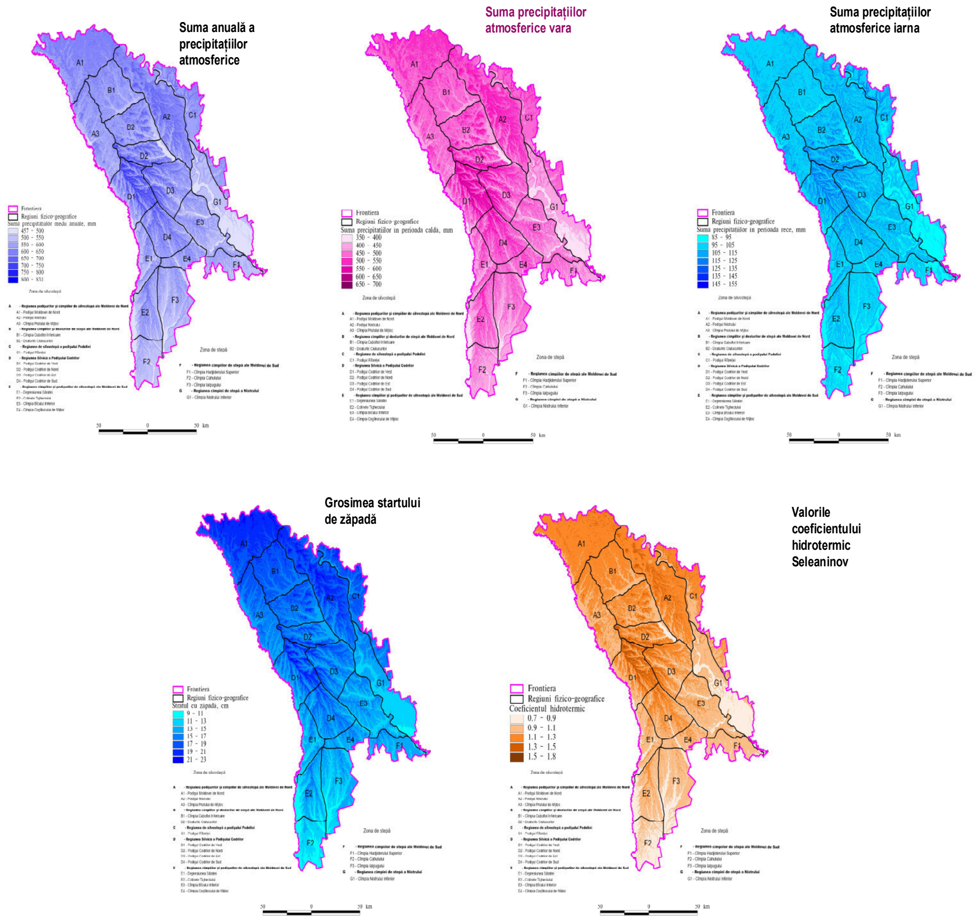



Fig. 1 - Cartographical modeling of agroclimatic indexes that characterize humidification resources for physico-geographical regions in Republic of Moldova.

Cartographical modeling of agroclimatical indexes that characterize heat regime show that, for example that qualificatory 1 corresponds to the biggest number of days with frost (>85zile) and, on the opposite, qualificatory 4 is attributed to the biggest number of non-frost days (300-305 days) according to the pretability grading system. The lowest thermic values of absolute minimum that are manifested once in 10 years (-22,0-28,0) correspond to grade 1 of pretability, as they will install non-pretable conditions for certain multiannual thermofilic cultural plants' wintering. As well, less pretable grading means installing climatic conditions where the duration of average diurnal temperatures higher than $5^0$C will be shorter (220-225 days), and active temperature's sums (2800-2900) will be the lowest (Fig.2).

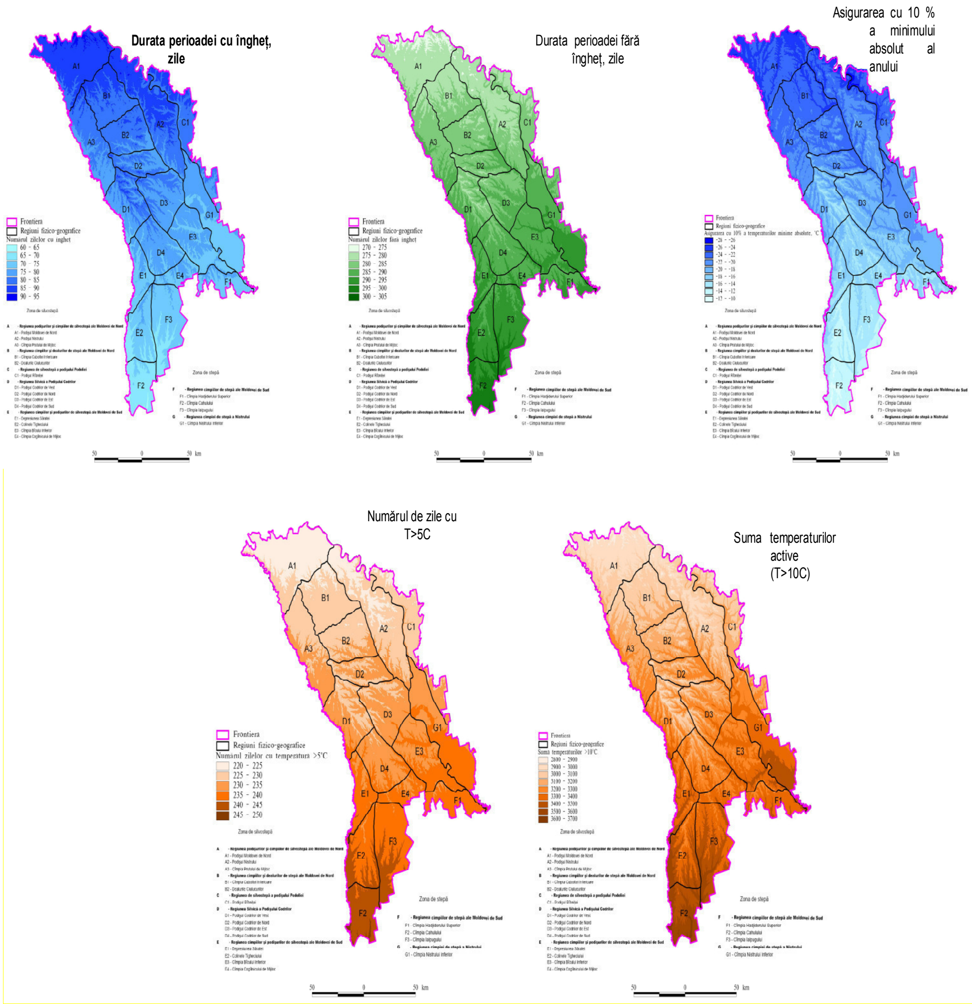
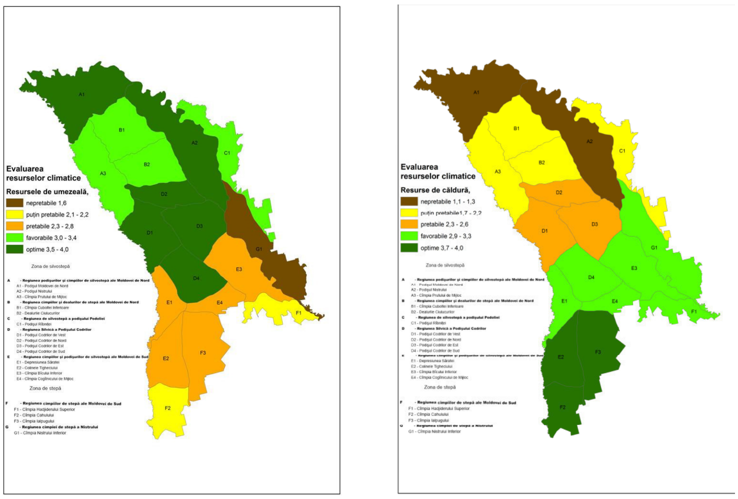



Fig. 2 - Cartographical modeling of agroclimatic indexes that characterize heat resources.

Net estimation for agroclimatical indexes that characterize humidification resources shows us that the most optimal conditions of humidification are in Moldova’s North woodsy moores’ plateaus and planes and in woodsy region of Codry Plateau. Less pretable conditions are in Cahul and Ialpug planes. Non-pretable climatic conditions from humidification point of view are in Dniester’s moore planes’ Region (Fig. 3a).

The most optimal conditions from heat resources point of view, on the contrary, are in the Region of moore planes of Moldova’s South. The heat resources on Moldova’s North plateaus and Dniester plateau are non-pretable. Less pretable are heat resources in Moldova’s North moores’ planes and hills (Fig. 3b).




*a* *b*

Fig. 3 – Evaluation of humidification: *a* – and heat resources; *b* – according to pretability grade of agricultural development (Republic of Moldova).

## 4. Conclusions

Agroclimatic systems evaluation on Republic of Moldova's territory using Geographical Informational Systems as an instrument for investigations, allowed identifying regional particularities of humidification and heat resources' distribution. Similar evaluations can be executed referring to direct cultivation of certain groups of agricultural species. In this case, one also has to consider the elaboration of heat and humidification resources' evaluation criteria, according to concrete biological particularities of their development. Such evaluations are extremely necessary, as they contribute essentially to effective usage of actual agroclimatic resources, increasing cultural plants' productivity.

*Received: February 14, 2008*

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TEHNOLOGIILE SIG ÎN ESTIMAREA RESURSELOR AGROCLIMATICE ALE REPUBLICII MOLDOVA

(Rezumat)

Grație Sistemelor Informaționale Geografice, ca instrument de cercetare, a fost posibilă evaluarea resurselor de căldură şi umezeală cu diferit grad de pretabilitate în dezvoltarea agriculturii pe teritoriul Republicii Moldova. Asemenea investigații pot fi efectuate în baza elaborării criteriilor de evaluare a gradului de pretabilitate a climei pentru dezvoltarea anumitor grupuri de culturi agricole, ținând cont de particularitățile biologice concrete ale acestora.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LV (LIX), Fasc. 1, 2009
Secţia
HIDROTEHNICĂ

# USING GIS TECHNIQUE IN REAL CADASTRE COMPUTER AID ON 54 DISTRICT FROM SUCEAVA

BY

**GABRIELA BIALI and DUMITRU ILIOI**

**Abstract.** This paper presents an example of automation in the real estate cadastre 54 Suceava, based on digital cadastral plan.

Digital cadastral plan is moving to a new form of presentation only numerical cadastral data through the possibilities offered by automatic retrieval of their equipment.

The present work shows the advantages of using the GIS technology (Geographical Information Systems) in the special cadastre by giving an example, in a quarter of a place from Romania in which a territorial informational system was put into practice/implemented. The authors emphasize a few of the GIS exploitation facilities, namely, the query of the database (graphic and descriptive ones) by which one can make some analyses and statistics and can also obtain synthesis information.

**Key words:** relational database, cadastre automatization, explorer database, GIS.

## 1. Introduction

GIS is a powerful set of computer tools for collecting, storing, retrieving at will, and transforming spatial data from the real world for particular set of purposes. LIS is a GIS where that data are for land ownership [1].

When it comes to arranging the territory and the cadastral evidence, the Geographical Information Systems (GIS) also called (LIS) – Land Information Systems, are the most complex informational systems having the capacity to adapt to all the potential beneficiaries requests [3].

Frequently LIS includes parcel based information and cadastral data and generally refer to territorial administrative units strictly delimitated, which in our case are: the commune, the town, city of the district and the country’s surface, respectively. If such a system is completed with economic, juridical and descriptive data as regards the holders as well as with the manufacturing and interrogative functions of these new data, it becomes one of the most important informational systems in the cadastre domain [4].

The cadastre, in this context, which practically represents a SIT/LIS has two categories of analytic and synthetic information.

The group of analytic information contains descriptive information with regard to the administrative – territorial distribution forms and their subdivisions, the property forms, the economic destinations, the land categories, the land characteristics and the investments characteristics as well. The group of synthetic information is made by systematizing the analytic information which includes data regarding the land fund on administrative – territorial units, property sectors, categories of owners etc [5].

As in comparison with the classic DBMS (Database Management Systems), when it comes to the geoinformational systems, in order to obtain the cadastral analytic and synthetic information/examination technique which is based on the physics relation implemented as part of the model of representation the geographical data between the graphic part and the descriptive attached one [6].

By examinations, one makes a selection of the database with a certain purpose, such as the elaboration of reports or synthesis on a set of data, the making of new strata, the preparation of data for the complex spatial analyses, the exporting of data towards similar or complementary software [2].

If one wants to extract or deduce some more complex pieces of information, are has to add to the initial database some other statistics functions and algorithms for the modification of the data variation range, the class segmenting, the indices extracting, the improving of the graphic display etc [4].

One can give as an example the attributive examination which is based on the specification of some selection criteria applied to the attributes of the graphic entities. For applications in the cadastre field with the help of creation functions of the AutoCAD Map specific topology (from the AutoDesk software package) and of the information resulted from the network grid topology creation, one can make graphic examinations or text reports and thematic/ special maps (such as distinguishing the parcels with surfaces between certain values introduced by the user).

## 2. Localization of Research in GIS Project

Generalization and standardization of cadastral work in Romania is done in parallel with its maintenance and upgrading, the tendency to create a complex and automated cadastre and that an information system of the country.

In this context, spatial planning and cadastral records, most complex information systems, the ability to adapt to all requirements of potential beneficiaries, are geographical information systems or information of territorial systems.

By this cadastre we have wanted to show the technical utility inventory of the parcels and building belonging to the physical and juridical persons as well as of their urbanistic equipments, by using for this purpose the date and documents of the technical part of the general cadastre and the “land book”.

To point out what has been shown before, we give an example regarding the computerization of the special technical utility cadastre by using Romanian software, GEO-GRAPH, for a cadastral sector from the Suceava city (Fig. 1).

*The stages of the project were:*

a.) The updating and completing of data as part of the general cadastre and of the existing cadastral plane, identifying the owners of the buildings, houses and of the lands.

b.) Collecting the data and information regarding the land and the constructive characteristics of the building (on the grounds of the land, and also the soil mechanics characteristics of the lands) with the purpose of evaluating the technical criteria of lands and buildings.

c.) The making of the informational system of the special urban cadastre whose database has to allow in any moment the up-dating, interrogation, especially to the public administration and to the managing of the urban public works of the city.

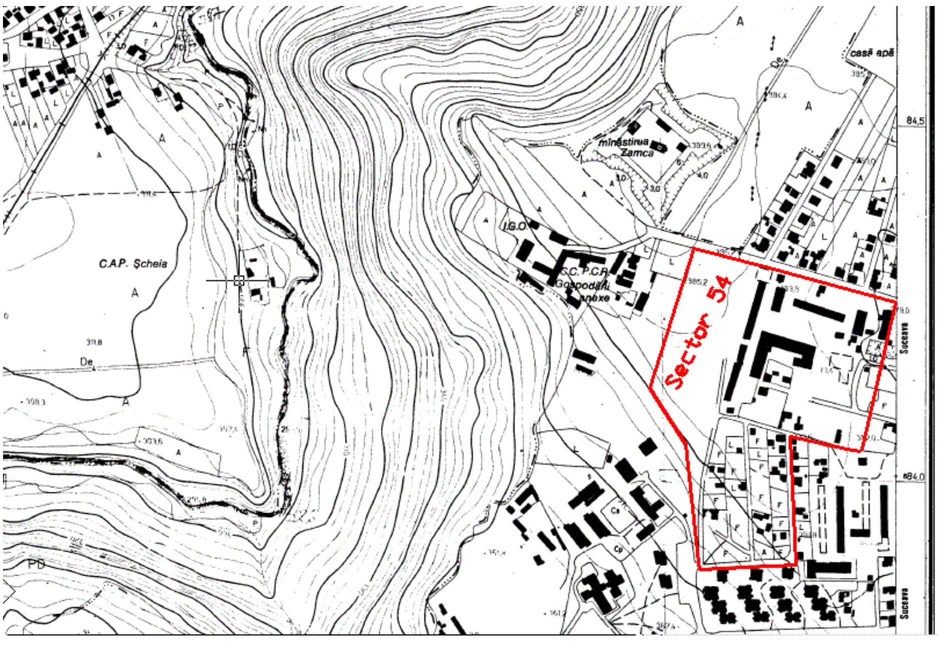


Fig. 1 – The framing of the cadastral sector no. 54 into the topographic plane.

For automatization of the public urban utility cadastre from the example in this paper Romanian software GIS (achieved in Society of Informatics Services Suceava), namely, the GEO-GRAPH, was used [7].

## 3. Presentation of the GEO-GRAPH Software

This GIS software proved to be a useful instrument for the administration and processing the graphics and attribute-typed pieces of information referring to: public urban utility cadastre, networks (electric, telephone, thermic, gas, water, sewer) town planning and territory arrangement.

The GEO-GRAPH system is build from three separate interconnected subsystems (Fig. 2):

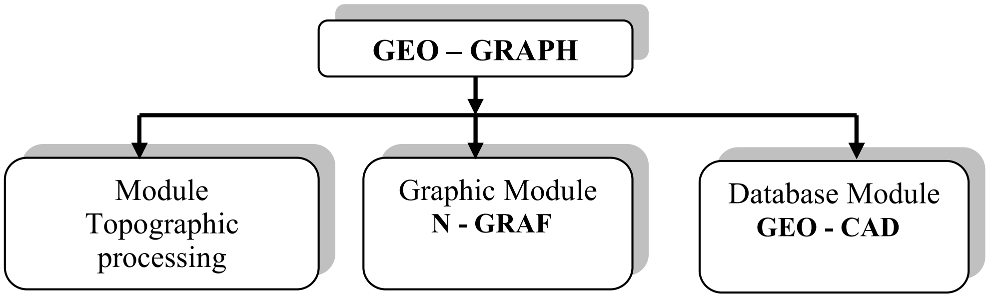


Fig. 2 – The scheme of the logical component parts of the GEO-GRAPH system.

The system is destined for the following types of operations:
- map drawing and map making plans and cadastre map
- database explorer.

In the GEO-GRAPH system, the non-graphic (attribute) type database are administrated by the Database Management System (DBMS):

- dBase
- FoxPro; Visual FoxPro
- xBase

GEO-GRAPH system accepts the relational database of the administration systems Client/Server, by RIS module (Relational Interface System) of Intergraph Company, such as:

- Oracle
- MSSQL, Informix etc.

The Geographic Information System GEO-GRAPH is based on the Windows technology which represents a standard in the "interface – user" for the selection of option and button for generating commands.

## 4. Phases of the Spatial Database Creation

The topographic gathering of the land data was done by using precise electronic topographic apparatus (Sokkia, Rec Elta) which made possible the measurement and automatic stocking (Fig. 3) as well as the necessary calculations were done with the help of the GEO – TOP modulus of the GEO – GRAPH software:

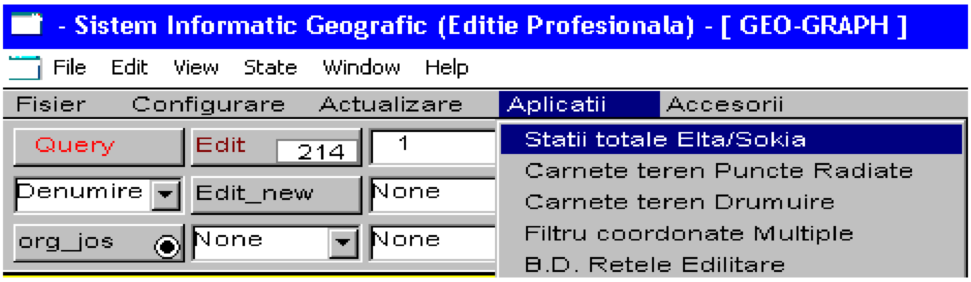


Fig. 3 – The command pin for the system with the total station.

After the automatic report of the points (in the projection system STEREO 70) the digital cadastral plan according to the land sketch; the editing was done by having permanently on the desktop the slider's coordinates, a fact that made was edited possible the creation of the drawing in absolute coordinates having double precision (Fig. 4).

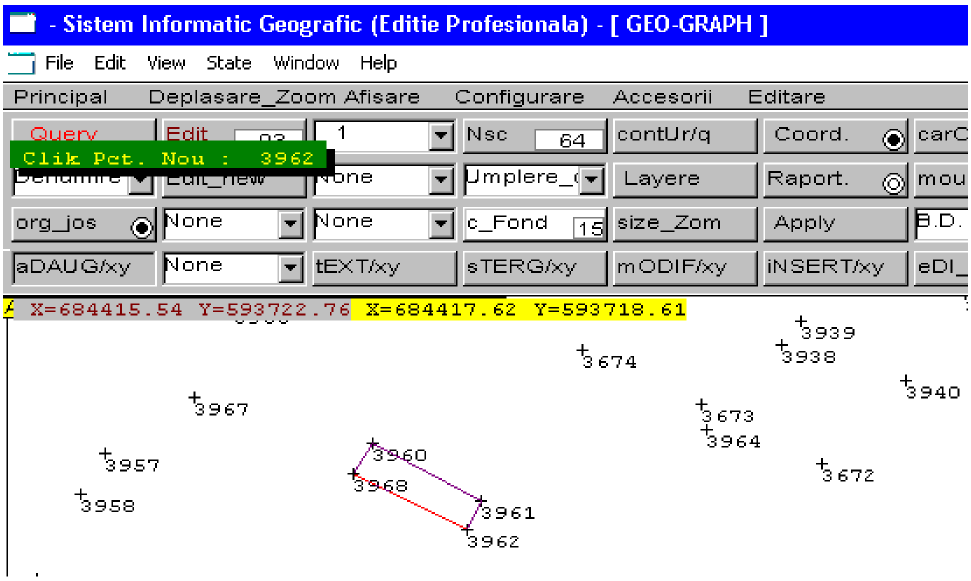


Fig. 4 – The creation/making of the vector drawing in absolute plane coordinates.

As part of the drawing, each object contains a text attribute which allows the identification of the object. The command in Fig. 5 sets the displaying of the text attribute of the current number for the defined graphic objects. The attribute that needs to be attached to the graphic object (for example C1, C2, 53.41) is used for the spatial graphic localization in the case of the non-graphic database examination (the type interrogation of GIS ).

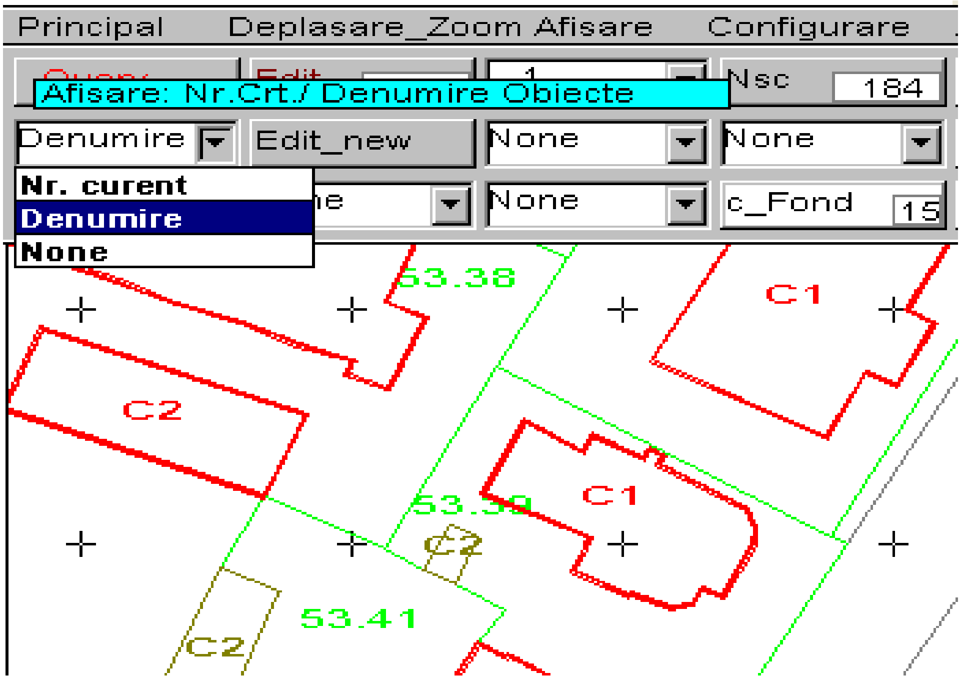


Fig. 5 – Editing sequence that names the graphic objects.

The position of coordinate (text center) represents the selection point for the edition and interrogation of the graphical object (with ± 10 pixels).

During this phase, the vector plane topology was created. The GEO-GRAPH System allows the creation of different types of topology, namely, the point type, polygon type and network type.

On order to store data in a vector pattern the topological structure, is based on the proximity properties and spatial relations between the objects of a vector plan. Thus, the structures of the folders included in a data bank can be realized. These folders are essential for the exploration of the informational System: updating, area superposition, entities that take shape through the superposition of the medium borders etc.

The lack of topological relations trough vector representation reduces a lat the interrogation possibilities.

Through the creation functions of the topology polygon-type the surface and perimeter are automatically generated for each graphical separately (parcel, building), (Fig. 6).

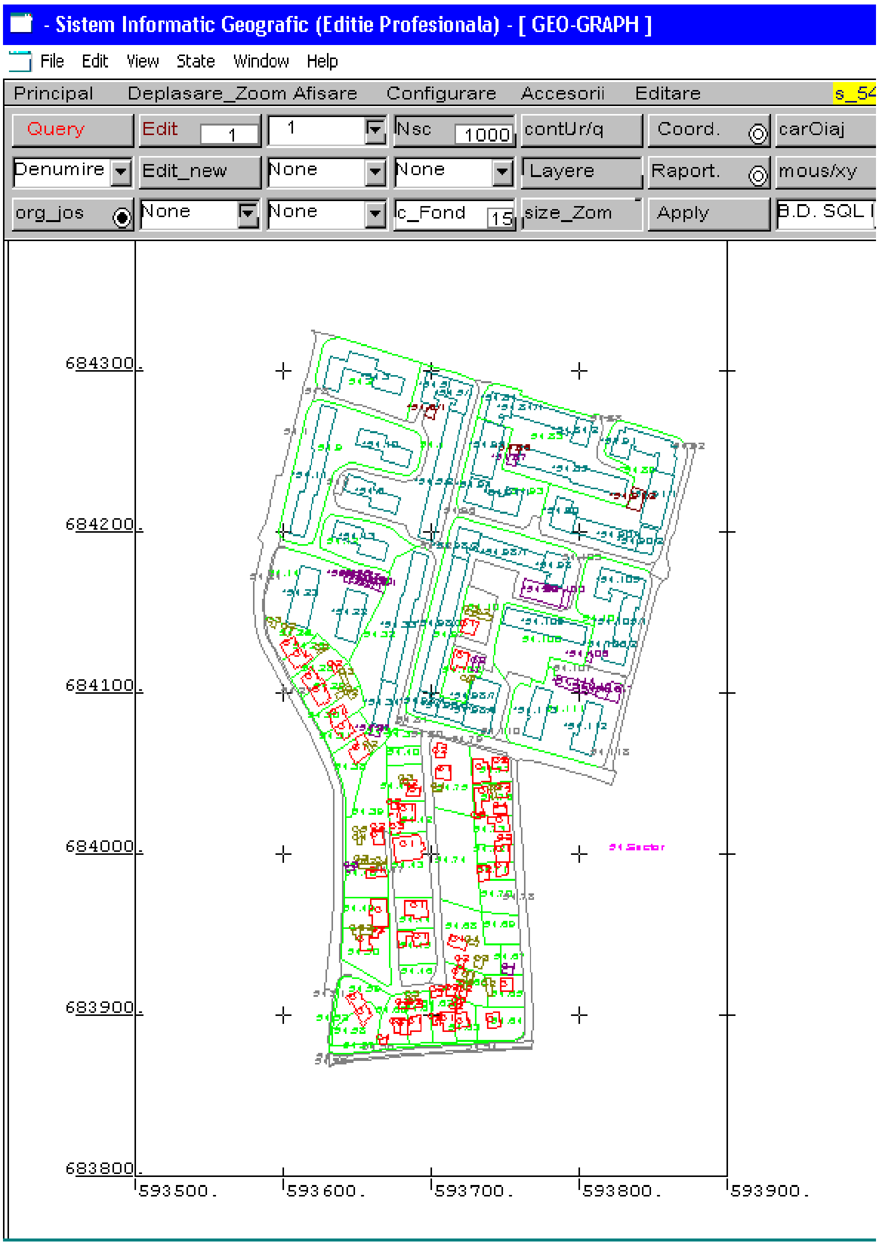


Fig. 6 – The vector plan for sector 54, Suceava city, in STEREO 70 coordinates.

## 5. Descriptive Database (Attribute Database)

For the management of the descriptive database in the cadastral sector, DBMS FoxPro for Windows was used. This DBMS is a system for relational database administration. A relational system means more databases (tables) activated simultaneously, connected through a common field. The number of database and common fields of connection defines the complexity of the system (Fig. 7). An application becomes complex when it makes use of more than four data bases simultaneously activated.

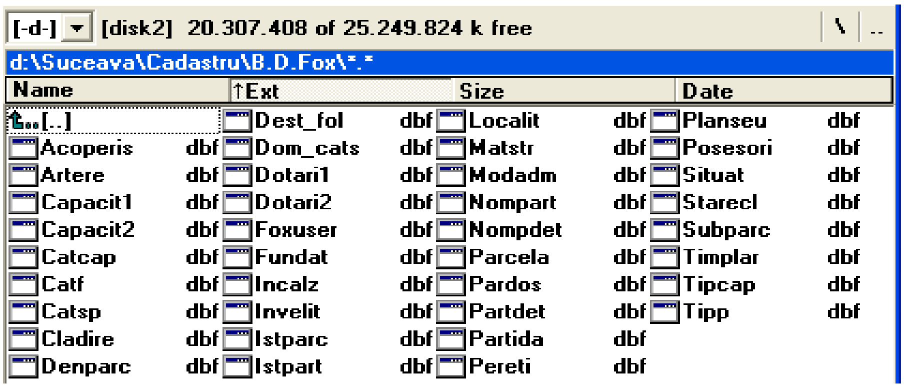


Fig. 7 – The 37 tables of the relational database in FoxPro.

Tables that compose this attribute database, contain pieces of information referring to parcels id no., surface, category of use, owners, address, and id information about owners etc. and to the buildings technical and constructive elements: surface at soil, unfolded surface, fundation type, structure, roof, floor, facilities urbanistic improvements.

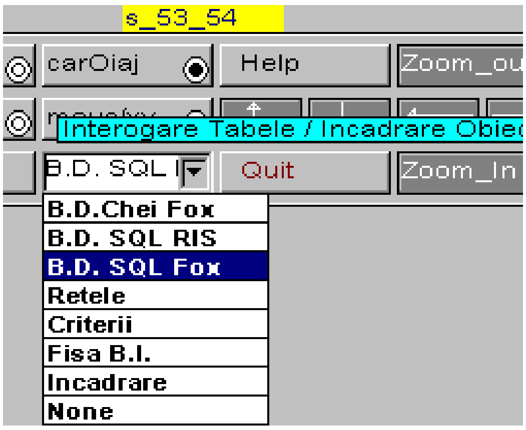


Fig. 8 – Buttons menu for choosing the interrogation type.

*Database graphical and attribute-type database interrogation.* Interrogation is the vast employed function for the exploration of geographical database.

This function makes the difference between the CAD system and the GIS system. In order to accomplish the attribute interrogation we need to reset Administration Database used for this interrogation (Fig. 8).

This menu allows the user the following commands:
- the DBMS setting used for the interrogation of attribute information;

- the setting of the criterional examination option on the attribute type information;
- the setting of the "Documents: land + building" making option;

When the user activates the "Query" pin from the main menu (Fig. 3), the user asks the selection of a graphical object to be interrogated (this is the classic interrogation from the graphical to the attribute database).

Because the database is relational, the interrogation can continue from a table to another, just by the simple relation between the tables.

## 6. Conclusions

As GIS software, well – known (such as Arc/Info, ArcView, MapInfo), the GEO – GRAPH software allows the work in an active way with a database, independently created or not, by the digital plan. This offers the optimal exploration of the data in order to obtain an "intelligent" map which completely satisfies the beneficiary demands, whether or not this is familiarized with the GIS concept.

The implementation of a geo-informational system (GIS/LIS) in the cadastre of an administrative territory, allows the accomplishment (making of a database on a cartographical support, the knowledge and properties delimitation of the land building and of the technical – urbanism patrimony, creates the support for planning, urban development and qualified institutions), making the right decisions in time, the permanent updating of the cadastral works.

The quality of the informational systems integrated into the general cadastre at the administrative territories level (cities) also depend a lot on the performances of the manufacturing programs GIS-type, and on the insurance of the connections with other different programs.

*Received: September 27, 2009*

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## UTILIZAREA TEHNICILOR GIS ÎN INFORMATIZAREA CADASTULUI IMOBILIAR, ÎN CVARTAL 54 DIN JUDEŢUL SUCEAVA

(Rezumat)

In această lucrare se prezintă un exemplu de automatizare a cadastrului imobiliar din sectorul 54 Suceava, având la bază planul cadastral digital.

Planul cadastral digital este trecerea la o formă nouă de prezentare exclusiv numerică a datelor cadastrale prin intermediul posibilităţilor oferite de echipamentele de preluare automată a acestora.

Generalizarea şi uniformizarea lucrărilor de cadastru din România se realizează în paralel cu întreţinerea şi modernizarea acestuia, cu tendinţa de creare a unui cadastru complex şi automatizat şi respectiv a unui sistem informaţional al teritoriului ţării.

În acest context, în amenajarea teritoriului şi evidenţele cadastrale, sistemele informaţionale cele mai complexe, având capacitatea de adaptare la toate cerinţele potenţialilor beneficiari, sunt Sistemele Informaţionale Geografice sau Sistemele Informaţionale ale Teritoriului.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
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Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LV (LIX), Fasc. 1, 2009
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# THE ANALYSIS OF LAND COVER CHANGES IN PIATRA-NEAMT AREA USING GIS TECHNIQUES

BY

**DAN-ADRIAN CHELARU and ADRIAN URSU**

**Abstracts:** The current study is an analysis of land use change in Piatra-Neamt area. The most obvious changes occurred in the field of territorial expansion, so the study analyzes the conditions that lead to producing this phenomenon. The analysis is achieved using Geographical Information System techniques.
**Key words:** land cover, model, anclysis, GIS.

## 1. Introduction

Located at the outer limit of the Carpathians, at an altitude of 310 m, the city of Piatra-Neamt marks the spot of intersection of the coordinates $46^{o} 56'$, northern latitude and $20^{o} 22'$ eastern longitude, and it is about 220 km closer to the North Pole than the Equator. It has a central position in the Neamt County, representing the largest urban center of the county and most polarizing. Piatra-Neamt city enjoys a special geographical location, being a climate, geological, geomorphological, hydrological, pedological and phytogeographical contact zone.

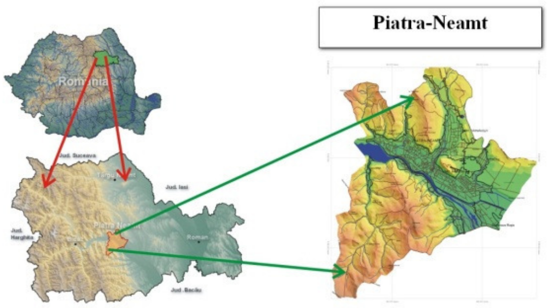



Fig. 1 – Localization of area of study.

Due to natural conditions, which are favorable for human settlements, this passing area of two major relief units, Carpathians and Subcarpathians, was a hearth housing over two millennia for our Geto-Dacian civilization.

The emergence and development of the city was favored by the interference of geographical, historical and economic factors, being an obvious "contact zone".

The objective of this study is a competent analysis of land use change in Piatra Neamt, regarding mainly the phenomenon of territorial expansion, a phenomenon that witnessed an accelerated growth in post-communist period. To achieve this objective, in addition to on-site assessment, it has been appealed to a number of specialized studies and some cartographic material on the studied area. The analysis phase of information is equivalent in this case with the laboratory stage represented by the use of GIS techniques, following the interpretation of data and comparison of results.

## 2. Materials and Methods

For a better analysis of the phenomenon and for a more complex study GIS techniques were used with the help of the professional software MicroImages TNT mips 6.9.

The main materials used for the achievement of the study are the topographic maps at scale of 1:25000 which led to obtaining the numerical terrain model (MNT) of the studied area, going through several stages.

First of all, the 4 topographic maps were imported into GIS software, and then were georeferenced into the Gauss-Kruger coordinate system with the Krassovsky 1938/1940 reference ellipsoid.

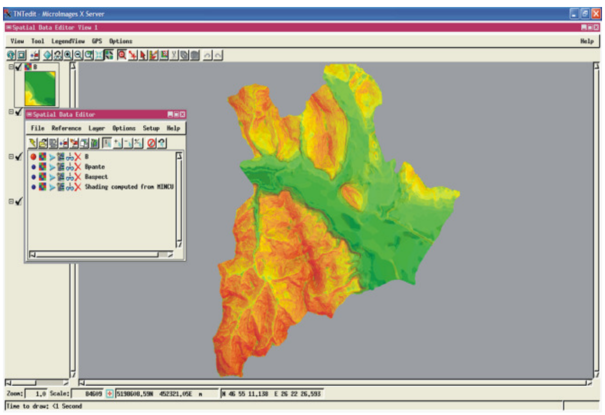


Fig. 2 – The process of obtaining the MNT.

The maps were joined automatically using the georeference points in order to have a topographic base united in a single file.

Over the digital topographic representation of the city Piatra Neamt it was made a vector layer of level curves through "stretch" method of drawing lines and polygons, having georeferenced points transferred by default from the digital topographic support. Contour Digitization was performed using ON SCREEN method. Afterwards, to the vector layer were assigned "Z" values, essential to achieving MNT. Finally, the numerical terrain model is obtained by applying the operation "Surface Modeling".

Based on MNT were realized three thematic layers that will be used forward in analysis: *shading, slope, aspect.*

By combining the three layers with the MNT and different other vector layers (like human settlements, hydrography, roads, land use, toponyms) will result next maps:

- Hypsometric map;
- Land use map;
- Slope map;
- Slope orientation map;
- Favorability for construction.

The last step consists in making layouts and printing them in graphical format (TIFF at a resolution of 300dpi).

## 3. Research Results

### 3.1. The Current State of Land Use and Recent Changes

In order to achieve land use map were used in addition to the above materials, orthophotomaps from 2006 over the Piatra-Neamt area.

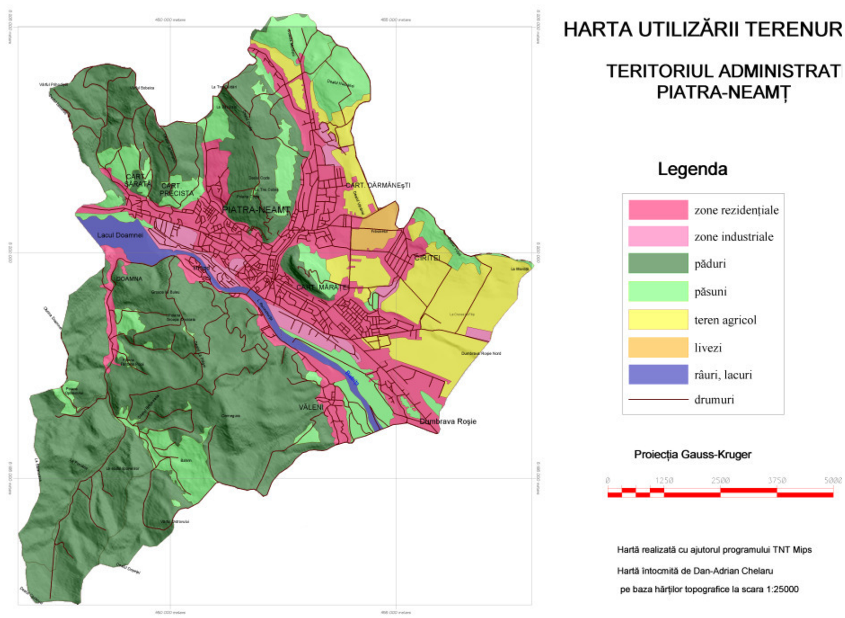



Fig. 3 – The land use map.

By analyzing this map it was concluded that the largest share of the administrative territory of Piatra-Neamt is represented by mountain covered with forest - about half of the city's total 7.700 ha (3.844 ha), followed by actual built-up area (1.719 ha), pastures (1.090 ha) and agricultural land (850 hectares), while water surfaces represented by the Bistrita River and its tributaries, but also Bâtca Doamnei Lake occupies a share of only 3%, or 196.96 ha.

Regarding the recent changes occurring in land use the most significant are represented by the expansion of the perimeter of the city built. Of the analysis of the map which shows the extended areas of the city built-in period 1983-2006 it was observed that these changes occurred generally at the expense of agricultural land. Overall, the total area in this period is extended by 313 meters, and this is accomplished mainly due to demographic factors.

In the area of study it have been also produced some changes, but in small areas. Thus, it can be remembered some areas affected by deforestation, which have since become pastures.

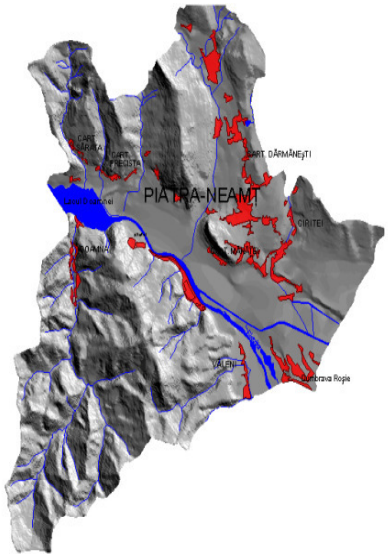



Fig. 4 – The extended areas (1983-2006).

**3.2. Territorial Expansion**

For the analysis of territorial evolution of the city Piatra-Neamt, we reported on two periods: 1896 - 1983 and 1983 - 2006 according to cartographic materials which were available. Thus, it has been made the territorial evolution map of the city in which was tried an accurate rendering of the phenomenon studied.

Cartographic materials which are used as the basis are 1:25000 scale topographic maps of 1896 and 1983 and 2006 orthophotomaps. They were used to extract limits of the built perimeter of each year and then were compared, resulting a number of facts such as: finding extended areas, the type of extension and areas within which were extended in relation to physical and geographical position, and extensive surface area.

**3. 3. Territorial Expansion Depending on the Favorability for Construction**

To better analyze the phenomenon and to identify the appropriate areas for territorial expansion of built and build space were considered three factors: slope, slope orientation and distance from roads.

Some of these parameters can have a bigger influence on certain areas in the perimeter of analysis than other factors, and also their contribution is lower in other areas.

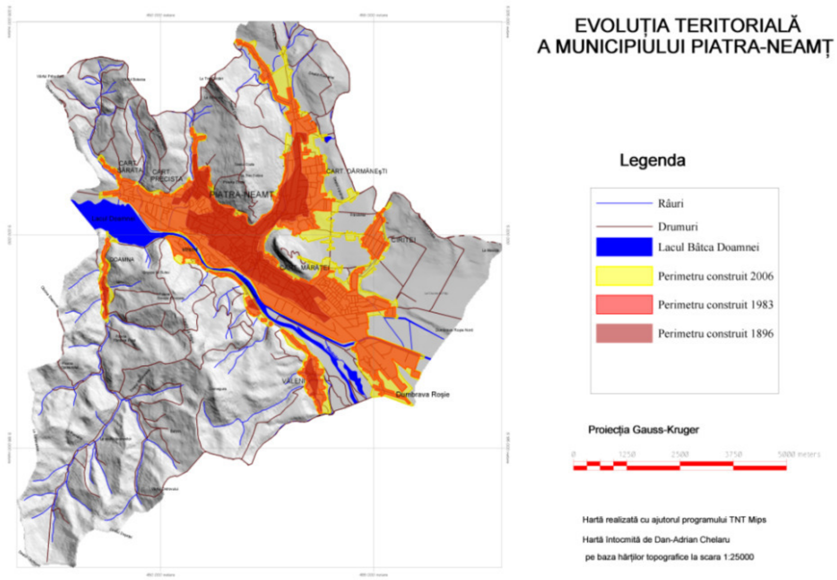



Fig. 5 – The map of territorial expansion of Piatra-Neamt.

These parameters were assigned favorability classes according to specific criteria in order to identify areas favorable or less favorable for construction.

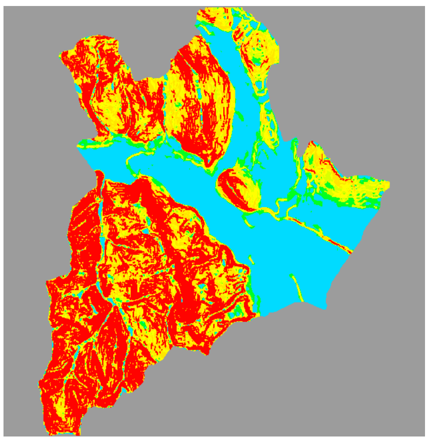


Fig. 6 – The slope map.

*Slope* In the analysis of building favorability towards slopes were considered more stages. The first step was the classification of slopes map made for Piatra-Neamt city resulting a map of slopes with 6 classes of favorability. Thus, for each class was assigned one qualifier from 5 to 0 and a specific color to highlight them, the last representing an overall restrictiveness in terms of built area. If the first 2 classes, with the qualifier 5 and 4, represented by slopes of less than 3 °, and those between 3 to 5 ° has a high favorability, the more we move towards lower values, the favorability for construction decreases reaching restrictive factors.

*Slope orientation.* First stage of analysis was the classification of the orientation map giving 5 classes of favorability. In this case south orientation represents maximum favorability (5) which then decreases to the north with intermediate cardinal points as follows: orientation southeast and south-west falls in Class 4, the east, west respectively in Class 3, the north-east and north-west Class 2, leaving the northern orientation have a minimum favorability, representing Class 1. Horizontal surfaces represented by meadow of Bistrita were assigned favorability class of order 5 because the constructions has a maximum favorability.

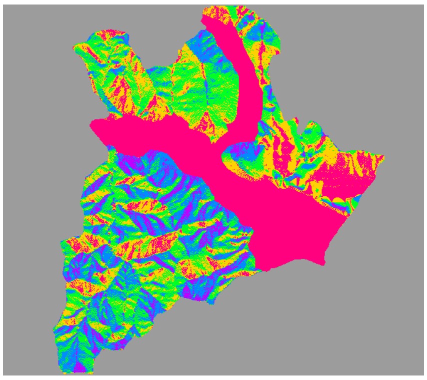


Fig. 7 – The slope orientation map.

The range of colours was awarded as follows: bright colours for classes with high favorability to dark colours for those with minimal favorability (northern direction).

*Distance from roads.* The third parameter used in the analysis of the favorability is the distance from the road. To achieve this, it was prepared a map which generates one buffer (a so-called "buffer zone") for each value of remoteness. Chosen values are less than 50 m (which corresponds to the highest class and favorability), between 50 - 150 m, 150 - 250 m, 250 - 500m, 500 - 750 and over 750 meters. The last class receives the value 0 for unlikely to achieve such a large building at a distance from the road and the rest will receive consecutive notes up to the maximum (respectively 5).

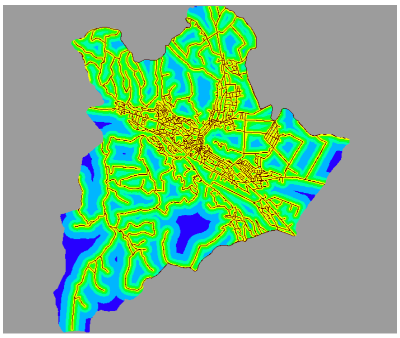


Fig. 8 – Distance from roads (buffer).

The separate analysis of these parameters lead to some results that can be improved by creating a general favorability with the operations of combining classes of favorability values of previous maps. By applying these operations resulted two maps: the summation and multiplication.

The value of the parameters on the multiplication map is the product of the values of the maps of slopes, slope orientation and the distance from the road, while the summation map was obtained by adding the values of the parameters studied.

Examining the general favorability of the relief and each trait it can be said that there is similarity of graphic expression and localization.

Based on these two maps were drawn up a series of graphs showing the evolution of territorial expansion of the city Piatra Neamt according to the 2 considered periods: between 1896 and 1983 and from 1983 to 2006. To obtain them, the areas extended in the period were extracted, and then collected the values from each histogram, which were placed in tables. By making these graphics can be done a rather complex analysis on the territorial expansion to the classes of favorability.

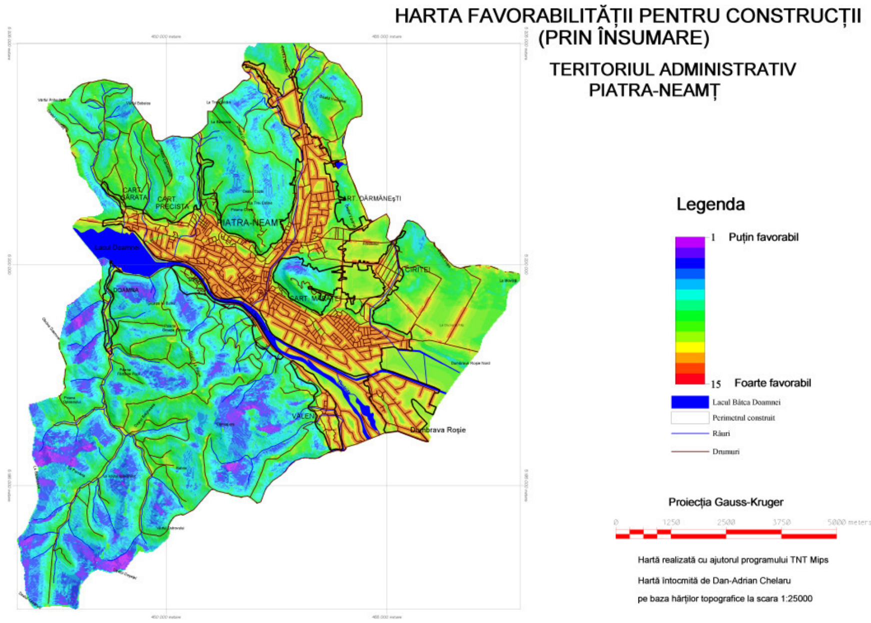



Fig. 9 - The map of favorability for construction made by summation.

Given the map of favorability for construction made by summation were achieved the following two graphs:

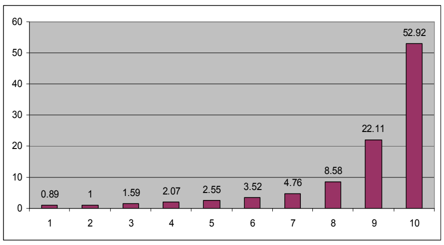



Fig.10 - (1896-1983)

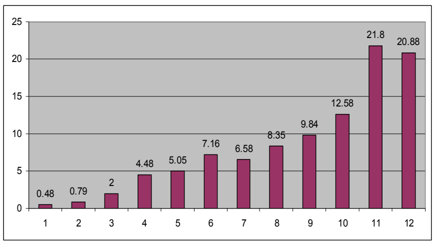



Fig.11 – (1983-2006)

From the first graph can be seen that in this period the highest share of construction was on areas with high favorability classes, more than half of them being found in the most favorable class, thanks to the favorable physico-geographical conditions. We notice some construction areas that are less favorable but they are just a few and are located in isolated areas.

The analysis of the second graph leads to an obvious increase on the classes with smaller favorability; hence we can deduce that territorial expansion was achieved as a result of reaching a saturation level of the building in the most favorable areas. The main reason is the explosive growth of population during this period, thus imposing the need for city development even on less favorable areas.

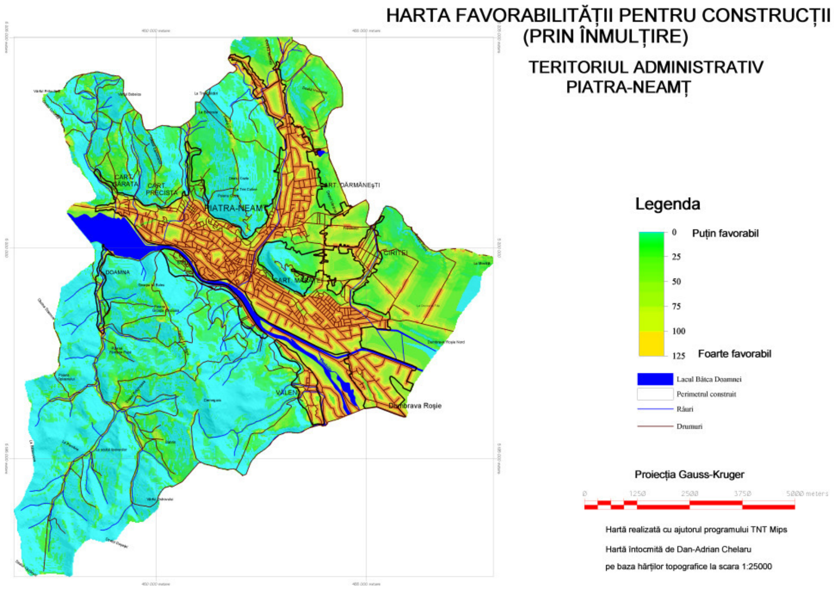
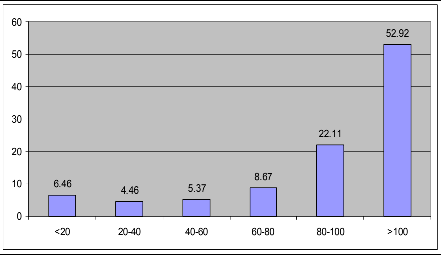
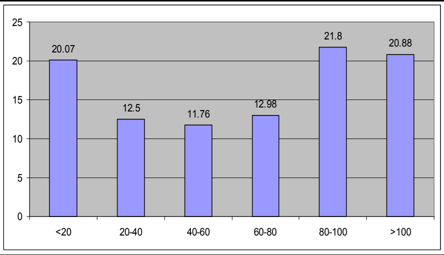



Fig. 12 - The map of favorability for construction made by multiplication.

From the analysis of the map based by multiplication also resulted two graphs for each period of development.

| | |
|---|---|
|  |  |
| Fig.13 - (1896-1983) | Fig.14 – (1983-2006) |

From their analysis can be seen a similarity with the previous ones, only in the second the expansion of areas built-up on less favorable classes is highlighted better. If the first time most of the built area of the city was placed on very favorable areas as Bistrita valley corridor, in the second period there was a proportional distribution in all classes of favorability of the extended areas. In this case, anthropogenic pressure has led to expansion of built even in the mountain area, on the slopes with less favorable orientation such as the north or a considerable distance from the main ways of communication.

## 4. Conclusions

Evolution and current situation of the administrative territory of the city are the result of a complex natural and socio-economic factors, whose role and weight has changed over time and space. Natural conditions were favorable for human settlements, but these aspects of the landscape has been altered in a significant extent by human actions more or less conscious.

Regarding the recent changes occurring in land use are the most significant expansion of the perimeter of the city built. It has an extremely fast growth rate in only 23 years, which resulted in an environment very high anthropogenic pressure.

The analysis of favorability for construction observed that the city has grown especially in areas which are suitable for building such as those with a lower slopes value, with an exhibition of the slopes favorable, but also to the smallest distance from the main communication routes. The best example is the Bistrita valley corridor. However, after reaching the saturation of the building in the most favorable areas, there was need to extend to areas that are less favorable. Another factor that led this expansion stems from the desire of people to improve their lifestyle by growing demand for housing, reflected as an increased need for area.

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*Received: September 15, 2009*

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ANALIZA SCHIMBĂRILOR ÎN UTILIZAREA TERENULUI DIN ARIA MUNICIPIULUI PIATRA NEAMŢ CU AJUTORUL TEHNICILOR GIS

(Rezumat)

Lucrarea reprezintă o analiză a schimbărilor în utilizarea terenurilor din aria municipiului Piatra-Neamţ, vizând în special extinderea teritorială, fenomen care a cunoscut o dezvoltare accelerată în perioada postcomunistă. Pe lângă evaluarea pe teren s-a apelat la o serie de studii de specialitate şi la unele materiale cartografice avute la dispoziţie. Etapa de analiză a informaţiilor coincide cu etapa de laborator reprezentată de utilizarea tehnicilor SIG, urmând interpretarea datelor şi compararea rezultatelor.

BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi" din Iaşi
Tomul LV (LIX), Fasc. 1, 2009
Secţia
HIDROTEHNICĂ

# INTEGRATE GPS SURVEYS AND PDA TO GATHER THE NECESSARY DATA FOR A HYDRAULIC MODEL

BY

**BOGDAN VĂDUVA, *RADU MARIAN and *EDUARD KELLER**

**Abstracts:** This paper will present how to integrate PDA and GPS surveys in order to help gathering necessary data to build the hydraulic model of a city. Our study will show how we imported the gathered GPS points into a PDA/Windows application (in house built) and how that application helped engineers in developing the model. That application was developed for the city of Baia Mare.

**Key words:** GPS, software, hydraulic model.

## 1. Introduction

When this project started none of the people involved in it knew how it can be done and how to have the data ready for a digital use. After a few days of brainstorming and internet research we came up with a solution that fit our needs.

So we decided to have a system that will follow the next steps (Fig. 1):

1. Use GPS surveys to position the manholes
2. Several teams of 2-3 people with PDA's will next do the actual survey of the manholes.
3. At different points the data gathered by the teams will be merged into one database and used to do the hydraulic model.

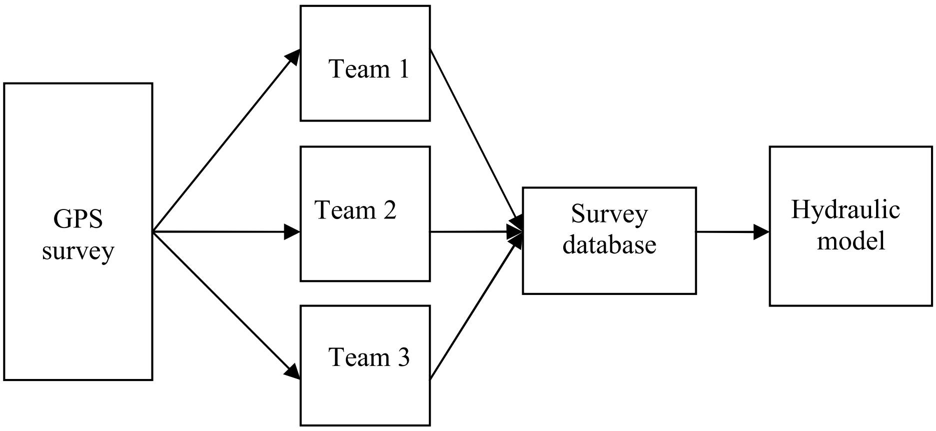


Fig. 1 – How data are gathered.

To do the GPS surveys we used two Trimble R6 GPS Systems. The data collected with the two GPS was exported into a flat file (using Trimble Office) and later used as a starting point for our PDA application. Those points look like the ones in Fig. 2.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | v.lucaciu20 | 685744.168 | 395757.778 | 246.509 | 5 | | CLADIRE | <By Layer | Survey quality |
| 2 | v.lucaciu19 | 685754.15 | 395687.144 | 246.514 | 5 | | CLADIRE | <By Layer | Survey quality |
| 3 | v.lucaciu18 | 685740.827 | 395683.436 | 246.531 | 5 | | CLADIRE | <By Layer | Survey quality |
| 4 | v.lucaciu16 | 685786.533 | 395496.075 | 243.447 | 5 | | CLADIRE | <By Layer | Survey quality |
| 5 | v.lucaciu17 | 685762.405 | 395592.661 | 244.659 | 5 | | CLADIRE | <By Layer | Survey quality |
| 6 | v.lucaciu15 | 685792.146 | 395472.598 | 243.166 | 5 | | CLADIRE | <By Layer | Survey quality |
| 7 | v.lucaciu14 | 685791.654 | 395393.058 | 242.261 | 5 | | CLADIRE | <By Layer | Survey quality |
| 8 | v.lucaciu13 | 685795.712 | 395357.339 | 241.777 | 5 | | CLADIRE | <By Layer | Survey quality |
| 9 | v.lucaciu12 | 685791.519 | 395293.638 | 241.094 | 5 | | CLADIRE | <By Layer | Survey quality |
| 10 | v.lucaciu11 | 685785.45 | 395235.223 | 240.266 | 5 | | CLADIRE | <By Layer | Survey quality |
| 11 | v.lucaciu10 | 685779.518 | 395180.896 | 239.861 | 5 | | CLADIRE | <By Layer | Survey quality |
| 12 | v.lucaciu9 | 685773.923 | 395129.115 | 239.317 | 5 | | CLADIRE | <By Layer | Survey quality |
| 13 | v.lucaciu8 | 685773.519 | 395123.034 | 239.304 | 5 | | CLADIRE | <By Layer | Survey quality |
| 14 | v.lucaciu7 | 685772.566 | 395111.783 | 239.105 | 5 | | CLADIRE | <By Layer | Survey quality |
| 15 | v.lucaciu6 | 685768.361 | 395074.632 | 238.64 | 5 | | CLADIRE | <By Layer | Survey quality |
| 16 | v.lucaciu5 | 685764.346 | 395033.619 | 238.26 | 5 | | CLADIRE | <By Layer | Survey quality |
| 17 | v.lucaciu4 | 685757.158 | 394969.146 | 237.613 | 5 | | CLADIRE | <By Layer | Survey quality |
| 18 | v.lucaciu3 | 685752.819 | 394940.121 | 237.284 | 5 | | CLADIRE | <By Layer | Survey quality |
| 19 | v.lucaciu2 | 685741.866 | 394872.525 | 236.554 | 5 | | CLADIRE | <By Layer | Survey quality |
| 20 | v.lucaciu1 | 685734.809 | 394823.257 | 236.16 | 5 | | CLADIRE | <By Layer | Survey quality |
| 21 | nisiparilor1 | 685559.277 | 394652.977 | 234.338 | 5 | | CLADIRE | <By Layer | Survey quality |
| 22 | nisiparilor2 | 685552.347 | 394593.026 | 233.336 | 5 | | CLADIRE | <By Layer | Survey quality |
| 23 | nisiparilor3 | 685558.289 | 394544.947 | 233.067 | 5 | | CLADIRE | <By Layer | Survey quality |
| 24 | nisiparilor4 | 685504.044 | 394377.839 | 231.943 | 5 | | CLADIRE | <By Layer | Survey quality |
| 25 | nisiparilor5 | 685478.192 | 394343.203 | 231.384 | 5 | | CLADIRE | <By Layer | Survey quality |
| 26 | nisiparilor6 | 685461.195 | 394319.323 | 231.015 | 5 | | CLADIRE | <By Layer | Survey quality |
| 27 | nisiparilor7 | 685441.477 | 394256.569 | 230.594 | 5 | | CLADIRE | <By Layer | Survey quality |
| 28 | nisiparilor8 | 685437.183 | 394239.057 | 230.532 | 5 | | CLADIRE | <By Layer | Survey quality |
| 29 | nisiparilor9 | 685430.473 | 394211.935 | 230.423 | 5 | | CLADIRE | <By Layer | Survey quality |
| 30 | nisiparilor10 | 685417.088 | 394163.537 | 229.948 | 5 | | CLADIRE | <By Layer | Survey quality |
| 31 | nisiparilor11 | 685392.603 | 394111.626 | 229.791 | 5 | | CLADIRE | <By Layer | Survey quality |
| 32 | s.barnutiu1 | 685372.601 | 393970.541 | 228.555 | 5 | | CLADIRE | <By Layer | Survey quality |
| 33 | nisiparilor12 | 685334.099 | 394015.785 | 229.073 | 5 | | CLADIRE | <By Layer | Survey quality |
| 34 | s.barnutiu2 | 685264.176 | 394083.175 | 229.33 | 5 | | CLADIRE | <By Layer | Survey quality |
| 35 | s.barnutiu3 | 685248.67 | 394095.415 | 229.475 | 5 | | CLADIRE | <By Layer | Survey quality |
| 36 | s.barnutiu4 | 685185.149 | 394137.791 | 231.938 | 5 | | CLADIRE | <By Layer | Survey quality |
| 37 | horea1 | 685168.365 | 394061.411 | 231.932 | 5 | | CLADIRE | <By Layer | Survey quality |
| 38 | horea2 | 685154.547 | 393986.902 | 231.143 | 5 | | CLADIRE | <By Layer | Survey quality |
| 39 | horea3 | 685140.91 | 393897.076 | 230.038 | 5 | | CLADIRE | <By Layer | Survey quality |
| 40 | horea4 | 685135.171 | 393871.038 | 229.539 | 5 | | CLADIRE | <By Layer | Survey quality |

Fig. 2 – GPS points.

To be noted that the points are already in STEREO 70 system (conversion is made by the GPS).

At this point we have only a collection of GPS points indicating the position of manholes in the city.

I will make a note at this point saying that we got a little help from an external consultant which had provided us with a survey format. This survey format was followed when we developed the PDA application. Someone could ask at this point why we needed the PDA application. So for those who have this question in their minds we will answer saying that digital data is the only useful data in GIS. For the application we decided to use SQL Server mobile edition because:

- is mobile (can be use on PDA devices) and also can be used on Windows systems with the appropriate software installed
- the data can be manipulated with SQL commands
- the data can be easily converted into a SQL Server 2005, MySQL or PostgreSQL

In order to be able to manipulate manholes we decided to have codes for every street. For every street the manholes will be numbered starting from 1. So if the street code is for example 10 and we have 4 manholes on that street, the complete set of codes will be 10_1, 10_2, 10_3, 10_4. In this way we can't mix up the manholes codes and are easy to read.

## 2. The Application

At this point we will start presenting the PDA application (Fig. 3).

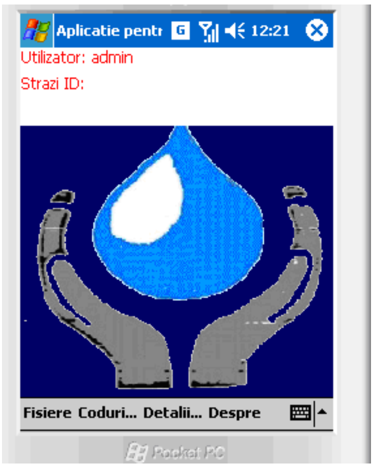


Fig. 3 – Main screen of the PDA application.

This application has a few options. We will present each option:

- Fisiere (File) with the following suboptions (Fi. 4):

- Export … - used to export the entire database content into Excel files
- Iesire (Exit) – exit the application


Fig. 4 – File menu.

- Coduri (Codes) with the following suboptions (Fig. 5):


Fig. 5 – Codes menu.

- Creare (Create) – to create new street codes (Fig. 6)

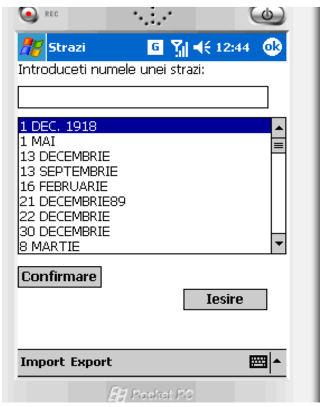


Fig. 6 – Create option.

At this point we will notice the two options available (Figs. 7 and 8): Import and Export. Import is used to import the GPS points into the application and Export is used to export the data into an Excel file format, which can be easily imported into the database of choice. Be careful in choosing the database because the effort involved in moving the data is the same either you are using some home use database or a more serious one. By using inappropriate database servers you can find yourself in that situation in which you will have to do the above step again, but using a different database server. *It is a waste of your time!*


Fig. 7 – Import option.

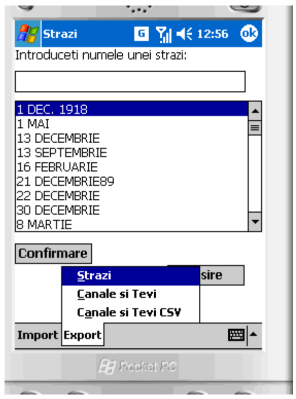


Fig. 8 – Export option.

○ Vizualizare coduri strada (View codes - street) – to view street codes

○ Vizualizare coduri introduce (View codes - insert) – to view the entered street codes (Fig. 9).

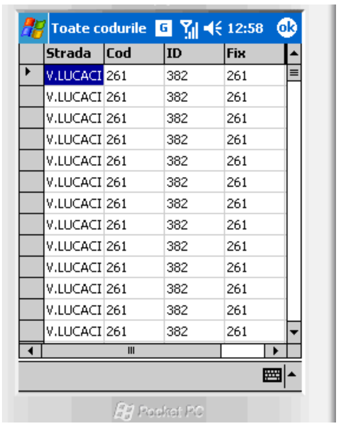


Fig. 9 – View codes.

• Detalii… (Details) – used to enter the actual survey of the manhole. The user will work on a street at one moment. So he/she will have to select the street using a search screen (Fig. 10).


Fig. 10 – Details option.

To note that we tried to use similar user interfaces.

Once a street was selected a selection screen for the manhole numbers will appear (Fig. 11).

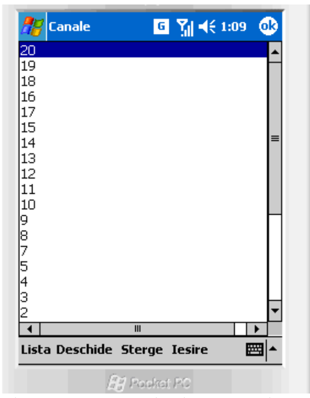


Fig. 11 – Manholes numbers.

The user has now the ability to select a manhole and work with it. Once he selected a manhole a new screen will popup (Figs. 12, …, 17).

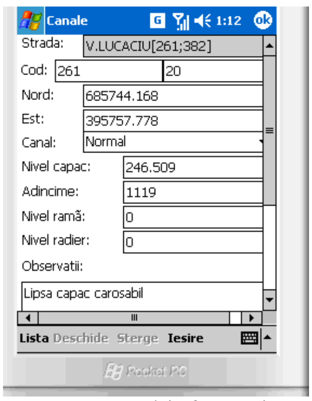


Fig. 12 - General information. (1)

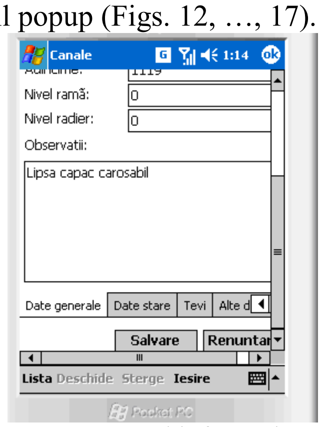


Fig. 13 – General information (2)

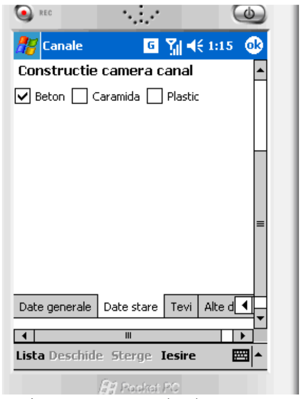


Fig. 14 - Manhole status.

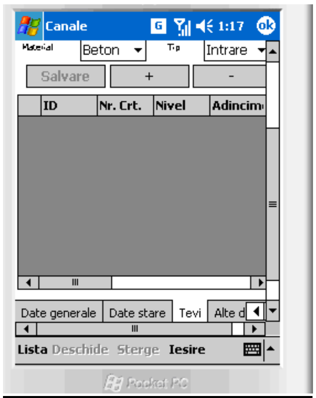


Fig. 15 – Pipes.

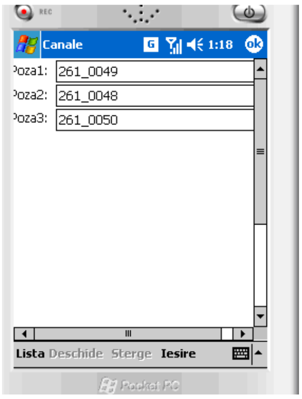


Fig. 16 – Pictures.

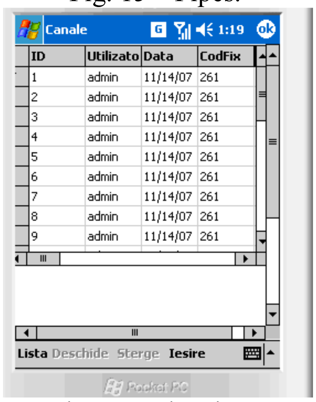


Fig. 17 - List view.

Of course the project wasn't an easy one and we've got issues. The main issue that we confronted with was the level of computer knowledge for the people doing the survey. Some of them weren't able to use the PDA's and they did the surveys on paper, those surveys being entered into the database at a later time. To do that the same application can be started on Windows systems.

Once the data is populated it can be merged into a single database which can be used in different software as a starting point. In our case InfoWorks was the software of choice and that was used to produce the hydraulic model. At the time this article has been written about 3000 manholes had been surveyed.

## 3. Conclusion

We will conclude our short article with a few notes/recommendations:

1. Be open in using in house built software (GIS is not only of the shelf products).
2. Be flexible when developing the software by providing exports to different formats.

3. PDA applications *can* be integrated with GPS.

*Received: November 21, 2008*

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## R E F E R E N C E S

1. *** http://www.trimble.com, http://www.microsoft.com

## UTILIZAREA GPS-URILOR ŞI A PDA-URILOR ÎN CULEGEREA DATELOR NECESARE CONSTRUIRII MODELULUI HIDRAULIC AL UNUI ORAŞ

(Rezumat)

În această lucrare am prezentat cum am integrat GPS-urile şi PDA-urile pentru a culege datele necesare construirii modelului hidraulic al unui oraş. Modalitatea noastră de integrarea a fost următoarea:

1. Una sau mai multe echipe au identificat canalele folosind GPS-urile
2. În pasul următor s-au trimis mai multe echipe pe teren pentru a completa formularele (culegerea de informații)
3. Datele culese de echipe au fost îmbinate la sediul firmei
4. Datele adunate au fost exportate într-un format care permite importul în aplicația de generarea a modelului hidraulic.