STUDY OF MORPHOLOGICAL CHANGE OF RIVER OLD BRAHMAPUTRA AND ITS SOCIAL IMPACTS BY REMOTE SENSING

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ABSTRACT

Old Brahmaputra River is one of the main rivers in Bangladesh. In this study, the part of the old Brahmaputra River, offtaking from Jamuna is located under the district of Mymensingh and partially under the district of Tangail, Jamalpur, Sherpur and Netrokona. Analyzing the image of part of the old Brahmaputra River among the year 1997 and 2004, it is found that Significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town where China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed. Transportation of sediment is the major contributing factor of morphological changes.

Key words*: meandering, remote sensing, sediment transport, morphological changes, river protection.*

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1. INTRODUCTION

Bangladesh stands on a thick alluvial deposit. It is the result of deltaic activity of the Gangas and the Brahmaputra. These main rivers, their tributaries and distributaries control its hydrological and morphological behavior. The Padma, the Megna, the Jamuna are the big and wide rivers of Bangladesh. The Buriganga, the Surma, the Kushiyara, the Monu, the Sitalakshya, the Dhaleswari, the Teesta, the Gumati and the Karnafuli are small rivers. Rivers differs from one another in their physical characteristics and general behaviors. Among these small rivers, the Old Brahmaputra is an active river and play important role in changing morphological changes in the others rivers of downstream [1]. Constant changes of the river's course constitute a significant factor in the hydrology of the Brahmaputra; the most spectacular of these changes was the eastward diversion of the Tista River and the ensuing development of the new channel of the Yamuna, which occurred in 1787 with an exceptionally high flood in the Tista. The waters of the Tista suddenly were diverted eastward into an old abandoned course, causing the river to join the Brahmaputra opposite Bahadurabad Ghat in Mymensingh district. Until the late 18th century the Brahmaputra

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flowed past the town of Mymensingh and joined the Meghna River near Bhairab Bazar (the path of the present-day Old Brahmaputra channel). At that time, the course of the Yamuna River (now the main Brahmaputra channel) was a minor stream called the Konai-Jenai, which was probably a spill channel of the Old Brahmaputra.

After being reinforced by the Tista flood of 1787, the Brahmaputra began to cut a new channel along the Konai-Jenai and gradually converted it after 1810 into the main stream, now known as the Yamuna. So, the study is strictly focused on the Old Brahmaputra river. This study provides the finding of morphological change, its cause, its effect by using remote sensing and GIS.

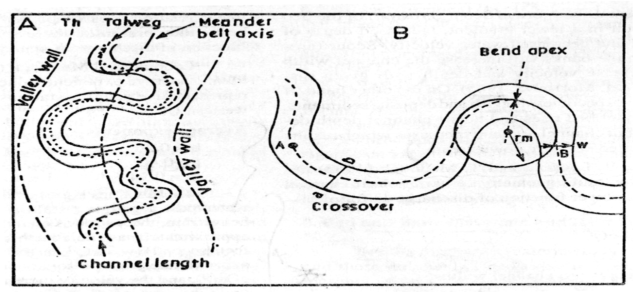


Fig. 1. ***Channel form-valley walls, channel length, channel thalweg, meander belt axis, crossover, curvature of radius (rm) and channel width***

Channel morphology is the result of mutual interactions of four broad categories of variables such as fluid dynamics (which include velocity, discharge, roughness and shear stress), channel character or channel configuration (e.g. channel width, channel depth, channel slope, channel shape, channel pattern etc.), sediment load and Bed and bank materials (composition and character i.e. coarse, fine, medium etc.). Fig. 1 shows its different variables of channel morphology [2, 3, 4, 5]. Fig. 2 shows the different types channel pattern. The rivers studied are meandering rivers in pattern. Different types of meander changes are shown in fig. 3.

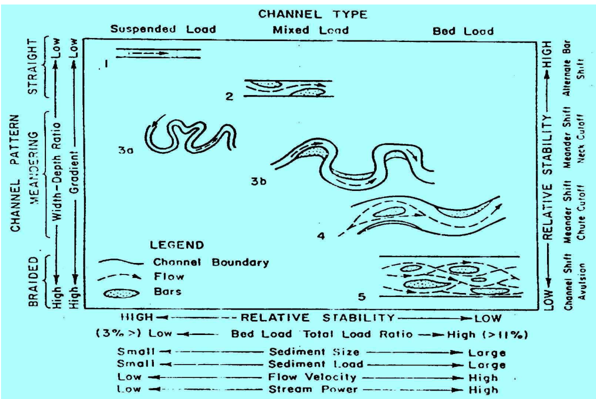


Fig. 2 ***Channel classification based on pattern and type of sediment load, showing types of channels, their relative stability and some associated variables [6]***

Many researchers use remote sensing technology in studying channel pattern study which is a part of morphological change study [7, 5]. Alam and Hossain [7] studied identifying the morphological changes of a distributary of the ganges in response to the declining flow using remote sensing. In response to the changes of the hydraulic regime, morphological characteristics of the river have been changing as well. Remote Sensing and Hydrologic Data Satellite images are mainly used to identify the morphological changes. Kolejka J. (2006) was realized an application of digital landscape model in crisis management (intensity and frequency of occurrence of extreme atmospheric and hydrological phenomena; erosion, land sliding, subsidences etc.)

On the other hand hydrologic data are used to show the relation between the changes of morphological parameters with the change of hydraulic regime. For planning and sustainable development, identification of morphological change is essential. So, in this study, an attempt has been taken to present the pattern of morphological change of one of the main river of Bangladesh (Old Bramaputra) and its social impact for future planning to protect agricultural land, ecology of the surrounding area.

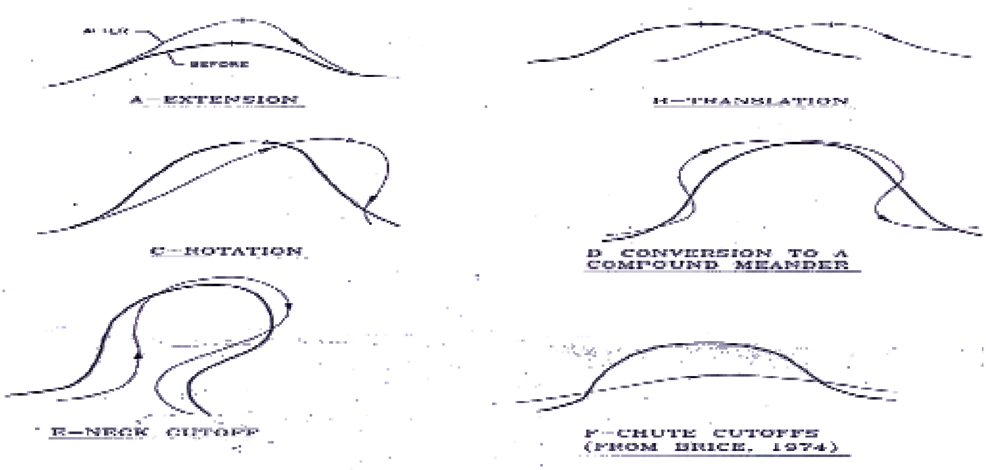


Fig. 3. Different types of meander changes [6]

2. STUDY AREA

The main part of the study area is under the district of Mymensingh and partially under the district of Tangail, Jamalpur, Sherpur and Netrokona. Fig. 4 shows (inside the rectangle) the study area along with the major river networks. Geographically the study area is situated within $90^0\ 03'\ 34.34''$ to 90 41 08.93 E longitude and 24 28 43.64 to 24 59 48.83 N latitude. The climate of the study area is tropical monsoon. Figure 5 shows typical monthly minimum and maximum temperatures and rainfall variation characteristics in Bangladesh over the year (Mymensingh district).

The general soil types of the area are Non-calcareous gray flood plain soils. The landuse / land cover of the area is categorized in to cultivated land, forest, plantation and barren land. The inhabitants of the study area are mainly dependent on agricultural production. The main occupation is agriculture. Most of the farmers practice non-mechanized conventional agriculture. In general, the inhabitant of the area is in lack of knowledge of soil conservation.

3. METHODOLOGY

Input Data Used

Landsat TM data has been used for the present study. To detect the changes of two images data were used and those are:

January 10, 1997 and

January 25, 2004.

In both cases Band 2, 3 and 4 has been chosen for the present study.

Unsupervised Classification shows how to create a thematic raster layer by letting the software identify statistical patterns in the data without using any ground truth data. ERDAS IMAGINE uses the ISODATA algorithm to perform an unsupervised classification. The ISODATA clustering method uses the minimum spectral distance formula to form clusters. It begins with either arbitrary cluster means or means of an existing signature set. Each time the clustering repeats, the means of these clusters are shifted. The new cluster means are used for the next iteration [8].

The ISODATA utility repeats the clustering of the image until either a maximum number of iterations have been performed, or a maximum percentage of unchanged pixel assignments have been reached between two iterations. Performing an unsupervised classification is simpler than a supervised classification because the signatures are automatically generated by the ISODATA algorithm.

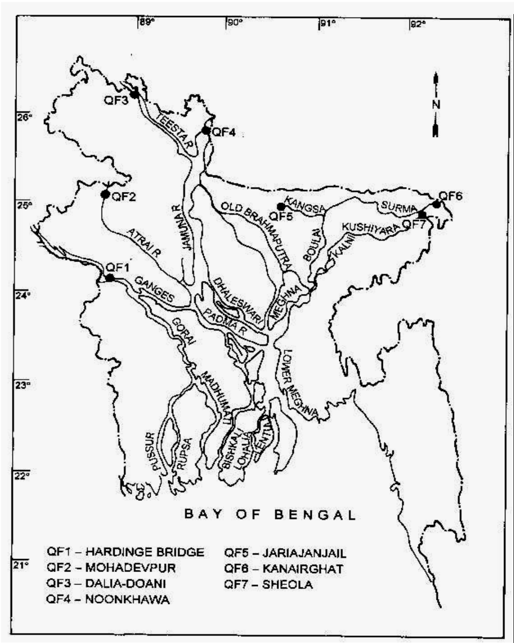


Fig. 4. ***Location Map of the study area map***

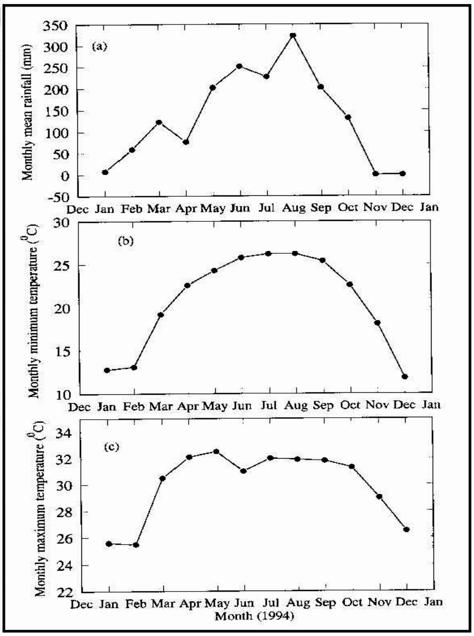


Fig. 5. ***Typical monthly variation characteristics of rain and typical monthly minimum andmaximum temperatures in Mymensingh district.***

Raster Attribute Editor to compare the original image data with the individual classes of the thematic raster layer that was created from the unsupervised classification. This process helps identify the classes in the thematic raster layer. Also use this process to evaluate the classes of a thematic layer that was generated from a supervised classification.

Thresholding divides an image into two classes. For example, in the near IR band, water has low reflectance values while land areas, either vegetated or bare ground, have higher reflectance values. By examining a frequency distribution of the brightness values, we may be able to determine that water bodies have brightness values less than 40 (on a scale of 0 - 255). This threshold is used to separate water from land. In the present study, the threshold value 37 (1997) and 33 (2004) for better land water separation were found out. After land water classification two classified image has been overlaid through "indexing" operation in ERDAS Imagine environment. Thus the thematic layer of two images of different year has been indexed (added) to create a composite layer. The output layer contains the sums of the input layer values. Finally the changed statistics has been calculated for results and discussion. Figure 6 shows the methodology of the study.

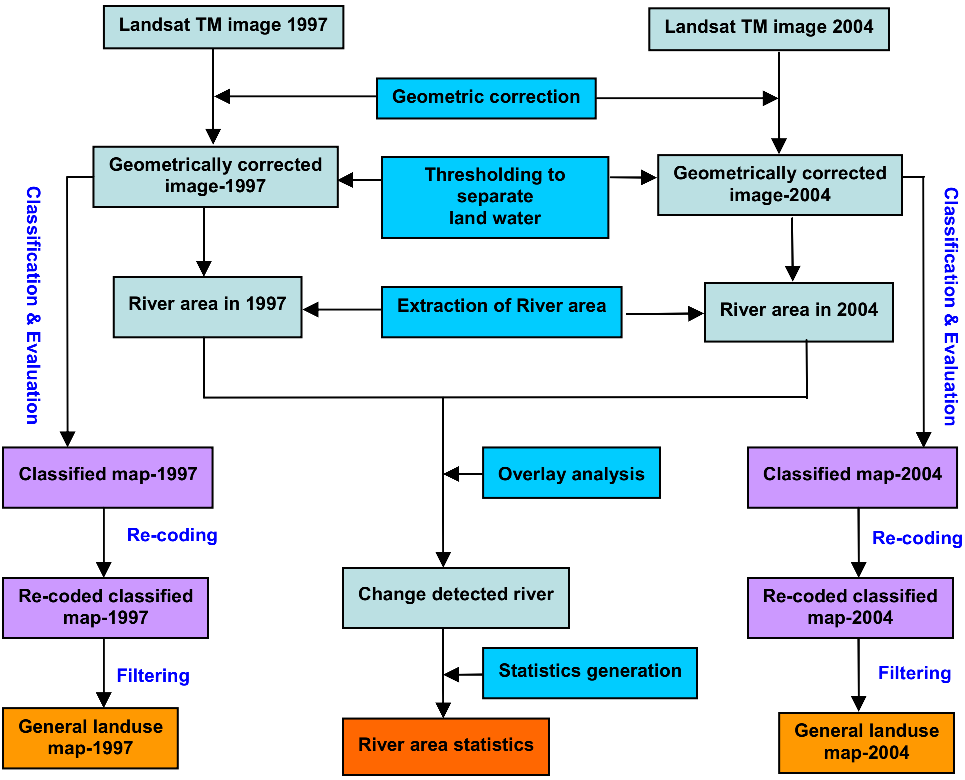
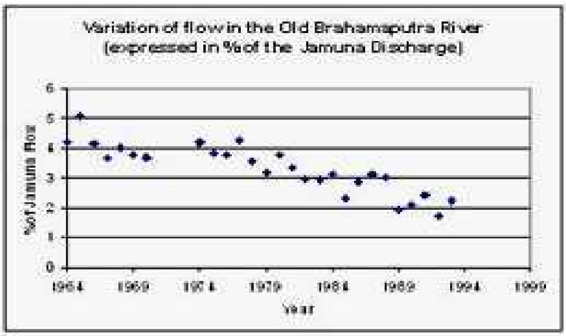


Fig 6. ***Flow diagram of the whole study***

4. RESULT AND ANALYSIS

Hydrological characteristics of the study area

Old Brahmaputra River a river that originates from the left bank of the Brahmaputra to the north of Bahadurabad. Flowing more or less to the southeast it passes by Jamalpur and Mymensingh towns and falls into the MEGHNA at Bhairab Bazar. River shifting has been a characteristic feature of the BENGAL BASIN, affecting small sections or even the entire river. The most dramatic was the shifting of the courses of the TISTA, Brahmaputra and lower GANGES river channels as evident from maps prepared hundreds of years ago. James RENNELL produced the most accurate map back in 1760. According to this map, the Brahmaputra at that time was flowing a course east of the MADHUPUR TRACT, presently known as the Old Brahmaputra. The lower part of the Brahmaputra channel between Dhaka and Mymensingh subsequently was silted up diverting the Old Brahmaputra flow to SHITALAKSHYA river and then to the DHALESHWARI and Meghna rivers southeast of Dhaka. The Old Brahmaputra acquired its present course between the Madhupur Tract and the BARIND TRACT in the year 1787. In that year the river shifted its course and was named the JAMUNA. This shifting followed a major FLOOD in the same year. The severe EARTHQUAKE reported from Mymensingh region in 1782 may also have contributed to this shift. The shifting of the Old Brahmaputra, along with other major shifting rivers, is now considered the effect of neotectonic activities in recent times. The shifting process seems to have taken place over a period of 30 years. The Old Brahmaputra floodplain stretching from the southwestern corner of the Garo Hills along the eastern rim of the Madhupur Tract down to the Meghna river exhibits a gentle morphology composed of broad ridges and depressions. Soils of this geomorphic unit are more oxidized.



In both of the year to total area is not two much changed even land area are also similar but river area has decreased in 2004. The possible reason behind that is the 2004 image has been acquired 15 days latter than 1997 (Table 1 and Table 2).

Fig. 7. ***Variation of flow with year***

Land water area in 1997

Table 1

Class name	Class ID	Area (in ha)
Land	1	360430
River	2	1780.74
Total area		362210.7

Land water area in 2004

Table 2

Class name	Class ID	Area (in ha)
Land	1	361031
River	2	1564.81
Total area		362595.8

Composite statistics of changing the land – water area

Table 3

Class name	Class ID in 1997	Class ID in 2004	Area (in ha)
Land in both year	1	1	359379
Land in 1997 but river in 2004	1	2	834.69
River in 1997 but Land in 2004	2	1	1049.63
River in both year	2	2	729.5

From the above table it has been found that the river area is changing towards land area from 1997 to 2004. The probable reason is siltation. River normally gets silted during their course of flow. Every river carries certain amount of sediment load. The sediment particles try to settle down to the river bottom due to the gravitational force, but may be kept in suspension due to the upward currents in the turbulent flow which may overcome the gravity force. Due to these reasons, the river carries the fine sediment in suspension as suspended load. Whenever the flow velocity in the channel reduces, the silt carried by the water in suspension gets deposited on the bed and sides of the canal. The deposition of sediment in the river is known as 'River Silting' or 'River Sedimentation'. The silt so deposited reduces the effective canal cross-section and the carrying capacity of the channel. Also impacts of river course changes on agriculture, settlement, forest, fisheries, infrastructure, hydraulic structure etc.

Significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town. China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed in the place Patugudam more; Mymensingh town where the less changed has been occurred (figures 8, 9). The reason of change may be due to meandering nature of river [9].

Engelund and Hansen equation:

$$g_s = 0.05\gamma_s v^2 \sqrt{\frac{D_{50}}{g(\frac{\gamma_s}{\gamma}-1)}}\left[\frac{\tau_0}{(\gamma_s-\gamma)D_{50}}\right]^{3/2}$$

kg/m^2

Where: g_s = Sediment transport/unit time/per unit width

τ_o = bed shear stress = γRS= 0.23

v = average flow velocity = 1.17 m/s

D_{50} = 0.00034

γ_s = Specific weight of sediment particles = 2650

γ = Specific weight of water = 1000 kg/m^3

S= slope = 0.00007 and B= width = 74.6 m

g_s = 26.21 kg/sec

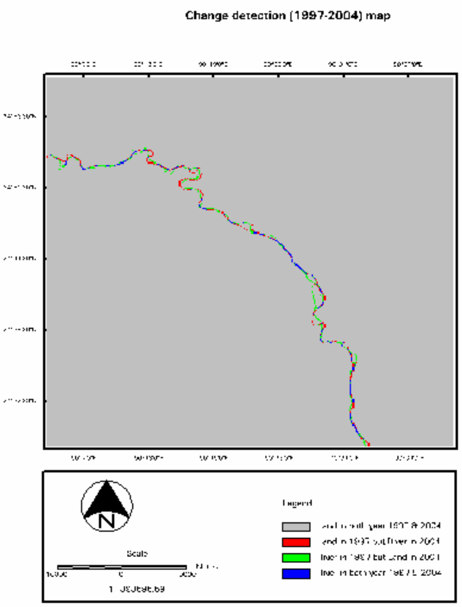


Fig. 8. ***Change detection map of the study area (Landsat TM data: January 10, 1997- January 25, 2004)***

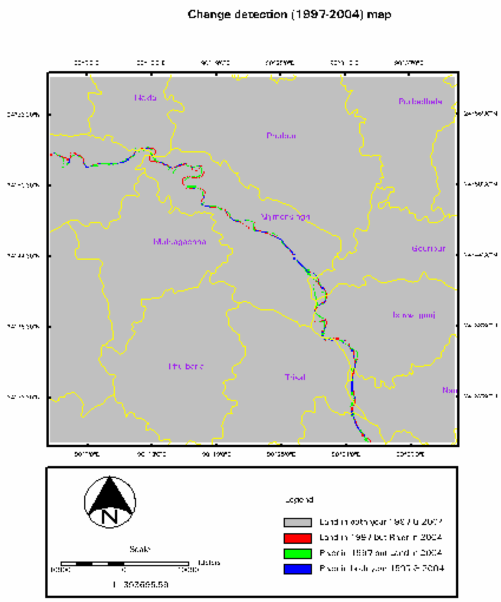


Fig. 9. ***Change detection map of the study area (Landsat TM data: January 10, 1997- January 25, 2004)***

It is clear from the Figure 8 that changes occurred at east part of Mymensingh sadar upazila. The reason of change may be due to meandering nature of river [9]. Use of satellite images provides more information regarding bank erosion. Erosion occurs along a 1.12 km long (maximum) at China Bangladesh Friendship Bridge (Shambhuganj Bridge) over time. The river course-changing pattern due to sedimentation is measured 168.34 ha by using plani-meter.

With the help of figure 3; the change showing in figures 8 and 9 at Shambhuganj Bridge is chute cutoff type change. At north east part of Mymensingh mainly translation occurs. At Raysrr neck cutoff type of change occurs. At close to the Mymensingh town chute cutoff and translation combinedly occurs at the middle section and at the upper and lower portion rotation occurs and at Telibil chute cutoff type change occurs. The cause of morphological changes of the rivers is sediment transport. The rate of sediment transport in rivers depends on many variables, such as water discharge, average flow depth, flow velocity, energy slope, shear stress, stream power, particle size and gradation as well as temperature. Based on concept of dimensional analysis and similitude argument, Hossain [1] proposed that sediment concentration in a stream of steady water and sediment flow is a power function of the product of Froude number and slope of energy gradient, the settling velocity ratio and the discharge ratio. Change of averaged width and braiding intensity with year for the river at north east part of Mymensingh is significant.

In order to getting idea about socio-economical impact of morphological change during the study period, a questionnaire survey was conducted among the people, local representative, experts (200 persons) through Focus Group Discussion (FGD). The randomness of the sample, which was 234 house hold in size, was kept. In each unit, proportionate representation of social class was maintained in selection of the households. However, in order to present the actual picture of the existing condition of effected area, in terms of social categories samples were distributed as follows: poor 147, middle 75 and rich 12. Number of poor and middle class respondents was proportionately much higher like the universe and henceforth it can easily be assumed that the sample represents the population exactly.

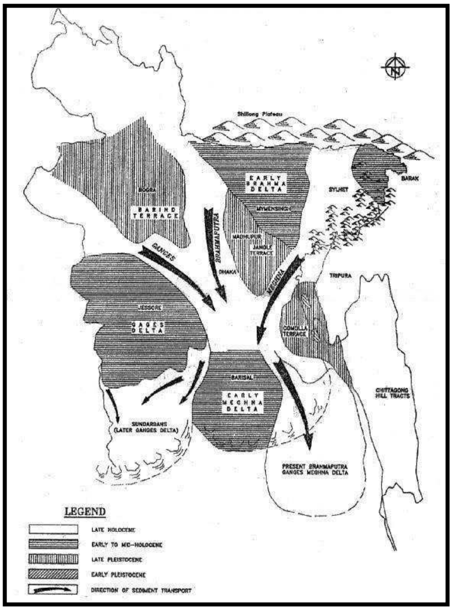


Fig. 8. ***Quaternary Sedimentation in Bangladesh***

Using a face-to-face technique, empirical data were collected for the study by sample survey method where the universe contains whole area. Based on the information and the data, collected from the first visit, several meetings of the team members were held and an interim test information-checklist was prepared. The information-checklist was pre-tested in the non-sampled area through a pilot survey before finalization. The final information-checklist contained both pre-coded and open-ended questions. Table 4 shows the present socio-economical parameters which area mostly affected due to erosion and siltation. Major causes of erosion are currents, strong river discharge, high waves, and increases of population. The historical maps are used to analyze the complex pattern of sediment movements. Analysis of historical maps of 1990 and 1997 reveals very large changes near Mymenshing town and its erosion/accretion pattern is a function of the increased currents, high upstream flow, high water level, most of the plain of the study area is composed of silty sand and clay deposits, which is highly susceptible to erosion. According to Khan (1999) the gargling effect of water in rivers of Bangladesh will increase with the rise of water level in sea. The major environmental imbalances in the river basin are described below:

From time immemorial, people of Bangladesh Prefer to settle along the bank of the river. Fertility of soil and stableness of the river regime guide the density of the habitation. Habitation along the flood plain bank of the river decreases flood passage of the river. In the river, there are habitations along the both bank of the rivers. People live in very close proximity to the active river channels and are exposed to high risks from erosion and channel changes. In a flood plain, land use practices depend mainly on the depth of flooding due to population pressure, crop variety and intensity has increased. And low-lying area, fallow and pastureland are being cultivated to cope with the increasing demand of the food gain. The flood peak of Old Bramaputra is in fluctuating in nature. The entire main crops of the area are susceptible to flood damage.

Environmental Impact Evaluation of erosion and siltation in Old Bramaputra River

Table 4

		Probability (p)	Severity (s)	Impact Value (IV) = p * s	No Impact	Positive Impact	Insignificant	Low	Medium	High
1.	**PHYSICAL ENVIRONMENT**									
	Topography									
	Plane land	1	6	6				√		
	Soil									
	Erosion	6	6	36						√
	Siltration	6	6	36						√
	Pollution	2	1	2			√			
2.	**ECOLOGICAL ENVIRONMENT**									
	Terrestrial Flora									
	Destruction of plantation	3	6	18						√
	Terrestrial Fauna									
	Disturbance to wildlife	4	3	12				√		
3.	**SOCIO-ECONOMIC ENVIRONMENT**									
	Loss of Land									
	Agriculture	4	4	16					√	
	Residential/Community	3	4	12					√	
	Industrial/Commercial	2	3	6				√		
	Impact On									
	Crops/Plantation	2	6	12					√	

*Negative Impacts Severity (s)
1= No damage
2= Minor damage (hazard to single receptor)
3= Minor damage (hazard to multiple receptor)
4= Significant damage (hazard to single receptor)
5= Significant damage (hazard to multiple receptor)
6= Destruction of single/multiple receptor

Probability (p)
1= Negligible
2= Slight
3= Possible
4=Likely
5=Very likely
6= Inevitable

5. CONCLUSIONS

Remote sensing and GIS technology shows the great potentiality to study the morphological change study of the river. This type of study is helpful for further planning of river training and management in an effective manner as it could be incorporated the long time (historical) changes of the river morphology. Analyzing the image of part of the old Brahmaputra River among the year 1997 and 2004, it is found that significant changed has been occurred in north east part of Mymensingh sadar upazila and less change is found in the lower part which is close to the Mymensingh town where China Bangladesh Friendship Bridge (Shambhuganj Bridge) has been constructed. Use of satellite images provides more information regarding bank erosion. Erosion occurs along a 1.12 km long (maximum) at China Bangladesh Friendship Bridge (Shambhuganj Bridge) over time. The river course-changing pattern due to sedimentation is measured 168.34 ha by using planimeter. Transportation of sediment is the major contributing factor of morphological changes. From the study, agricultural land, associated people, irrigation, fisheries, hydraulic structures are identified as most affected parameters due to the morphological change of part of the old Brahmaputra River. River protection works suggested by Nahar [10] and Syed [11] can be applied in the study area.

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THE USE OF G.I.S. TO ESTABLISH SOME PARAMETERS USEFUL TO MEASURE THE TIME OF CONCENTRATION AND THE RUNOFF COEFFICIENT

– applied to: The Hydrographic Basin of Căpuş –

A. I. Crăciun[1]

ABSTRACT
The study presents a model of computing two of the hydrological indices (time of concentration and runoff coefficient), by using some GIS extensions (AGWA, Spatial Analyst). Analyzing the digital elevation model and using data referring to the soil texture and land use in the Capus Basin, a number of parameters have been estimated, and then integrated in the calculus equations of these two indices. Knowing these indices is necessary in evaluating the water reserve in a hydrographic basin, and thus increasing the efficiency in hydrological hazard forecasting.

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1. INTRODUCTION

The purpose of this study is to emphasize some different parameters used in measuring the time of concentration and the runoff coefficient, using a GIS application in the Căpuş basin.

The main objectives of the study refer to:

- ✓ presentation of the GIS extensions and functions and how to work with them;
- ✓ the analysis of the parameters necessary in measuring the time of concentration and the runoff coefficient;
- ✓ the spatial representation of the values specific to the time of concentration and the runoff coefficient.

The time of concentration and the runoff coefficient are very important indices in the analysis of the runoff through a territory. The use of these indices in the equation of maximum flow is due to make more efficient prediction of hydrological hazards. Once rainfall starting the interest is shifted towards the time the water takes to runoff the side or in the river bed and to reach the computation section.

The time of concentration and the runoff coefficient also depend on a lot of physical-geographic characteristics of the area studied: pedogeographic, morphometric and land use characteristics. Knowing the runoff coefficient that characterizes a watershed helps to determine the soil water reserve at one moment; this is a very important aspect in estimating the high flood amplitude generated by a rainfall.

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2. METHODOLOGIC ASPECTS

2.1. The elementary database, the G.I.S extensions and the equations used

The database support needed to elaborate and analyze these includes:

- *altimetry data*, obtained through the digitization the contours line from the topographic maps 1:100.000;
- qualitative data that refer to the *pedogeographic characteristics of the* basin (type, texture) resulted in the digitization through the pedologic maps 1:200.000 and adjusted by name to SRTS 2000 (Petrea Rodica, 2001);
- qualitative data that refer to the means of land use obtained through the digitization the topographic maps 1:100.000;

The most parameters used for estimating the time of concentration and runoff coefficients can be determined easily using some extensions specific to GIS technology (**Table no. 1**). The software used were ArcView 3.2a and ArcGIS 9.x. These G.I.S software was used , successfully, for analysis of maximum runoff for sides (Haidu I., Bilaşco Ş., 2005) or charcoal quarrieres (Haidu I., Crăciun A.I., 2006). Păcurar D. V. (2005) was used, for estimation of runoff coefficient, Idrisi software. Also, GIS application in hidrology was realized, by Pancescu M. (2006).

Processing G.I.S

Table no. 1

	Extension used	Function used	Result obtained
TIME OF CONCENTRATION	3DAnalyst/ Spatial Analyst	*CreateTIN/ Convert to GRID*	Digital Model Elevation
	XTools	*CalculateLength*	Length to the rivers bed
	AGWA	*DelineateWatershed*	Watershed delineation
			The division of the watershed in subwatersheds
			Flow direction
			Flow accumulation
			The perimeter of the basin
			Area of the basin
			The medium slope
			The medium slope of the main river bed
			The length of the main river bed
RUNOFF COEFFICIENT	Spațial Analyst	*DeriveSlope*	Slope map
		Convert to GRID	Conversion of a theme shapefile in a GRID theme
		Reclassify	Reclassification of the attributes of a GRID theme
		Map Calculator	The sum of GRID themes

For calculating the time of concentration (Diaconu C., Şerban P., 1994) it was used a relation that take into consideration the sides length (L_v) and river bed length (L_a)and in the same time the water speed on the sides (V_v) and in the river bed (V_a):

$$T_c = t_{c\ versant} + t_{c\ albie} = \frac{L_v}{v_v} + \frac{L_a}{v_a} \quad ; \quad (\text{min.}) \qquad\qquad (\textit{relation no. 1})$$

The main river bed length (L_a) was obtained automatically; the side length (L_v) was determined as ratio between the basin area (F) and sum of sides length ($\sum L_a$). The water speed on the side (V_v) and the river bed (V_a) were estimated considering the valley and side type, the side slope and the land use.

For estimating the values of the runoff coefficient on the basin the synthesis elaborated by Frevert where he takes into calculus the relation between the land slope, the soil texture and the land use was used.

2.2. Layers necessary

Delineating watersheds and determining the morphometric parameters that will be included in the calculus of the time of concentration have as processing support the Digital Elevation Model (fig.1) and can be obtained by using the extension AGWA (Automated Geospatial Watershed Assessment).

AGWA represents a GIS extension with versions also for ArcView 3.2a and for ArcGIS 9.x, for the analysis and modeling of different hydrologic processes. In the same time, it offers the possibility to create parameters for the pedogeographic and land use characteristics.

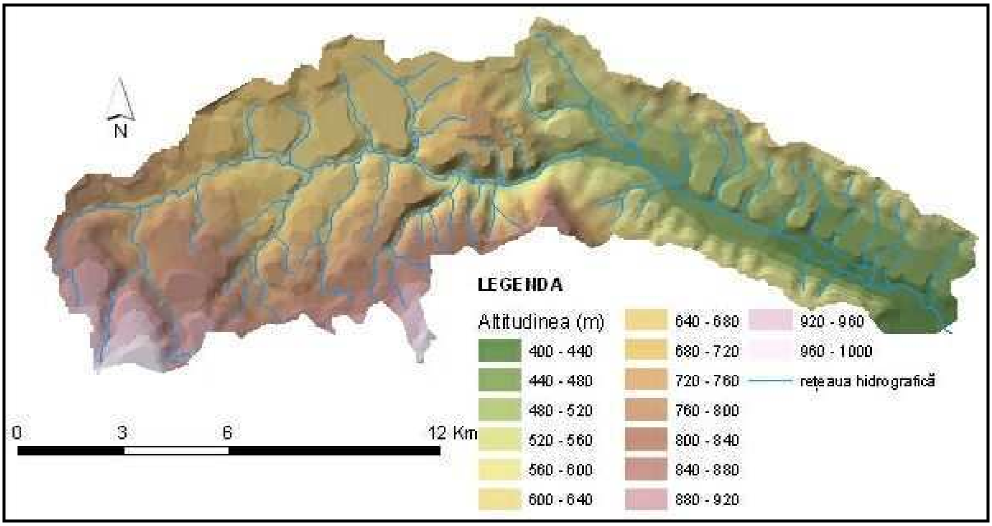


Fig.1. ***The Căpuş Basin. Digital Elevation Model***

The processing in **AGWA** is realized by using the text models: KINEROS (**K**inematic **R**unoff and **E**rosion **M**odel), respective SWAT (**S**oil **W**ater **A**ssessment **T**ool).

As far as the runoff coefficient is concerned, for the estimation method the relations between slope, soil texture and land use (Frevert coefficients) were computed. For each of these characteristics a layer was realized for each than a simplification (reclassification) using the **R**ecassify function and intersection using the **M**apCalculator function. The results are converted in a layer that will include all of the three sets of basin characteristics.

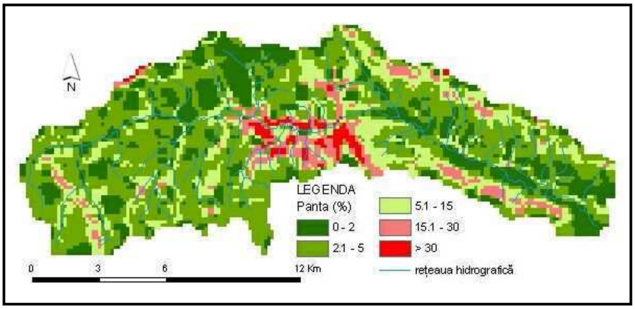


Fig.2. ***The Căpuş Basin . Declivity layer***

Slope (Fig.2) has a decisive influence on the spatial distribution of the runoff coefficient; so, the little values of the slope (watersides, platforms, watersheds) have the effect of decreasing the runoff speed, increasing the infiltration water in the soil.

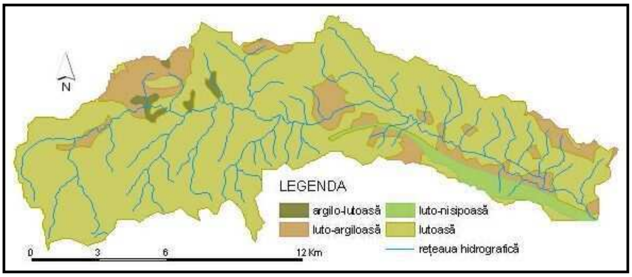


Fig.3. ***The Căpuş Basin. The soil texture***

The basin *pedogeographic characteristics* (Fig.3*)* influence the quantity of water infiltrated in the soil first by texture: during a rainfall the soils are characterized by a huge capacity of infiltration having the role to put off the runoff process.

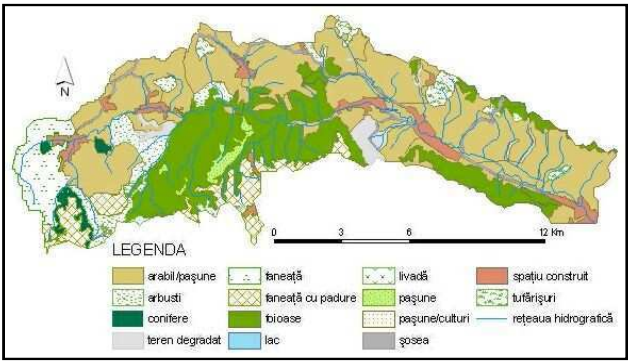


Fig.4. ***The basin of Căpuş. Land use layer***

The land use (Fig. 4) influences the hydric runoff process: the effect on the slopes with forests is that it acts as „the brake" of runoff (the retention of the precipitation drops on the crowning) while in deforested areas it makes it easier for an increase of water speed and flow.

4. RESULTS

In order to determine the parameters that are used in the time of concentration equation is necessary, first, to generate, automatically, using DEM, the layers that refer to flow direction and flow accumulation. (Fig.5).

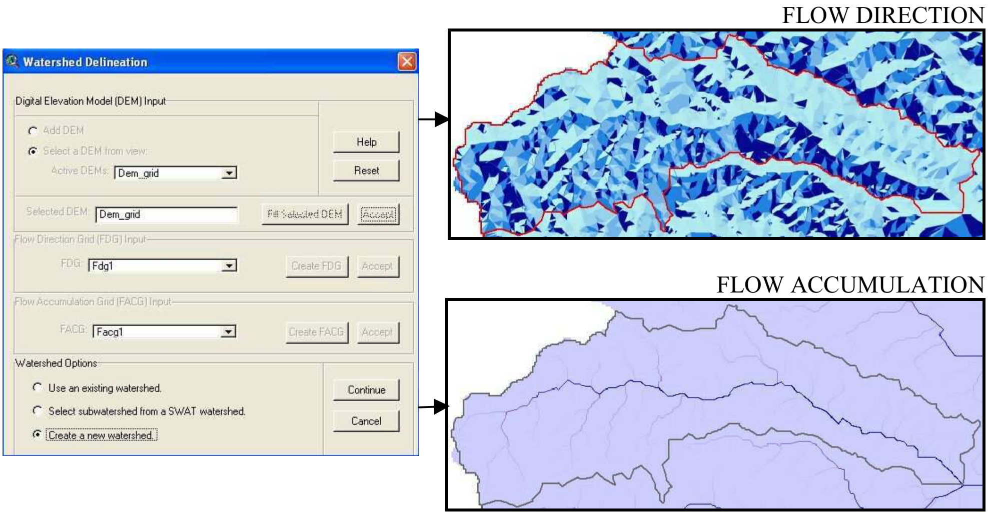


Fig.5. ***Generate flow direction and flow accumulation data***

Next, the use of SWAT model results in the delineation of the watersheds that we are interested in, their shared sectors and the graphical representation of the main river beds (Fig.6). Also, this model calculates a lot of morphologic and hydrometric characteristics of the basin (**table no.2**). Thus eight sectors with variable surfaces from 4,8 km^2 to 37,8 km^2 have been generated, based on the configuration of the river bed and on altitudinal levels. The time of concentration values have been highlighted for each of the component sectors.

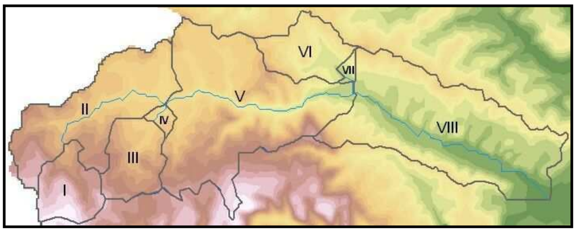


Fig.6. ***The division of the basin in sectors of calculus***

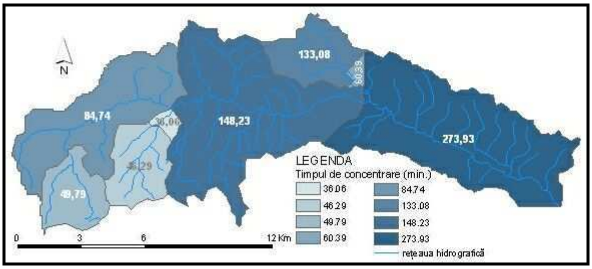
The morphometric characteristics of the basin

Table no.2

	P (km)	F (km^2)	La (km)	∑La (km)	Lv (km)	Vv (m/s)	Va (m/s)
SECTOR I	13,69	8,82	5,08	7,91	1,12	0,6	4,5
SECTOR II	31,79	25,06	12,05	18,57	1,35	0,6	4,25
SECTOR III	13,22	9,77	5,36	11,2	0,87	0,55	4,5
SECTOR IV	4,82	1,19	2,14	1,41	0,84	0,5	4,5
SECTOR V	37,88	43,1	15,43	53,92	0,81	0,4	2,25
SECTOR VI	15,22	9,4	6,24	7,35	1,34	0,35	1,5
SECTOR VII	6,41	0,9	2,66	1,39	0,65	0,35	1,5
SECTOR VIII	35,24	43,26	15,09	49,57	0,87	0,2	1,25

Using the **relation no.1** and the synthesized information in **table no.2** the calculus of the concentration time was realized, followed by the spatialization of the results (Fig.7)

By analyzing the results we observed an increase in the time of concentration ranging from the superior sector to the inferior one, in parallel to the decreasing of the altitude and side river bed slope; the exception s represented by two sectors (IV and VII) where the reduced areas and the small sides length represent aspects that determine the decrease of the concentration values.



	$T_{c\ versant}$	$T_{c\ albie}$	T_c
Sect.I	30,97	18,81	49,79
Sect.II	37,49	47,25	84,74
Sect.III	26,43	19,85	46,29
Sect.IV	28,13	7,93	36,06
Sect.V	33,93	114,30	148,23
Sect.VI	63,75	69,33	133,08
Sect.VII	30,83	29,56	60,39
Sect.VIII	72,73	201,20	273,93

Fig.7. The Căpuş Basin . The spatial representation of the time of concentration

The spatial analysis of the runoff coefficient was possible using the Spatial Analyst extension. The main condition for this type of analysis implies that all the layers that are used in the calculus have to be characterized by a raster structure. As a result we started by converting the Shapefile themes that refer to the soil texture and land use in grid themes, the slope already had this type of structure. All the three grids have a 10 m resolution (1 pixel = 10 · 10 m).

The next step was the reclassification (simplification) of the three themes, by assigning some unique values to each element considered. This method is known as „bonitare" and it was realized using the **R**ecalssify function. The slope has been assigned three values: 1, 2, 3 (**1** = 0-5%; **2** = 5-10%; **3** = 10-30%, in the same group of 3 we also, included the slopes over 30%); for the land use two values have been assigned: 10, 20 (**10** = forest; **20** = crops and other uses); for the soil texture three notes have been assigned: 100, 200, 300 (**100** = high; **200** = middle; **300** = heavy).

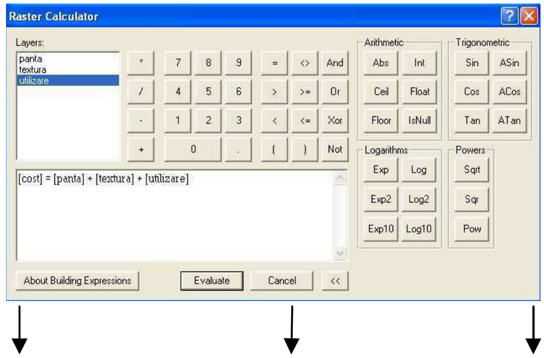
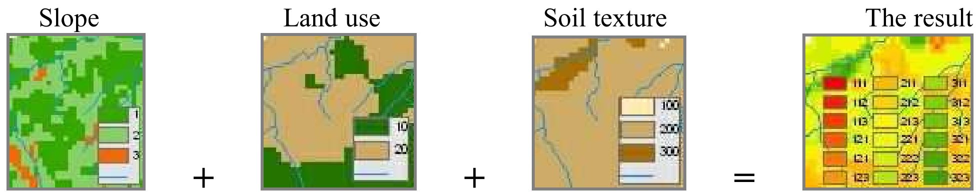


Fig.8. *Using the RasterCalculator function*
(resolution: 1 pixel = 10·10m)



After this stage of reclassification, the three layers had been summed up, obtaining a new layer that puts together the three types of attributes (Fig.8). The GIS function that makes possible this operation is called **M**ap**C**alculator for **A**rc**V**iew GIS 3.2a, respectively **R**aster**C**alculator for **A**rcGIS 9.x. Using the indices elaborated by Frevert, the table attribute to the new layer was completed with values concerning to the runoff coefficient, resulting a grid with 10 m resolution (Fig.9).

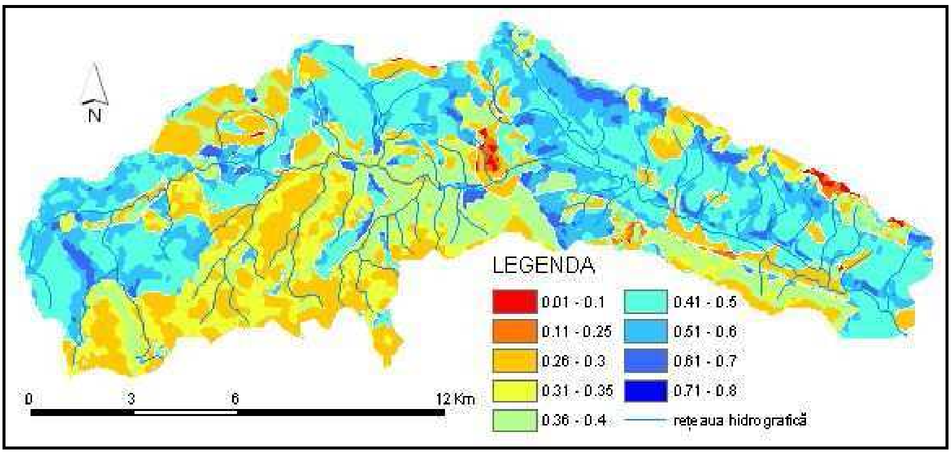


Fig. 9. ***The Căpuş Basin. The spatial representation of the runoff coefficients***

4. CONCLUSIONS

Using G.I.S technology in the hydrologic process analysis is proved to be an efficient method, in the conditions when very great speed in the forecasting activity in order to prevent the hydrologic hazards is needed. Knowing the physical-geographical characteristics, the simulation of hydrologic response of a basin to the inputs (precipitation), intern transformations (clears, urbanization) or outputs (evapotranspiration) from the system makes possible the elaboration of a better management strategy for a hydrographic basin as far as the water resource is concerned.

Concerning the spatial repartition of time of concentration in hydrographic basin analyzed we established:

- ✓ the dependence of the time of concentration to the size of the studied surface;
- ✓ a ratio of direct proportionality between the river bed length and time of concentration;
- ✓ a lower correlation of sides length with time of concentration on the sides, caused by the influences gave by the deforestation level or the side slope;

Concerning the runoff coefficient we established an increase of the values in ratio with:

- ✓ the decrease of the afforested surfaces;
- ✓ the frequency of the heavy texture soils;
- ✓ the increase of declivity values;

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Harta topografică 1:100.000

Harta pedologică 1:200.000

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GIS BASED GAZETTER OF HUNGARIAN TOPONYMS

A. Guszlev[1]**, L. Lukács**[2]

ABSTRACT
The Hungarian Toponymic Program (HTP, MTA-ELTE Research Group on Cartography and Geoinformatics, Budapest, Hungary) is dealing with research on place name usage in Hungary, and compiling databases and guidelines for supporting the elaboration process of toponymic contents on maps. The main purpose of HTP is collecting Hungarian place names of the Carpathian region and establishing a spatial database and on-line gazetteer of them.

*

1. INTRODUCTION

Gazetteers are compiled to support identification of place names. Gazetteers are sources of name forms in map-making, administration, and other fields. Use of gazetteers is not widespread among professional cartographers, geographers, experts of geoinformatics and non-professional readers in Hungary. The most possible reason for that is the difficult availability of data suitable for cartographical use.

Thousands of Hungarian toponyms can be found also in official gazetteers of Hungary and in diverse world gazetteers on the Web. The official Gazetteer of Hungary contains correct name forms, coordinates and useful attribute data, but does not embrace the whole Hungarian naming area, only the current state. The largest multilingual world gazetteers store plenty of past and current Hungarian name forms for the Carpathian Basin, but names in them are often not correct in spelling. For these reasons it could be useful to compile an on-line gazetteer with visualization possibilities for the whole Carpathian Region.

2. DATABASE OF HUNGARIAN GEOGRAPHICAL NAMES

2. 1. Purposes

Gazetteers are rarely used in Hungary. Their use is not widespread among professional cartographers, geographers, geoinformaticians and non-professional readers. The most possible reason for that is the difficult availability of data suitable for cartographical use (Guszlev and Lukács, 2006).

The main goal of HTP is to develop an organized **Database of Hungarian Geographical Names (Magyar Földrajzi Névi Adatbázis, MFNA)**, a user-friendly Hungarian name database and publish it on the Internet according to international standards and recommendations. The gazetteer is suitable for medium and lower scales *(Figure 1).*

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- MFNA takes into consideration aspects of a *gazetteer for cartographical use*:
    - Contains geographical names with object-type and location information
    - Overview of current and past name versions
    - Ethimological references
    - Multilingual identification (official names for trans-border Hungarian names, names in minority languages in Hungary, and recommended English terms for Hungarian features.
    - In case of landscape region names the division-system and its hierarchy are represented.
    - Information for cartographical representation
- The framework of the MFNA is a *geoinformation system*, including facilities:
    - different accessing levels for using, editing or supplementing the gazetteer,
    - visualization of gazetteer entries by tables and maps
    - name search, selecting objects by attributes, spatial query
    - temporal analysis of areal references
    - comparison of landscape region delineation systems

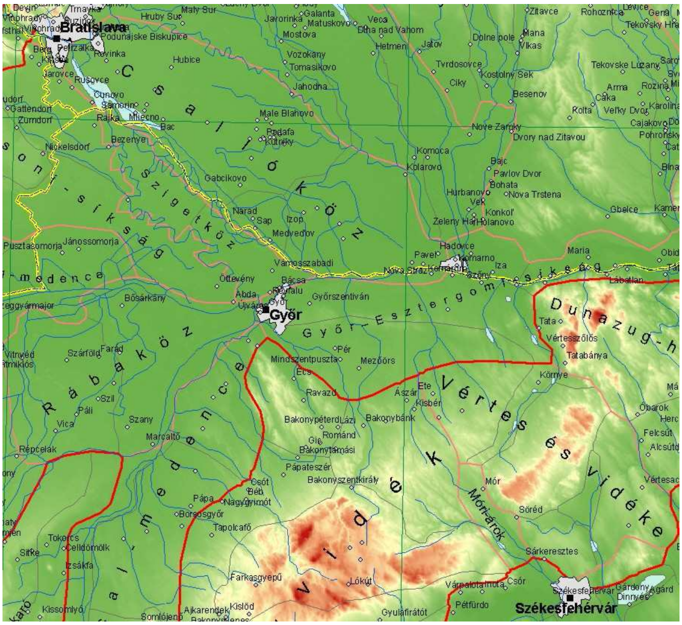


Fig. 1. ***Part of the MFNA gazetteer***

2. 2. Contents and data sources

The gazetteer will cover the Carpathian Region *(see Figure 2)*. For the first step, the database is according to a medium scale (1:250000) map, with approximately 50 000 names. In the future, names of larger scales (e.g. street names and land names) can be integrated into the database.

Temporal scope of the MFNA is from the Middle Ages to the present days. For visualizing historical events or phenomena cartographers usually use historical milestones on the background map: maps of some well-documented states and changes of administrative units, data and names from census documents. In this gazetteer some of these milestones are elaborated: borders of administrative units before the World War I, in 1950, in 1990 and in 2007. In these years, there were significant reconstructions in the Hungarian administrative system and borderlines of units were changed largely because of political events.

For compiling a multilingual GIS gazetteer various map and attribute data are used. Base map of relief, hydrography, borders and settlements is required with detailed geometry. For implementing the base map of MFNA, several sources were used with different scale, project and precision. The data integration was complicated because different integration methods had to be chosen for each type of data source.

Entries in the gazetteer are geographical names. Their spatial references are recorded with geographical features as map elements, points, polylines or polygons.

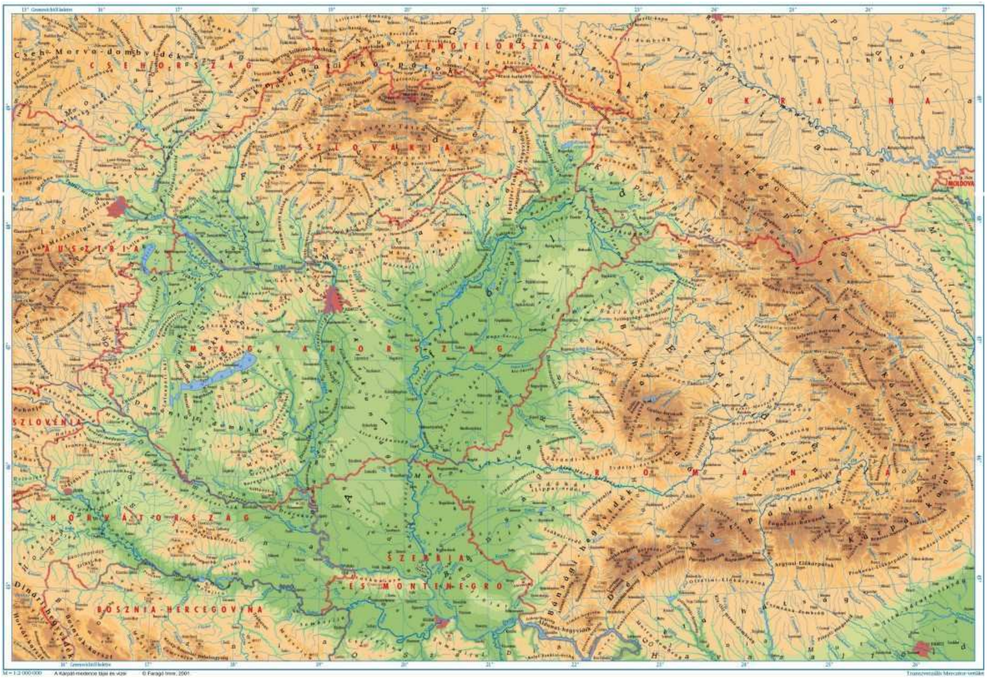


Fig. 2. ***The Carpathian Region, area of the gazetteer (Faragó, 2005)***

Map data in the MFNA

- Relief (raster format)
- Marked geographical points: main peaks, passes (point geometry)
- Watercourses (polyline geometry)
- Lakes (polygon geometry)
- Administrative units and settlements (polygon geometry)
- Landscape regions (polygon geometry)
- Geographical names as map labels (annotations)

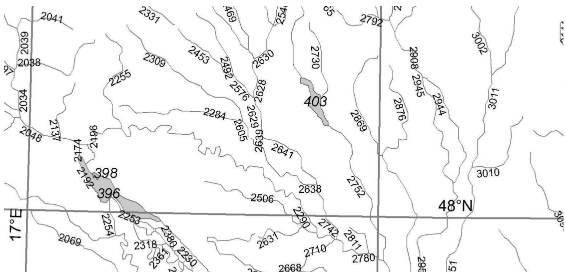
The source of relief data is the SRTM dataset. SRTM (Shuttle Radar Topography Mission) is a project of the NASA (National Aeronautics and Space Administration) and the NGA (National Geospatial-Intelligence Agency) to create a near-global DEM (digital elevation model) of the Earth using radar-interferometry (SRTM, 2005).

Current NUTS borders (nomenclature d'unités territoriales statistiques) are processed in the gazetteer. Dataset of Hungarian NUTS is provided by FÖMI (Hungarian Institute of Geodesy, Cartography and Remote Sensing) and KSH (Central Statistical Agency), and developed by the GeoX Ltd.

Borderlines of former administrative units are collected from historical thematic map files of Hungary in 1910 (edited by the Institute of History of the Hungarian Academy of Sciences).

The gazetteer contains main rivers, watercourses, canals and lakes. Spatial data source is a geographical map of the Carpathian Basin in scale 1: 600 000 (edited by Imre Faragó). The names were gathered with the help of students of the Department of Cartography and Geoinformatics of Eötvös Loránd University (Budapest) *(see Figure 3).*

The MFNA project relates to another project, a research on **landscape region names**. Therefore landscape region systems are emphasized in the gazetteer. The base system of the gazetteer is the Landscape Region System of the Carpathian-Pannonian Region (LRSCPR), established by Hungarian geographers, József Hajdú-Moharos and Attila Hevesi in 1990. In this system transborder regions are specially elaborated, and even the region names in different languages are harmonized (Hajdú-Moharos, Hevesi, 1996) *(see Figure 4).*



térképszám	típus	folyószakasz /tó száma	magyar név	hivatalos nyelvű név	angol név	a név forrása
12	folyó	2908	Nyitra			Faragó-Hibernia-Szal
12	folyó	2909	Nyitra			Faragó-Hibernia-Szal
12	folyó	2912				
12	folyó	2939	Visnya			Faragó-Hibernia-Szal
12	folyó	2944	Nyitra	Nitra		Faragó-Hibernia-Szal
12	folyó	2945	Öreg-Nyitra	Stará Nitra		Topográf: Szlovákia a
12	folyó	2951	Zsitva	Zitava		Topográf: Szlovákia a
12	folyó	2952				
12	folyó	2953				
12	folyó	2954				
12	folyó	2961		Vlára		Topográf: Szlovákia a
12	folyó	2967	Vág	Váh		Faragó-Hibernia-Szal
12	folyó	2976				

Fig. 3. ***Parts of the map and the attribute table of hydrographical names***

The second represented system is a complex geographical system of Gyula Prinz from 1936. Paper source of this was only in text originally but the system has been reconstructed and plotted on a map in a previous research work (Lukács, 2003)

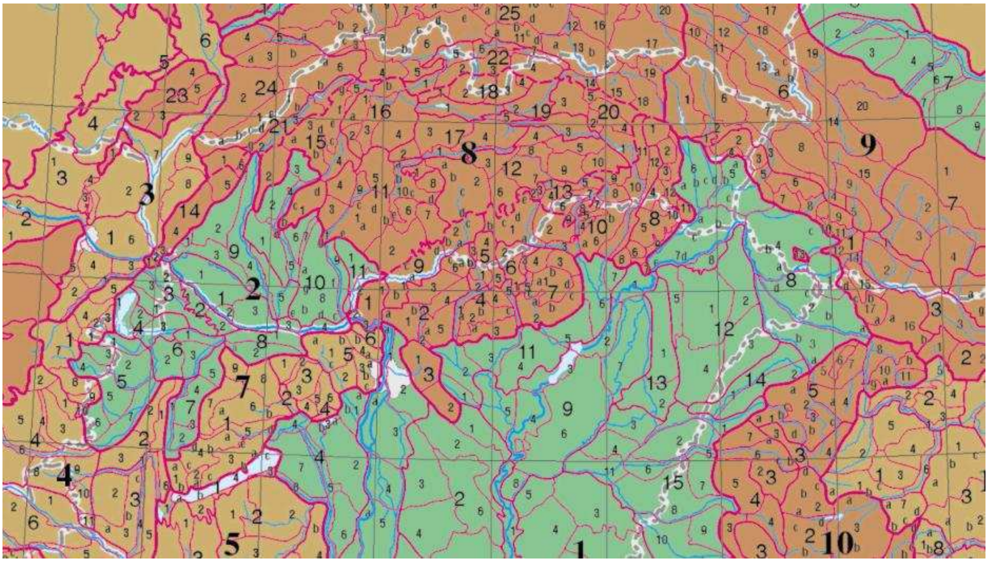


Fig. 4. ***The Landscape Region System of the Carpathian-Pannonian Region***

Most of GIS name-databases store names as attributes. In a gazetteer for cartographical purpose recording and representing labels on maps may come forward, so texts become map objects instead of being simply attributes. The labels can be located automatically in various orientations according to the reference point. Positions of the labels could be specified one by one; they could be stored and treated as **annotations** in separate map layers *(see Figure 5).* Advantages of using annotations are the higher cartographic quality and that topology of the labels can be also analyzed. Analyzing of the labels can be interesting because they contain additional information about the objects and the names by graphical and typographical attributes (placing, font type, orientation of labels, etc.).

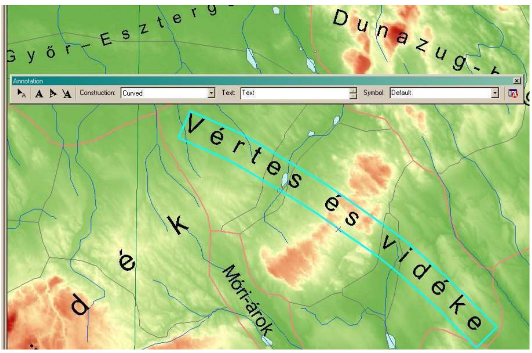


Fig. 5 ***Annotations in ArcGIS***

Attribute data in the MFNA

- Name
- Status
- Temporal validity
- Origin
- Source
- Language
- Writing system
- Object type
- Cartographic name-type

Each **name variant** is a separate record in the database. The **status information** shows that the name is *official, alternate* or *former* name. Geographical names are continuously changing also in Hungarian language, new names come to existence and sometimes former and rarely used names vanish. The gazetteer is multilingual for identification of geographical features laying in overlapping name areas. Most of the toponyms used in the Carpathian Region are in Latin writing system, but there are lots of names in Cyrillic (Ukrainian, Serbian and Bosnian names) and some native names also in Greek letters (e.g. Μπελογιαννηω=Beloiannisz, a village with Greek inhabitants in Hungary). Problems related to characters can be eliminated by appplying Unicode character sets.

Some attribute data were collected from academic publications, textbooks on geography and history, name-lists and several maps.

Name origin was the only attribute, which has been collected from special source. The most complete Hungarian database of the origin of toponyms is the Ethimological Dictionary of Toponyms (FNESZ, Földrajzi nevek etimológiai szótára; edited by Lajos Kiss). This dictionary contains ethimological data (and further name variants) of 13330 toponyms, most of them are Hungarian. This dataset is in paper form and moreover the data content is much more detailed than required in MFNA, so some base data of origin (first occurrence and the meaning of the name) was digitized for the gazetteer.

The source of recommended English terms was the Gazetteer of English Names for Topographical Objects of Hungary (compiled by Gábor Gercsák, 2002.) This gazetteer is a simple name list with pairs of Hungarian and English terms, but without any spatial references *(see Figure 6).*

Abaúj Abaúj	*Által-ér Által Brook*	*Balota Balota*
Agár-tető Agár Peak	*Bácska Bácska*	*Bán Bán*
Ágasvár Ágasvár	*Badacsony Badacsony*	*Baranya Baranya*
Aggteleki-karszt Aggtelek Karst	*Bakony Bakony*	*Baranyai-dombság Baranya Hills*
Alföld Great Hungarian Plain	*Bakonyalja Bakonyalja*	*Baranyai-Hegyhát Baranyai-Hegyhát*
Alpokalja Alpokalja	*Bakonyerdő Bakonyerdő*	*Bársonyos Bársonyos*
Alsó-Kiskunság Lower Kiskunság	*Baláta-tó Baláta Lake*	*Béci-hegy Béci Hill*
Alsó-Válicka Alsó-Válicka	*Balaton Lake Balaton*	
	Balaton-felvidék Balaton Uplands	

Fig. 6. ***Part of the Gazetteer of English Names for Topographical Objects of Hungary***

Object type (e.g. hill, pass, settlement, etc.) is the most important information of a geographic place and a required basic data for gazetteer entries. For this reason, a controlled vocabulary or a thesaurus is necessary for a gazetteer database. Controlled vocabulary is a collection of generic terms used in a gazetteer; thesaurus is a vocabulary which contains also the hierarchy and relations between vocabulary elements. Vocabularies or thesauri could contain hundreds of object types in the huge world gazetteers. MFNA has just a few types because of its relatively small scale and content but it could be elaborated in the future.

2. 3. GIS framework

Gazetteer is compiled in GIS environment, in ESRI ArcGIS 9.1 software. Spatial data of the gazetteer (points, polylines and polygons) are stored as OGC simple features. Excel tables of attribute data are joined into an Access database, and this Access database is linked into the ArcGIS system.

MFNA has a simple **relational database** structure *(see Figure 7).* The attribute data are recorded in relational database tables. Elements of the database are rows of a table (*records*), and the attributes are recorded in the columns (*fields*). Data can be stored in a lot of tables which are linked to each other by a *key*. Key fields contain the same data in the different tables. Using more tables can result in faster queries in the database and helps to avoid storing redundant data. This way of data storing results in smaller database size and eases modification and broadening of attribute tables.

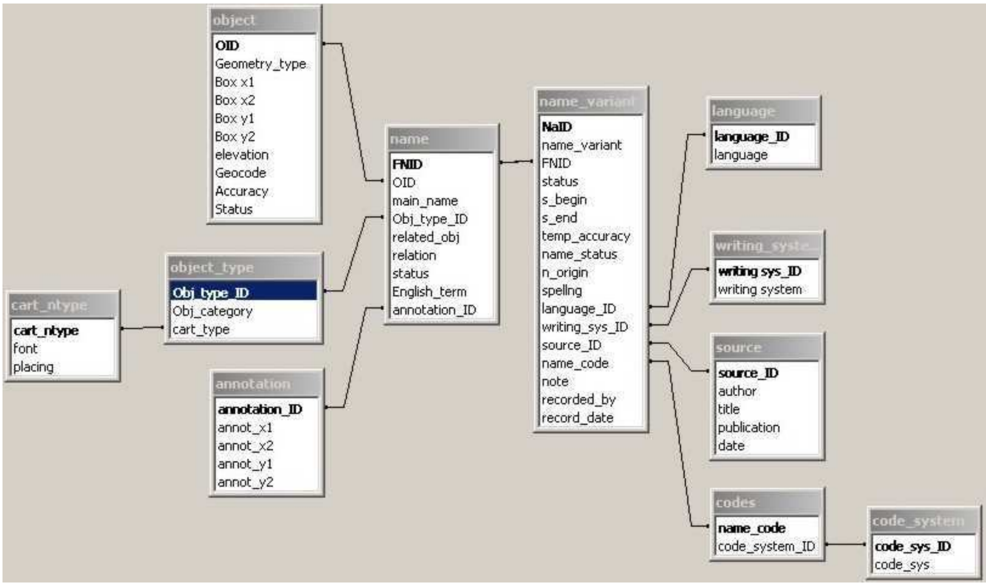


Fig. 7. ***Data structure in the MFNA***

Name variants (and not the primary names) are unique elements in the MFNA, therefore 'Name variants' is the main table of the database. 'Object' table also contain identifier numbers of the map objects as key field, connecting spatial and attribute data.

Attribute data can be stored in Attribute Tables of the layers or in joined Access databases *(see Figure 8).* In the MFNA data is stored in Access databases (except spatial data and Object IDs), because data records in Excel and Access can easily be modified and updated and also key fields can join additional external databases.

obj_id	jaras_varos	jszekhely	jogallas	mszekhely	Megye
390	Esztergom		rendezett tanácsú város	m	Esztergom
402	Párkányi	Párkány			Esztergom
388	Esztergomi	Esztergom			Esztergom
384	Váli	Vál			Fejér
375	Váli	Vál			Fejér
374	Adonyi	Adony			Fejér
383	Móri	Mór			Fejér
372	Sárbogárdi	Sárbogárd			Fejér
376	Székesfehérvári	Székesfehérvár			Fejér
513	Székesfehérvár		törvényhatósági jogú város	m	Fejér

Fig. 8. ***Attribute table of former administrative system (MS Access database)***

2. 4. MFNA system

MFNA will be stored and published on a map server in the future, which performs queries, data processing and provides data and information about the toponyms. The system will have a **catalogue** service managing metadata of the gazetteer *(see Figure 9)*.

Both *editors* and on-line *users* will be able to add new records to the MFNA or attribute data to existing records. In addition, editors will be able to create new fields and new tables in the database, or edit existing content. The database is controlled, a *moderator* checks on new data before entering them into the gazetteer *(see Figure 10)*.

MFNA considers international standards and recommendations. Standards for gazetteers can be found at International Standards Organization. Open Geospatial Consortium (OGC) as been important for years in developing and publishing open and interoperable geoinformation systems.

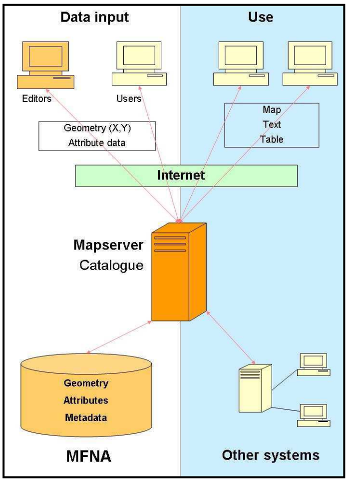


Fig. 9. ***The MFNA system***

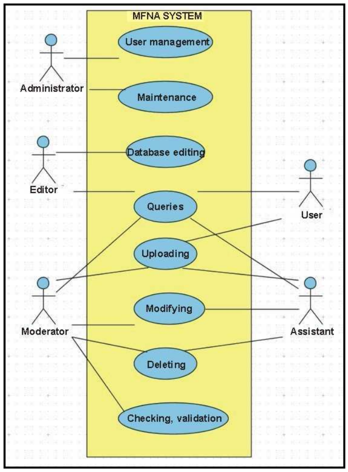


Fig. 10. ***Use cases of MFNA system***

MFNA considers international standards and recommendations. Standards for gazetteers can be found at International Standards Organization. Open Geospatial Consortium (OGC) has been important for years in developing and publishing open and interoperable geoinformation systems.

Advantages of the WGS standards:

- It provides an opportunity of integrating the MFNA into the Internet-based geoinformation systems, therefore makes it accessible in service.
- The application is supported by well-documented open source software
- Extendable and dynamic database

The open database format provides the possibility for transforming geographical names for one's own interest. Names can be easily visualized and used in map or database applications. As an example, the labels provided by Google Earth can be changed to the own selected and more correct version (Guszlev and Lukács, 2006).

The database will be published under **Creative Commons** license (creativecommons.org). It can be downloaded for free, for any non-profit usage or modification, while mentioning the source and property rights.

3. CONCLUSIONS

The aim of MFNA project of HTP is to elaborate an organic, multilingual, open name database by collecting and integrating available spatial and name sources of Hungarian toponyms. However, quality and structure of these data sources are very different. Therefore, eliminating of database gaps, reclassifying data and improving spatial accuracy are needed.

In the MFNA-project our research group tries to support and enable community collaboration in gazetteer development. The aim of our work is to elaborate an organic, multilingual, open database supplemented with up-to-date information and news.

Recent MFNA is suitable for designing toponymy content for maps in medium and lower scale. The database structure allows the enrichment of name-content and attributes for supporting toponym usage of larger scales. In the future, the gazetteer could be extended also spatially. Using buffer zones depending on geographical factors or using fuzzy logic could refine borders of landscape regions.

MFNA gazetteer would embrace the toponym content of several scientific and cultural fields in the Carpathian Basin and can support identification of spatial locations in international communication. MFNA project could take part in developing Hungarian Spatial Data Infrastructure, and could be joined to the European SDIs according to the Infrastructure for Spatial Information in Europe (INSPIRE) Directive.

For completing the MFNA gazetteer and for further developments more financial and human resources are needed. For further research project applications have to be prepared and submitted.

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ARCGIS SOFTWARE MODULE FOR CALCULATING THE S.P.I. VALUE

Zs. Magyari-Sáska[1]

ABSTRACT
Developing proper algorithm for different studies can have a major impact on research time, by decreasing the necessary manual work. If the algorithm is general on regional scale or with minor changes can be adapted for different locations its importance is even higher. The calculation of the S.P.I. value, characterizing the meteorological drought and excess of humidity, needs several steps and handles large amount of data. Because its calculus has a standard algorithm it's suitable to develop software to calculate it for every location of a raster layer. This study presents such a software module, capable to create raster layers with S.P.I. indices starting form locally measured precipitation, measure points' geographic location and altitude and digital elevation model.

*

1. INTRODUCTION

Drought or extreme moisture as natural risk phenomena were studied using several different approaches. Some of them use hydrological models (Haidu et al., 2004), others descriptive statistics regarding temperature and precipitation evolution (Croitoru et al., 2002). Towards the past period characterization, estimations for the future are also made in these studies. This is done using linear regression models or frequency analysis. While trend detection can estimate the value of the characteristic for a given temporal moment, frequency analysis determines the return period of an extreme (low or high) value (Haidu, 2003).

The S.P.I. (Standard Precipitation Index) is a well know measurement value for characterizing drought and moisture severity at different time scales (Moldovan et al., 2002). One of its advantages is that the only necessary data is the cumulated precipitation value for calculating the S.P.I. value. A comprehensive study (Lloyd-Hughes and Saunders, 2002) prove that the S.P.I. value can characterize the drought phenomena as well as the P.S.D.I. indices, which needs much more parameters and also some calibrated values.

The study of rainfall evolution, based on frequency analysis on different time scales represents one of the starting possibilities to determine extreme values characterizing drought or excess of humidity for given return periods. Such rainfall evolution study was made by Mercier and Haidu in 2003 for the Mediterranean region or Paul P. and David B. S. (2006) for the roumanian territory – Sulina Station.

Another possibility is to start the study from the generated S.P.I. maps of past periods, and the apply frequency analysis methodology on them. These kind of analysis was made for Thessaly region, Greece (Loukas and Vasiliades, 2004), were the calculated S.P.I. cell values were fitted on frequency distributions.

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2. GENERAL CONCEPT

It's also well known that large amount of data can be handled in an effective way only if adequate algorithms are performed on them. Considering that the S.P.I. value has a spatial but also a temporal dimension, calculating tens of raster layers holding S.P.I. values for each point in manual way could be extremely time consuming.

The most important GIS software offers some automatic calculation methods (Modeler or Batch Processing in ArcGIS, or Model Maker in IDRISI), but they presents several important lacks:

- reduced possibility of parameterization (IDRISI)
- all parameters have to be entered in a manual way even if they are repeating or has a variable index in the file names (ArcGIS, Batch processing)
- they do not have algorithm controlling elements (loops, decision structures)

For developing specialized analysis software the use of script or programming languages is hardly advised. Scripts languages represent an advanced batch processing approach, but in generally they can't collaborate with other software environments and a user friendly application interface cannot be developed based on their commands. The collaborative environments are very important especially in research fields, because complex analysis cannot be done using just a single software product (Magyari, Haidu 2006). In such cases – using several softwares – the data transfer between applications can be done just by manual file transfers, which can be cumbersome. Analysis software that uses internal (inter-environmental) data transfers is much easier to handle and the researcher can focus on the studied issue in stead of counting the algorithm steps.

Such collaborative software can be developed just by using high level programming languages combined with the operating system capabilities.

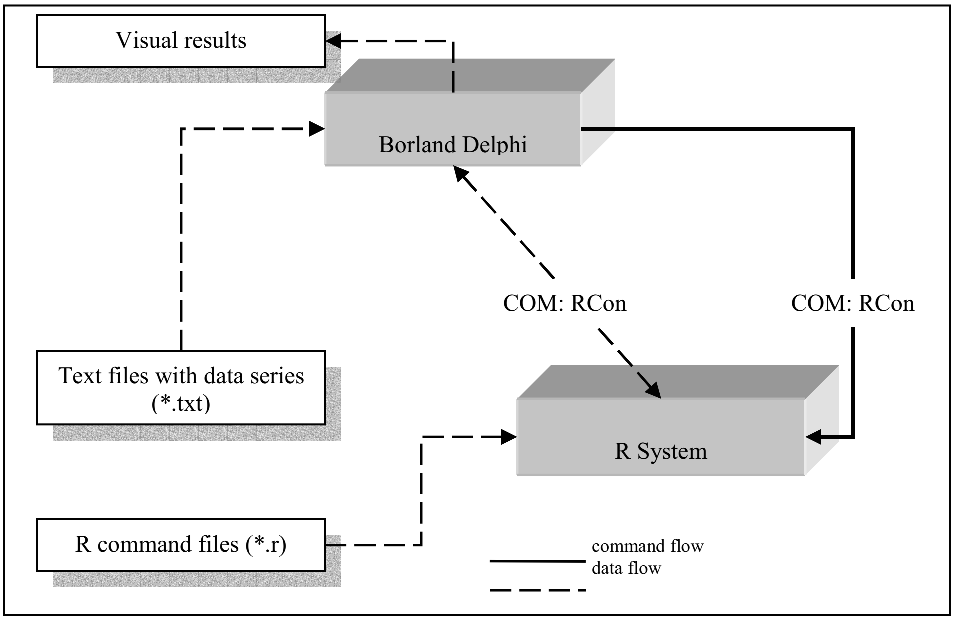

Fig 1. ***Conceptual design of the used collaborative environment***

This study presents an ArcGIS embedded methodology for calculating and estimating S.P.I. values by using probability distributions. Because such analysis use both spatial operations (existing in ArcGIS) and statistical calculus – which are not present in ArcGIS system –, a collaborative studying environment has to be developed. In this case the R System was chosen, based on two reasons: it's free being a GNU project and has an own programming language. This second argument is important for developing proper analysis function based on the existing ones. The R System's programming language with all the differences can be considered a C++ clone both in syntax and programming concept: all elements are considered to be objects.

The link between ArcGIS and R can be done using a COM (Common Object Model) component, RDCom freely available on Internet (www.sciviews.org) which makes possible also the MS Excel – R System command and data interchange. As mentioned before by using this component both data and command transfers can be done from ArcGIS towards the R System, and the analysis results can be accessible for ArcGIS environment.

3. THE APPLIED ALGORITHM

The aim of the study was to develop and implement an algorithm which easily can calculate and estimate future S.P.I. values for a chosen time period based on DEM and locally measured precipitation values.

The first level steps of the algorithm are:

- determining the precipitation field for the study area
- calculating the S.P.I. values for each chosen time segment
- determining the S.P.I. values for different return periods

Step 1. Determining the precipitation field

Different interpolation methods can be used for specializing locally measured values. In this study the multiple regression method was used, as the application should be used on poorly gauged regions, with different topographic properties, and prior investigation and other interpolation methods presented unsatisfactory results.

```
intp<-function(prec)
{
 expo=scan(file="expo.txt")
 pozx=scan(file="pozx.txt")
 pozy=scan(file="pozy.txt")
 inalt=scan(file="dem.txt")
 d=data.frame(expo,pozx,pozy,inalt,prec)

 teo=lm(prec~pozx+pozy+inalt+expo+I(pozx^2)+I(pozy^2)+I(inalt^2)+I(expo^2)+I(pozx*pozy)
 +I(pozx*inalt)+I(pozy*inalt))

 model=stepAIC(teo)

ln=c("(Intercept)","pozx","pozy","inalt","expo","I(pozx^2)","I(pozy^2)","I(inalt^2)","I(expo^2)",
"I(pozx * pozy)","I(pozx * inalt)","I(pozy * inalt)")

va=rep(0,12)
 for (i in 1:length(model$coefficients))
 {
  for (j in 1:12)
   {
    if (names(model$coefficients[i])==ln[j])
     {
      va[j]=model$coefficients[i]
     }
   }
  }
```

Fig 2. ***Determining the most suitable multiple linear regression model (R System)***

In the interpolation algorithm 4 major factors was considered: altitude, geographic position and aspect. Due to the fact that the first three values are in continuous space while the last one represents the North aspect using two separate interval (0-22.5 and 337.5-360, if we consider 8 geographic directions), for a multiple linear regression is necessary to translate the whole aspect range in continuous, successive intervals. The transformation used shifts the aspect values from 0 to 337.5 by 22.5 towards 360, and inserts the values between 337.5 and 360 at the beginning of the resulted interval.

The multiple linear regression equation is optimized by R System stepAIC command contained in the MASS package. For optimization the regression model should be transmitted as a parameter. The optimization process eliminates the model terms one by one. By this the algorithm determines the minimum AIC value, showing the resulted, final model. As the command result the correlation values between the tags are also displayed. The lower values indicate a less correlation between the tags, which is preferable because it means that there are less information overlap between the tags considering their importance on the model.

Starting from the optimized model the calculation of precipitation values based on the mentioned factors is done in R System using the exported ASCII raster files. The situation of calculated negative precipitation values also should be considered. The most simple way is to assign a zero value in this cases could not represent the differences between this regions, so a new approach was used. All those cells having negative precipitation values got new values which is the reverse on their modulus.

$$p = \begin{cases} p, \text{for } p \geq 0 \\ \dfrac{1}{|p|}, \text{for } p < 0 \end{cases}$$

Using the described method several raster layers are calculated, each one for a specified different time period (in general for 3, 6, 9, 12 or 24 months).

Step 2. Calculating the S.P.I. values

The S.P.I. value calculation is based on Gamma distribution. First the distribution is fitted on the obtained, corresponding cell values. In this case the distribution fitting was done using method of moment's methodology (Ricci, 2005). This method was chosen because the fitdist command in R System – which uses maximum likelihood method for distribution fitting – in some cases produces error (especially when some values are close to zero an the other ones has considerable higher values). After that the gamma probability values are calculated for every considered value. To obtain a normalized indices value the formulae use is developed by Abramowitz and Stegun (1964)

$SPI = -(t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3})$ when the calculated probability is in (0,0.5] interval

and

$SPI = +(t - \dfrac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3})$ when the calculated probability is in (0.5-1) interval

where

$t = \sqrt{\ln[\dfrac{1}{H(x)^2}]}$, for probabilities in (0,0.5] interval and

$$t = \sqrt{\ln[\frac{1}{1 - H(x)^2}]}$$, for probabilities in (0.5,1) interval

The c and d parameters has the following values:

c_0=2.515517, c_1=0.802853, c_2=0.010328, d_1=1.432788. d_2=0.189269, d_3=0.001308

For each selected time period the precipitation values for corresponding cells are cumulated and the S.P.I. values are calculated. In such manner several ASCII raster files are created holding the S.P.I. values.

Step 3. Calculating S.P.I. values for different return periods

Considering Gamma distribution the most suitable to characterize the precipitation at regional scale, this distribution was used to determine S.P.I. values for different return periods. This operation is done also in R System, using the files created in the earlier step. The resulted file is completed with a proper header, taken form the digital elevation model ASCII file, and presented in ArcGIS.

4. THE RESULTED SOFTWARE MODULE

The described algorithm was implemented in Visual Basic for Applications in ArcGIS. To use it you should hold an ArcGIS project file containing this macro. Before using it the DEM raster of the study region should be present in ArcMAP.

For using it, first the working directory should be specified. In this step the existence of a few text files are verified. These files should contain the measure point's altitude, transformed aspect and geographic position. The lack of it will be announced by their names showed in red, otherwise the names appears in green. From the specified directory all the files containing monthly cumulated precipitation values are collected and presented in a list box. These files are selected based on their name format: all of them should have an X as the first letter in their names. There should be at least 12 precipitation files, because the linear regression model uses 12 factors.

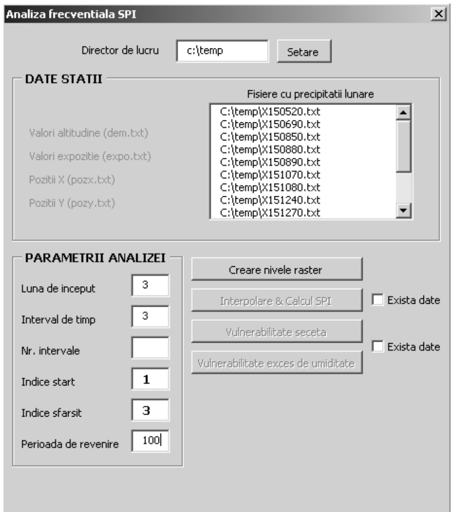

Fig 3. ***User interface of the developed ArcGIS module***

If everything is found the module enables the first analysis button, which creates the necessary raster layers (*Creare nivele raster/Creating raster layers in English*). These layers are:

- the aspect layer
- the transformed aspect layer
- a layer containing for every cell it's center X position
- a layer containing for every cell it's center Y position

The last three layers together with the DEM are the automatically exported in ASCII raster format. Because these layers are common for every study regarding a specified region their re-creation can be omitted by checking the first check button (*Exista date/Existing data in English*).

```
ListBox1.Clear

Dim FSO As Object
Set FSO = CreateObject("Scripting.FileSystemObject")
Dim Fl As Object

strfile = Dir(cale & "\X*.txt", vbNormal)
Do While strfile <> ""
If strfile <> "." And strfile <> ".." Then
Set Fl = FSO.GetFile(cale & "\" & strfile)
ListBox1.AddItem (Fl)
Set Fl = Nothing
End If
strfile = Dir()
Loop
```

Fig 4. *Populating the list box containing monthly cumulated precipitation values (VBA in ArcMap)*

Then, with a new button (*Interpolare si calcul S.P.I./Interpolation and S.P.I. calculus in English*) the first two steps presented in previous chapter are realized: precipitation interpolation and S.P.I. value calculus. These analyses are done based on two parameters defining the study period. The first values specifies the starting month (*Luna de inceput/Starting month in English*), while the second one the length of a study period (*Interval de timp/Time period in English*). If these calculus are done they can be used for determining two hazard types, and their existence can be notified for the module by checking the second check button in the window.

```
cmd = "f=1:" & Str(ListBox1.ListCount + 1)
RLink.EvaluateNoReturn (cmd)

For i = 0 To ListBox1.ListCount - 1
 cmd = "f[" & Str(i + 1) & "]='" & ListBox1.List(i) & "'"
 cmd = Replace(cmd, "\", "\\")
 RLink.EvaluateNoReturn (cmd)
Next

Dim st As String
Dim pe As String

st = TextBox2.Text
pe = TextBox3.Text

cmd = "h=recalc(" & Str(ListBox1.ListCount) & "," & st & "," & pe & ")"
RLink.EvaluateNoReturn (cmd)
```

Fig 5. *Calling R System commads form VBA environment in ArcMAP*

The final steps can determine the drought hazard (*Vulnerabilitate seceta/Drought hazard in English*) or excess of humidity hazard (*Vulnerabilitate exes de umiditate/Extreme humidity hazard in English*). For creating these raster layers the desired return period (*Perioada de revenire/Return period in English*) and two indices should be specified which represents the first (*Indice start/First indices in English*) and the last (*Indice sfarsit/Last indices in English*) S.P.I. files indices. The maximum possible value can be determined from *Nr. intervale/Inreval number in English* fields.

The resulted a raster layer is reclassified according to the standard S.P.I. intervals and presented in ArcMAP.

ACKNOWLEDGEMENT. The study was financed from CNCSIS Research Project No. 492/01.10.2007.

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VARIABILITE SPATIALE ET TEMPORELLE DES PRECIPITATIONS DU NORD-OUEST DE L'ALGERIE

H. Meddi[1], M. Meddi[1]

RESUME

Les projets de développement en agriculture et en aménagement hydraulique nécessitent une étude de la variabilité des précipitations à différentes échelles temporelles. Egalement, elle est précieuse dans l'étude des changements climatiques. Pour déceler d'éventuels changements dans le régime pluviométrique, nous avons utilisé un certain nombre de tests statistiques sur dix stations pluviométriques du Nord Ouest Algérien possédant de longues séries de mesures.

L'étude a montré une rupture dans la décennie 70 (réduction de la pluviométrie) pour la quasi-totalité des postes étudiés. La variabilité interannuelle des pluies augmente lorsque l'on se rapproche des régions arides. L'augmentation de la variabilité suit l'accroissement de la longitude et la diminution de la latitude. L'altitude atténue cet accroissement.

Mots clés: *Variabilité, précipitation, régime, Nord Ouest, Algérie*

ABSTRACT

Development projects in agriculture and water field require a study of the precipitation variability at different scales. Also, it is valuable in the climate change study. To detect any changes in the rainfall regime, we used a number of statistical tests on ten rainfall stations localized in the Northwest of Algeria with lengthy series of measures. The study showed a rupture in the 70's (reduction in rainfall) for the major part of studied stations. The interannual variability of rainfall increases when one approaches to the arid regions. The increased variability follows increasing in longitude and decreasing in latitude. The elevation mitigates this increase.

Key Words: *Variability, precipitation, regime, North West, Algeria*

*

L'étude de variabilité annuelle des précipitations est importante pour les projets de développement en agriculture et en aménagement hydraulique. Egalement, elle est d'un apport considérable dans l'étude des changements climatiques. Pour déceler d'éventuels changements dans le régime pluviométrique, nous avons utilisé un certain nombre de tests statistiques sur dix stations pluviométries possédants de longues séries de mesures. Afin d'établir une typologie des sécheresses, nous avons retenu la station d'Oran dotée d'une longue série et appliqué une méthode simple exprimant le déficit pluviométrique en pourcentage de la moyenne annuelle. La spatialisation des irrégularités des précipitations a été approchée par le coefficient de variation des séries de mesures disponibles (218 stations pluviométriques). Ce coefficient permet une comparaison entre les stations.

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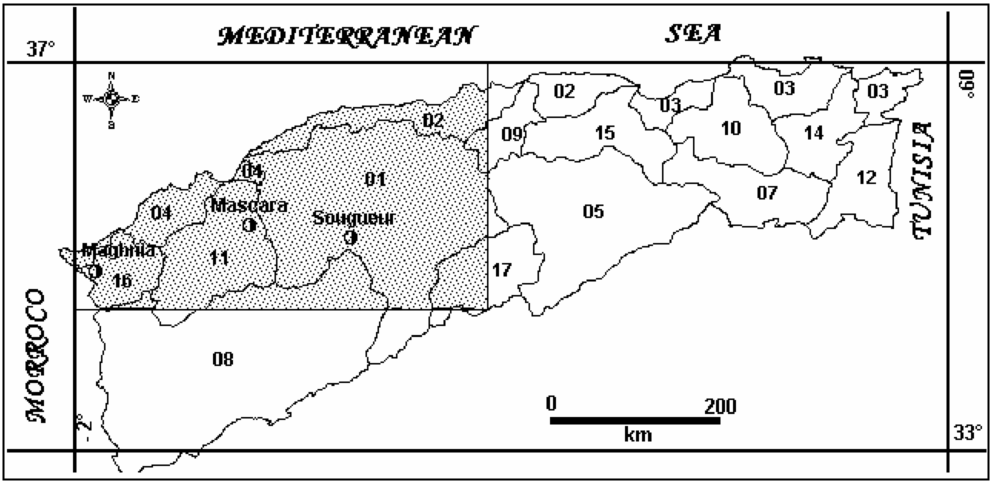
1. SITUATION GÉOGRAPHIQUE

La zone étudiée s'étend sur 89 420 km^2 environ. Elle est située entre 2°10'10 ''ouest et 3°10'11'' est de longitude et entre 34°18'54'' et 36°48'12'' de latitude Nord (Fig. 1). La région étudiée s'allonge sur 250 km du Sud au Nord et sur environ 500 km de l'Ouest à l'Est.



01 : Cheliff, *02* : Côtiers Algérois, *04* : Côtiers Oranais, *o8* : Hauts Plateaux Oranais, *09* : Isser, *11* : Macta, *16* : Tafna

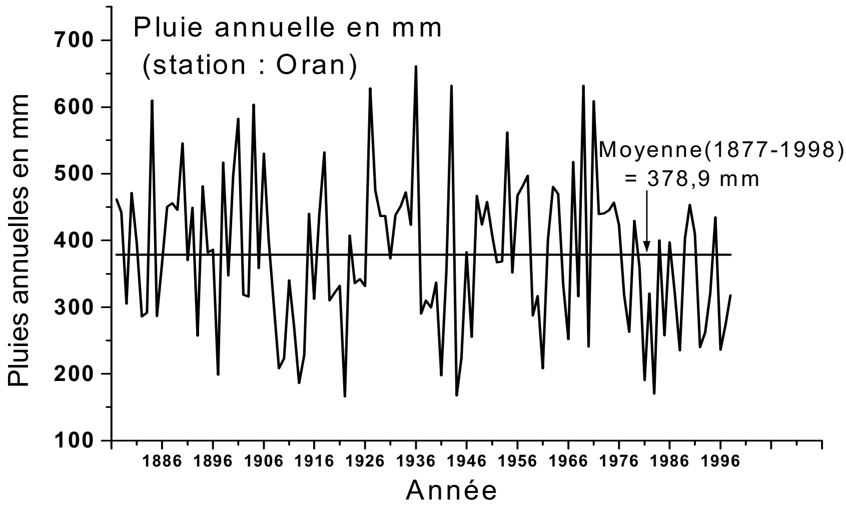
Fig. 1. ***Grand bassins versants selon le découpage de l'A.N.R.H. et la région étudiée***

2. VARIABILITE INTERANNUELLE DES PLUIES

L'étude de variabilité annuelle est importante pour les projet de développement en agriculture et en aménagement hydraulique (des études réalisées en se basant sur des données de période déficitaire ou excédentaire peuvent mener à des aménagement non adéquate à la réalité). Egalement, elle est d'un apport considérable dans l'étude des changements climatiques.

2.1. L'analyse temporelle

Dans cette partie, nous allons travailler sur un ensemble de stations possédantes des séries de mesures longues. Ces séries ont une longueur de 48 ans. Par ces stations, nous pouvons avoir une idée des variations annuelles des précipitations depuis 1950. La figure suivante montre l'évolution des pluies à la station d'Oran depuis 1877. Ce graphe nous montre la succession des périodes sèches aux périodes humides. Dans ce qui suit nous allons essayer de montrer l'évolution pluviométriques au niveau de certain nombre de stations. Aspectes d'analyse temporelle des precipitations ont été realisé par les methodes ASA – Autocorrelation Spectral Anaysis et MEM – Maximum Entropy Spectral Analysis (Paul P., David B. S. , 2006).



2.2. Détection de ruptures au sein des séries pluviométriques

Pour déceler d'éventuels changements dans le régime pluviométrique, nous avons utilisé les tests statistiques de Pettit, la statistique de Lee Héghinian et la segmentation de Hubert (Lubes et al., 1997 ; Hubert et al., 1989 et Hubert et al., 1993) . Ces tests sont regroupés dans le logiciel Khronostat réalisé par l'IRD, l'Université de Montpellier et l'Ecole des Mines. Les résultats obtenus sur les 10 stations de tailles différentes (nombre d'années observées diffère d'une station à une autre) sont regroupés dans le tableau n°3.

Tests statistiques de rupture des séries pluviométriques de quelques stations

Tableau 3

Stations	test de Pettit	de Lee Héghinian	segmentation de Hubert	Moy. avant la rupture	Moy. après la rupture	Différence en %
Ain Fekane	1974	1974	1974	704.52	421.43	40.2
Ghazaouet	1974	1974	1974	388.64	301.72	22.4
Khalouia	1980	1980	1980	486.85	341.66	29.8
Maghnia	1980	1980	1980	465.46	277.27	40.4
Tighenif	1980	1980	1980	512.77	282.42	44.9
Zemmoura	1973	1973	1973	483.74	347.68	28.1
Tamazourah	1973	1973	1973	463.09	335.05	27.7
Tessala	1971	1974	1974	526.6	314.54	40.3
Bensekrane	1964	1964	1964	518.63	386.17	25.5
Stidia	-	1980	-	406.64	341.67	16
Sid Ali B. Youb	1954	1954	1954	458.53	338.57	26.2
Oran	-	1976	1976	392.93	318.92	18.8

Il ressort que pour la quasi-totalité des stations, une rupture (diminution de la pluviométrique annuelle) dans les séries étudiées apparaît entre 1970 et 1980 avec un seuil de signification variable d'une station à une autre. Seuls deux postes enregistrent une rupture située en dehors de ces dates (1943 pour la station de Sougueur et 1954 pour celle de Sidi Ali Ben Youb). Ces résultats confirment l'apparition d'un déficit pluviométrique à partir de 1970, et la poursuite de celui-ci durant la décennie 80-90. Ce phénomène persiste encore actuellement et génère un grave problème d'ordre économique et social, compte tenu de la pression croissante qui s'exerce sur la ressource en eau (alimentation en eau potable, irrigation…), Meddi et Humbert, 2000. Le tableau n°3 montre bien cette diminution (différence entre les deux moyennes des deux sous séries).

3. TYPOLOGIE DES SÉCHERESSES

Afin d'établir une typologie des sécheresses, nous avons retenu quelques stations dotées de longues séries et appliqué une méthode simple exprimant le déficit pluviométrique en pourcentage de la moyenne annuelle. Cette méthode a déjà été utilisée par l'Institut National de la Météorologie de Tunisie (Hadjri, 1996) et peut s'énoncer de la façon suivante:

- l'année considérée présente une sécheresse modérée si le déficit varie entre 20 et 40 % de la moyenne annuelle;
- elle est sèche si le déficit varie entre 40 et 60 % ;
- elle est très sèche si le déficit varie entre 60 et 80 %;
- elle est hypersèche si le déficit dépasse 80 %.

Les valeurs minimales enregistrées durant les deux périodes d'observations

Tableau 4

	Période complète d'observation			Période 1950/51 – 1997/98	
Stations	Période d'observation	Année de la plus faible valeur	Pluie (mm)	Année de la plus faible valeur	Pluie (mm)
Stidia	1900-1998	1965	145.5	1965	145.5
Ain Fekane	1905-1998	1944	166	1989	167.5
Ghazaouet	1930-1998	1982	138.5	1982	138.5
Khalouia	1929-1998	1983	160.7	1983	160.7
Maghnia	1930-1998	1944	151.1	1987	189.4
Tighenif	1922-1998	1985	168.4	1985	168.4
Zemmoura	1930-1998	1992	102.7	1992	120.7
Sougueur	1914-1998	1944	115.5	1984	140.4
Tammazourah	1913-1998	1981	165.7	1981	165.7
Maghnia	1912-1998	1985	143.9	1985	143.9

L'analyse de la longue série de la station d'Oran (1877/78-1997/98) révèle que la période de déficit la plus sévère s'étale sur une douzaine d'années, de 1977/78 à 1988/89 avec un léger excédent durant l'année 1979/80 et un déficit maximal (-213,6 mm) enregistré durant l'année 1922/23. Sur la période étudiée (120 ans), on enregistre 62 années déficitaires, dont 21 ayant été affectées par une sécheresse modérée et une 11 pouvant être considérées comme sèches (selon le critère défini ci-dessus). Le déficit enregistré durant l'année

1922/23 (-213,6 mm) possède une période de retour de 244 ans, les déficits des années 1944/45 (- 212.3 mm) et 1982/83 (-208.9 mm) correspondant respectivement à des temps de récurrence de 81 ans et de 44 ans.

Toujours pour la même station mais pour la période de référence (1950/51-1987/88), le déficit maximal est de –203.5 mm, enregistré durant l'année 1982/83. Sur la totalité de la série, 25 années sont déficitaires (52 %), 10 années sont considérées comme modérément sèches et 3 années comme sèches. Cette année (82/83) se caractérise par une période de retour de 98 ans ; elle est suivie par l'année 1981/82 qui a une récurrence de 33 ans. A titre indicatif, le tableau n°4 regroupe les années où ont été enregistrées les plus faibles valeurs et leur période de retour.

4. L'ANALYSE SPATIALE

La spatialisation des irrégularités des précipitations peut être approchée par le coefficient de variation des séries de mesures disponibles. Ce coefficient permet une comparaison stations entre elles.

La distribution de la variabilité n'est pas aléatoire. trois éléments structurent les fluctuations annuelles des pluies, la latitude ; la longitude et l'altitude de la zoné étudiée. La figure est obtenue par krigeage (variogrammes annexe 4) entre les points de mesures. Par cette carte, nous avons essayé de montrer la variabilité inter-annuelle des pluies. La variabilité interannuelle des pluies augmente lorsque l'on se rapproche des régions arides. Cela a été vérifiée. L'augmentation de la variabilité avec un accroissement de la longitude et la diminution latitudinale. L'altitude atténue cette accroissement.

L'analyse de ce coefficient par bassin est représentée comme suit :

4.1. Bassin versant du Chellif (01)

Le bassin versant du Chellif est caractérisé par une pluviométrie moyenne annuelle (sur 25 ans) qui varie de 148 mm à 746 mm d'une station à une autre. Le coefficient de variation des moyennes annuelles est de 30 %, ce qui montre une variabilité plus au moins importante des précipitations.

A l'échelle annuelle (Tab 2), la variabilité spatiale (représentée par le coefficient de variation d'une station à une autre pour les 25 ans) varie de 29 % à 51 %. La variabilité spatiale est accentuée par :

- les pluies orageuses d'automne et d'été provoquées par les vents de direction Nord-Ouest (MEDDI M. 1992) touchent le Nord-Ouest et le Sud -Ouest,
- les pluies importantes, d'hiver et de printemps, reçues par les parties montagneuses (Djebel Dahra, 1604 m, Djbels El Ouancheriss, 1710 à 1786 m, les monts de Tiaret où l'altitude dépasse les 1200 m), par rapport à la plaine du Chellif et la partie Ouest du bassin (bassin de l'oued Mina). La variabilité inter-annuelle pour ces stations du bassin varie de 17% à 45%, ce qui montre l'existence d'une certaine stabilité autour de la moyenne pour 60 % des stations, alors que 20 % des stations ont une variabilité plus au moins importante (plus de 40 % et 10 % ont une variabilité inférieure à 10 %).

4.2. Bassin versant des cotiers de l'Algerois (02)

Le bassin versant des côtiers de l'Algérois (02) est caractérisé par un relief très accidenté avec des sommets qui atteignent 1415 m (Djebel Dahra) dans la partie Ouest du bassin et 2308 m (Djebel Djurdjura, Kabylie) dans la partie Est du bassin. Ces chaînes montagneuses et l'Atlas Blidiéen qui succèdent à la plaine de la Mitidja causent l'appauvrissement progressif de l'atmosphère en vapeur d'eau. Celles-ci ont une grande influence sur les variations spatiales de la pluviométrie (B. AISSANI, 1985; A. HALIMI, 1980).

La pluviométrie moyenne annuelle (25 ans) varie de 532 mm à 950 mm. Cette variabilité est engendrée par l'effet d'altitude, la distance à la mer et la forme du relief (exposition aux vents). Les vents humides dominants sont de direction Nord-Ouest ainsi les postes coïncidant avec cette direction sont les mieux arrosés (exemple: au niveau de la station de Chréa, 1550 m d'altitude on a enregistré une pluie de 949 mm, moyenne de 25 ans d'observations alors que la station de Blida, 267 m d'altitude, donne une pluie moyenne de 768 mm).

La variabilité spatiale de la pluviométrie d'une année à une autre varie de 18 % à 47 %. 70 % des stations ont une variation spatiale plus au moins proche de la moyenne (25 %) et 30 % ont une variation spatiale de plus de 30 %.

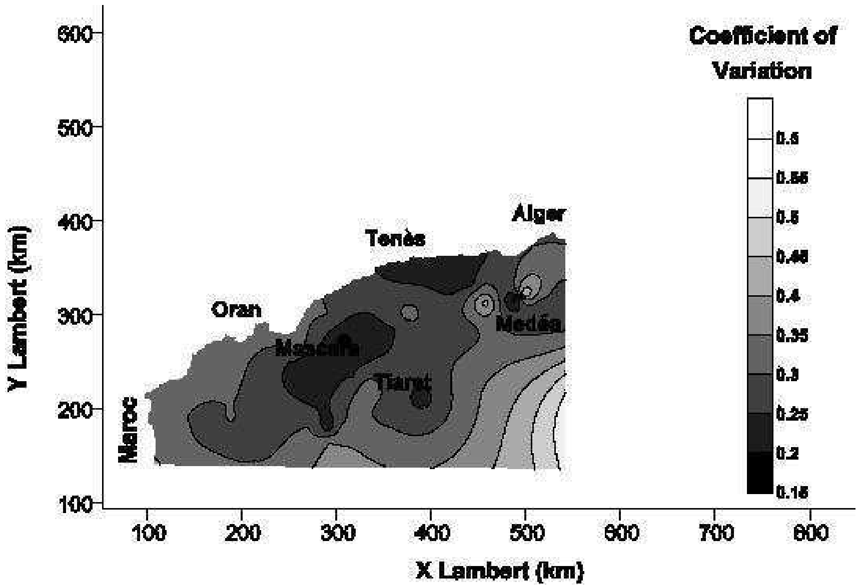


Fig. 2. ***Coefficient de variation des pluies annuelles***

4.3. Bassin versant des cotiers Oranais (04)

Le bassin versant des côtiers Oranais a une topographie moins accidentée par rapport aux autres bassins versants. On y trouve la plaine d'Oran où l'altitude n'excède pas 100 m. Il est caractérisé par une faible pluviométrie (de 302 mm enregistrée à la station de Marsa Ben Mhidi, littoral extrême Ouest, à 398 mm à Hammam Bouhadjar). La variabilité spatiale, d'une année à une autre et d'une station à une autre, est modérée (de 10 % à 36 %). Ces faibles pourcentages sont dus essentiellement au relief modéré et aux faibles pluies enregistrées dans ce bassin.

4.4. Bassin versant de la Macta (11)

Le bassin versant de la Macta (Ouest de l'Algérie) est limité au Nord par Djbels Beni Chougranne et Djbels Tessala et la plaine de Mohamadia, au Sud par les Djebels Saida et ceux de Daya (1356 m) au Sud Ouest par les Djebels de Tlemcen.

La pluviométrie annuelle est faible, elle varie de 206 mm enregistrée au versant sud des Beni Chougranne (Bouhnifia et Sfisef) à 380 mm sur les monts de Saida (1201 m) et sur le versant Nord-Ouest de Djbel de Sidi Belabess et Djebel Tessala. La variation spatiale est modérée, elle varie de 20 % à 43 % avec une moyenne (25 ans) de 25 %.

4.5. Bassin versant de la Tafna (16)

Le bassin versant de la Tafna longe la frontière Algéro-Marocainne (Ouest de l'Algérie). Il est limité : au Nord-Ouest par Djbels Terara (1021 m), et au Nord-Est par Djbels Tessala. Il est composé dans sa partie Sud-Est par Djbels Tlemcen (de 1576m à 1843m), et dans sa partie Nord, on trouve des plateaux de 200 à 500 m d'altitude.

La pluie annuelle varie de 260 mm au niveau de la plaine de Tlemcen à 650 mm sur les sommets des Djbels de Tlemcen. La variabilité spatiale varie de 21 % à 57 % avec une moyenne (sur 25 ans) de 30 %. Plus de 90 % des années d'observation donnent des coefficients de variation (spatiale) inférieurs à 40 %, ce qui confère à ce bassin une variabilité spatiale plus au moins modérée.

5. CONCLUSION

L'étude du changement du régime pluviométrique dans le Nord Ouest Algérien a montré une rupture dans la décinie 70 (réduction de la pluviométrie) pour la quasitotalité des postes étudiés. La variabilité inter-annuelle des pluies augmente lorsque l'on se rapproche des régions arides. L'augmentation de la variabilité suit l'accroissement de la longitude et la diminution de la latitudinale. L'altitude atténue cet accroissement.

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A FEW CONSIDERATIONS REGARDING THE ROMANIAN CARTOGRAPHIC DEVELOPMENT AT THE BEGINNING OF THE 20TH (TWENTIETH) CENTURY

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ABSTRACT
Before the World War I the territory of Romania was represented on more type of topographic maps. In 1916 the projection was unified: it was used the Lambert–Cholesky Conformal Conic Grid on the datum Clarke 1880. The scale of the base-maps were 1: 20 000. The maps were used until the publication of the Gauss–Krüger maps in 1959. The maps are digitized and georeferred by the authors – so these maps can be used as a basic material for historical and geographical researches.

*

1. INTRODUCTION

Before the 1918 Union, the Romanian territories were subject of several dominations, for which reason the cartographic data base for each Romanian province was different from an area to another. Starting from the second half of the 19th century, Valachia, Moldavia and Dobrogea (Dacia Pontica or Scitia Minor) field mapping was made, implicitly cartographic representations, different as structure. The projection systems used, the chosen geoid, the nomenclature and the distribution of the map pages were not uniform. For an example, the Bessel ellipsoid and the Cassini cross cylindrical projection were used especially to the eastern side of the Zimnicea central meridian (23^0 East from Paris), while to its western side the Bonne conic equivalent projection was used, as defined on the Clarke ellipsoid (Năstase, 1975, pages 86-87). In the other Romanian provinces, such as Transylvania, Romanian Banat, Bessarabia (Moldavia Republic) and Southern Bucovina, the major part of the cartographic products (surface contour maps) were made as polyhedral projections.

During the World War I, when artillery was a redoubtable weapon a necessary idea was born to articulate an unitary cartographic projection concerning the entire Romanian territory, which should respond to the principle of conformity. Between 1916-1917, pursuant to the above argumented measure, a new datum/location surface, a new projection system and a new nomenclature were introduced. The Lambert projection system was used as modified by the French land surveyor, the mathematician and officer Andre Louis Cholesky. He was born in 1875 in Mont Guyon and passed away on the battle field in

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Northern France in the month of August 1918. During September 1916 up to February 1918, following the Franco-Romanian military convention, he was a Commander of the Geographic Department of the Romanian Army (Brezinsky-Gross-Cholesky, 1996). The calculations for passing from the various projections (as previously mentioned), into the Lambert-Cholesky projection, were made by the Romanian officers (Osaci-Costache, 2000 page 138).

2. MAPS PROJECTION

The datum/location surface used by the Lambert-Cholesky projection was defined on the Clarke ellipsoid 1880. We have no data concerning the used datum. Employing Mugnier's (Mugnier 2001) data, we may state that the geometric elements of the ellipse used were: major semi-axis (a): 6378249,2 m; minor semi-axis (b): 6356515,0 m. These values differ only by 10 cm compared to the Clarke ellipsoid 1880, a difference which we may consider as a round-off error. We have no data on the actual position of the co-ordinates system centre. From the location surface it was arrived at the plane surface by using the conic conform projection of Lambert. The projection central meridian was located at 2 centesimal degrees western side of the meridian of the Military Astronomic Observatory in Bucharest ($24^0$18\`44,99\`\` eastern longitude, respectively $45^0$02\`29,216\`\` northern latitude). The size of the longitudinal deformation was reduced on the central parallel (l = 0,99844674), in this manner arriving in the situation where the longitudinal reducing on the central parallel and the longitudinal increasing on the parallel placed on the eastern border of the territory intended to be reciprocal one to each other (Cliford and Mungier, 2001 pg. 547). In this manner we are able to determine the projection central point in Valea Oltului in the closed vicinity of Stolniceni locality in Vâlcea county. The co-ordinates system was placed so that the crossing point of the 45^0 and the central meridian should observe the relation x = y = 500km. The Cartesian coordinate of the projection central point is x = 500000m, respectively y = 504599, 11m (Cliford and Mungier, 2001).

3. SCALE AND NOMENCLATURE SYSTEM

The basic map, called „Plan Director de Tragere" was drafted under 1:20000 scale in 2118 drawings, covering the Romanian territory. Under graphical aspect, such drawings had a 75 cm length (the equivalent of 15 km of land), respectively 50 cm (the equivalent of 12 km of land). Usually, at the upper part of the map, frequently to the left side, less frequently to the right side, the drawings nomenclature appeared, made following the principle: the first two letter meant the columns number and the last two characters represented the lines number. So, the drawing whose south-west corner had the Cartesian co-ordinate of 10 km, 20 km would have received the codification 1020.

Another series of maps of the same family was made under the 1:100000 scale, representing 102 drawings, covering the entire national territory. The drawings under the 1:100000 scale had the same size as the basis map, therefore they were covering a surface 25 times larger. The drawing nomenclature corresponded to the drawing under the 1:20000 scale in the south-west corner. The drawings under the 1:200000 scale were executed equally, with the same graphic dimension.

4. BASIC MATERIAL AND CONTENT OF THE MAP

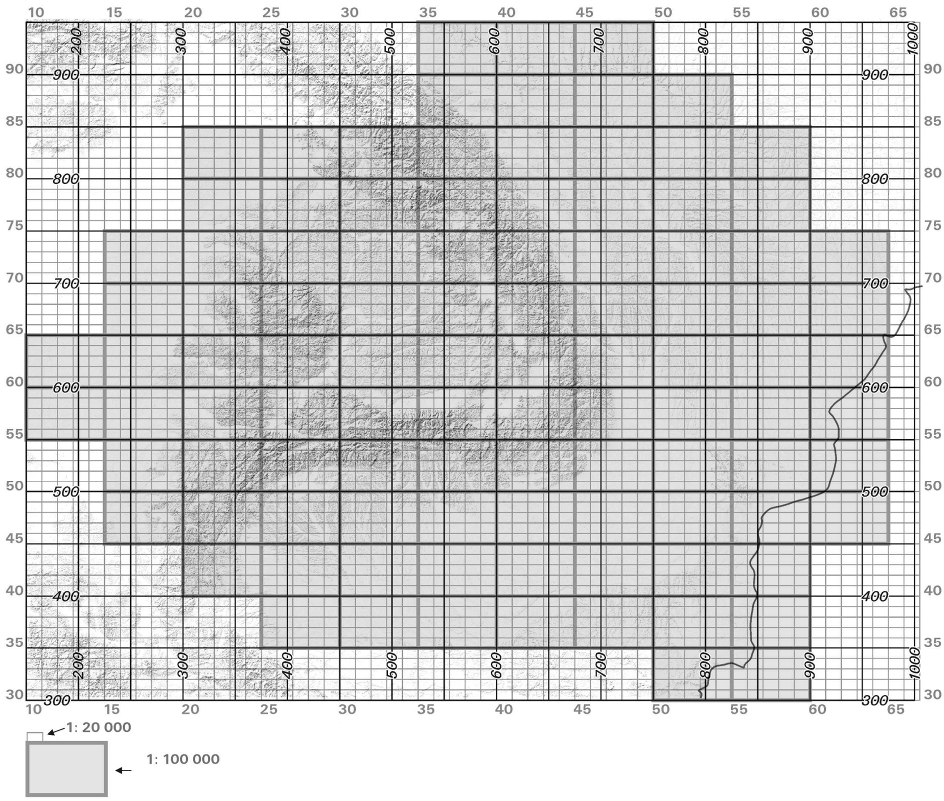

Fig. 1 ***Drawings rectangular system under the 1:20000 scale and the surface covered by the drawings under the 1:100000 scale of the Lambert-Cholesky projection.***

The maps under Lambert-Cholesky projection, especially those ones made in the first period, were not the result of some new measurements, but they proceeded from previous sources (Romanian, Austrian, Russian), graphically transposed. Since 1924, a major part of the data in these maps was updated on the grounds of the aerial photograms. Subsequent to the Agricultural Reform in 1921, the maps toponimy was modified, numerous Romanian denominations being added (Năstase, 1875 page 87).

On the maps under the 1:20000 scale, the relief was represented as elevation curves with an equidistance of 20 m, and on the maps under the 1:100000 scale, the equidistance was of 100 m. In order to represent the relief, the 1:200000 Variant employed the hachure method. The toponyms are usually written in Romanian language, while in Transylvania and especially in the transfrontalier areas, mixed toponyms are noticed. Colours used in the basic map printing were brown for the relief and black for the remaining representations. On the maps under the 1:100000 scale, a third colour appears (green for vegetation), and for the maps under the 1:200000 scale, only two colours are employed: green for vegetation and black for the rest of the represented elements.

Fig.2 ***Fragment of the Oradea drawing (1926) under the 1:100000 scale***

5. NEW EDITIONS OF THE MAPS. IMPORTANCE AND METHODOLOGY OF STUDYING THEM.

Editing, printing and spreading of the same covered many years, up to 1959.

Even at the beginning of the fourth decade, the projection changing have been decided (Hayford ellipsoid and the secant stereographic projection), a minor part of 5% of such maps were transposed in the new system (Năstase 1975, page 87). During the `50, the maps contents and accuracy gradually begin not to correspond anymore to the military topographic exigencies.

By this reason, and due to the fact that the maps under Lambert-Cholesky projection were not accordable to the Gauss-Kruger maps, as used by the soviet space, a decision to implement a new projection system for the Romanian space has been taken. This system is founded on large measurements campaigns, starting in 1951 and their results have been materialised into the new Gauss-Kruger projection maps. In parallel, between 1954 up to 1959, the most recent drawings under Lambert-Cholesky projection was edited and printed, bearing numerous toponymy corrections (Osaci-Costache, 2000).

The significance of the Lambert-Cholesky projection maps consists in the fact that they represent the first cartographic product referring to the entire Romania, under an unique projection system, and having an unitary legend.

Furthermore, these ones are the maps achieved at the highest scale up to that moment. In the mean time, they represent a public and not classified cartographic product, as well.

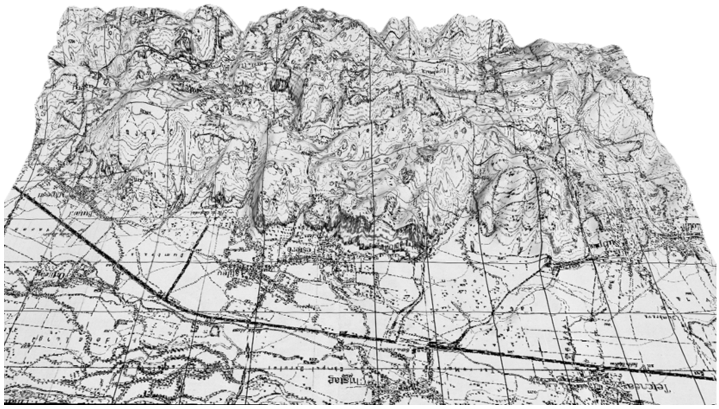

Fig. 3 ***Valea Crişului Repede (Lambert-Cholesky drawing under the 1:20000 scale) overlapping the altitudinal numerical template of the land (SRTM)***

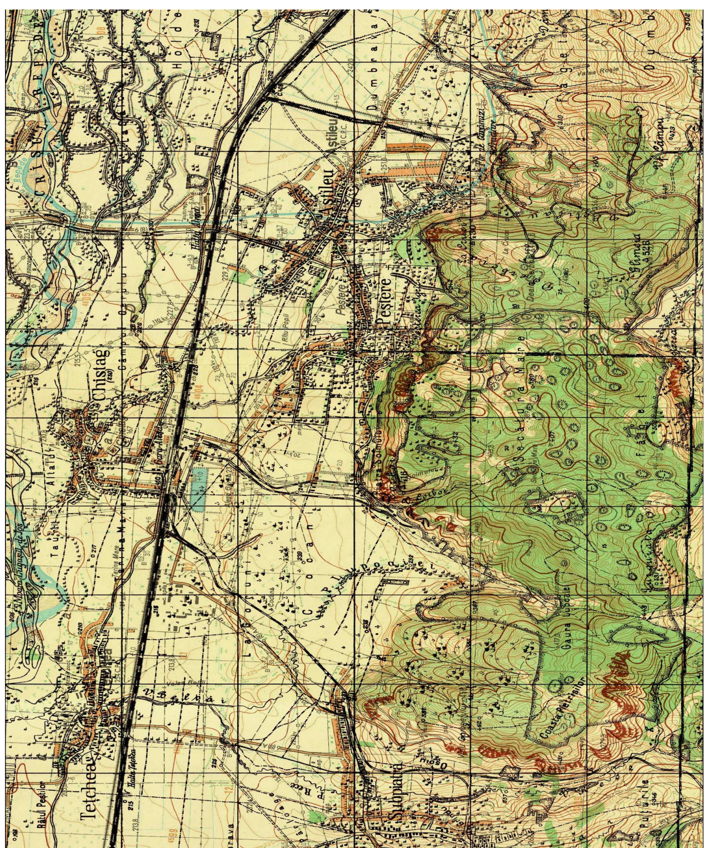

Fig. 4 ***Valea Crişului Repede (Lambert-Cholesky drawing under the 1:20000 scale, with Gauss-Kruger background under the 1:25000 scale).***

Part of the Lambert-Cholesky maps (1:200000, 1:100000, 1:200000) are kept at the Bucharest University, another part at the Babeş-Bolyai University. Their scanning was made at the Cluj University, using a reel scanner, A0 paper size, thus obtaining *.tif formats having a 300 dpi resolution. Employing the above mentioned parameters, these formats have been geo-referenced. Related to the errors occurring, we mention that the difference compared to the reality is comprised between 50 – 100 m. Such errors are caused, to a large extent, by the manner of graphic transposition by means of which the maps were drafted and to a smaller extent they are due to the parameterization.

6. CONCLUSIONS

Before the World War I, Romania had not an unitary cartographic system. Starting from 1916, it was attempted to standardize the previous projection systems and the nomenclature systems, aiming to guarantee the accordability premise.

With this purpose, the Lambert - variant Cholesky maps, under conic conform projection, have been made. Short time after that, the drawings under 1:20000 scale were edited under this projection. Such drawings were permanently updated, up to the year 1959, when the Gauss-Kruger projection imposed itself. Its authors transposed these materials on digital support, by scanning operations, actually the action of their geo-referring being in progress.

We therefore consider that such materials do constitute a proper foundation for the carto-topographic research, also enabling in the evolutional sense the development of the natural and the built environment. It is of a certain interest that this cartographical products, since they are geo-referenced, shout arrive to the interested persons in the geographical domain shaped as a multimedia product similar to the Austrian military measurements, as recently promoted by the ARCANUM Editing House.

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G.I.S PERSPECTIVES FOR SOCIAL SECURITY MANAGEMENT

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ABSTRACT
Lately, G.I.S techniques have been used for an increasing area of applications with more or less geographic implications. The paper proposes the finding of some useful applications in the management activity of the social security system. Insurances represent everything related to risk management. It is important to identify the riskier areas and which are the natural, human or economical factors that amplify risk. Following such an analysis one can take decisions concerning the risk level in some areas, improving sales, improving marketing or client activities. Also a localization of agents or clients is possible.

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1. MANAGERIAL FEATURES IN THE FIELD OF SOCIAL SECURITY

Managerial processes, unlike execution processes, can be defined mainly by the fact that part of the workforce (the leading team of the organization) acts over the other part of the majority of the labor force (the subordinate personnel) through a variety of decisions and actions in order to determine the organizational objectives, as well as the resources and the means for the efficient realization of objectives.

The managerial processes have several principal components linked to the functions and attributes of leading (prevision, organization, coordination, training and control-evaluation). (Fig.1). These are the typical parts of the typical managerial process, which acts throughout all the social – economical processes, including here organizations irrespective of their characteristics.

In the actual conditions of the Romanian economy when economical agents are still faced with a series of major difficulties economical problems are priorities (especially, the efficiency) correlated with the social ones.

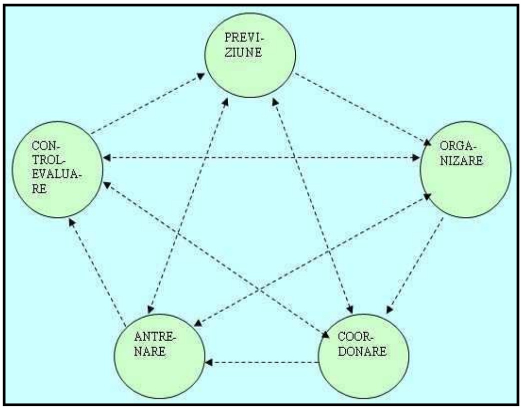

Fig.1. ***The interdependencies between the managerial functions***

Almost half of the Romanians think that the economical situation of the country is the most important issues, that is double the percentage of the inhabitants of the old members of EU (22%). The prices are seen as the second largest problem, and therefore seen

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accordingly by 26% of the Romanians. The third issue is the pension problem, 22% of the citizens („România Liberă”, 14 July 2006). In this context, social security – key component of the social security system – gathers new dimensions.

On one hand it is necessary to underline the fact that social security systems are dynamic systems, due to the alterations suffered in time, of the constitutive factors (such as the present and foreseen demographic situation and the health state of the population) and on the other hand due to the mobilization of the political, economical and social context.

Political factors (political stability, ideology, geopolitical connections and institutions), economical factors (natural resources, labor, capital, infrastructure and technologies) and social factors (the social structure and dynamics, the conception on human nature, time and space, religion, language and the role of man and women in) have their own laws which results in a permanent search for compromises to eliminate the contradictions which exist among them.

The management of social security institutions means knowing each of the characteristics of the named factors and the relations existing among them, so that they can be included in a unitary mechanism meant to model the nature of the social security system either at national or international level.

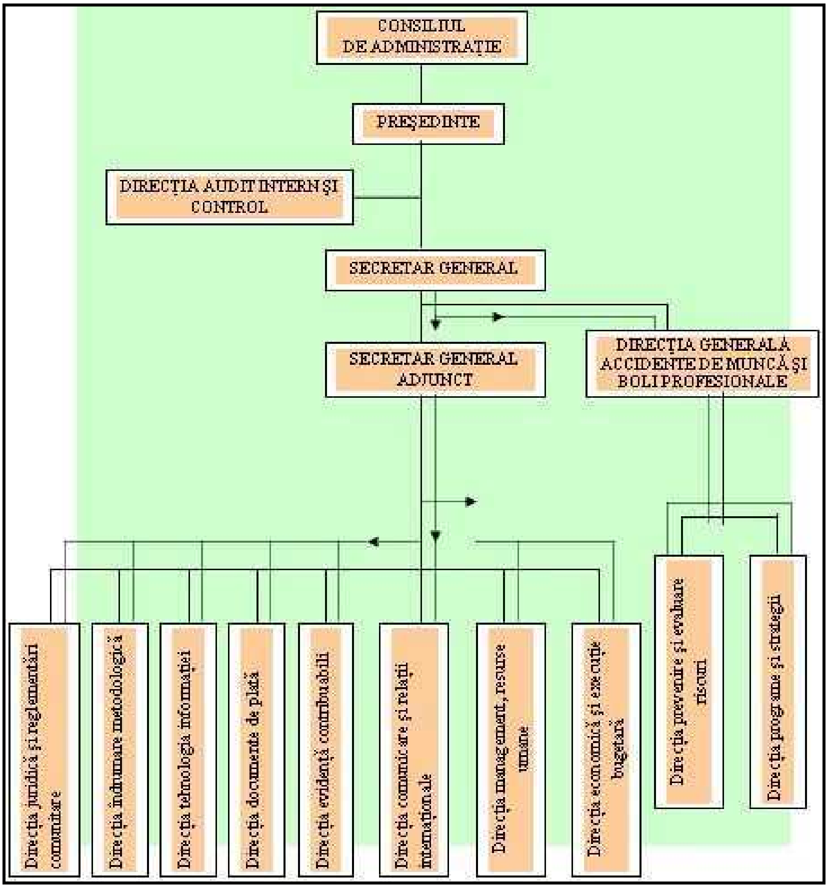


Fig.2 ***The structure of the National House for Pensions and Other Social Security benefits***

The main institution responsible for the administration and management of the state social security system and for the social insurance system for work accidents and labor related illnesses or professional disorders is **CNPAS** (The National House for Pensions and Other Social Security Benefits), founded in 2000, based on Law no 19/2000. This institution is subordinated to **MMSSF** (The Ministry for Labor, Social Solidarity and Family). This institution enforces the law through a network of local and regional pension agencies (all of them juridical persons) (Fig.2).

Apart from those already mentioned there are other public institutions involved in the social security activity from Romania: The National Agency for Employment (ANOFM); Ministry of Health (MS) The Agency for Health Assurance (CNAS); The Ministry of Public Finance (MFP); The National Agency for Fiscal Administration (ANAF).

The Ministry for Labor, Social Solidarity and Family (MMSSF) is organized and functions as specialized organ of the public administration. It is subordinated to the Government; has juridical personality and has a role of synthesis for ensuring and coordinating the application of the governmental strategies and policies in the fields of: labor, social security, social protection and family.

In the exercise of its functions MMSSF has attributions in the following directions: Social policies; European affairs and external relations; the protection of Romanian citizens working abroad; social security and family policies; labor force; social partnership; salary incomes; social insurance and special legislation; work legislation; human resource management; economic-social resource management and investments; security and work health.

The main attributions of MMSSF, in the field of social security and of special legislation are listed bellow:

- creates policies and programs in collaboration with other ministries and organs of the central public administration, in the field of pensions and other social security benefits;
- has control over the implementation of policies and programs by the National House for Pensions and Other Social Security Benefits (CNPAS);
- creates the methodology for the application of legal provisions by deciding the right to pension, other social security benefits and benefits entitled by special legislation at the proposal of CNPAS;
- creates the fundamentals and promotes the budgetary project for the state social security system based on the proposals issued by CNPAS;
- creates the legislation needed for the creation of the institutional framework needed for the implementation and functioning of the private social system.

2. THE SPECIFIC OF A GIS DATABASE RELATED TO SOCIAL SECURITY

In the field of social security the majority of observations which could constitute the database are of quantitative nature: the number of insured persons, the number of persons who benefit from employment aids or other social aids, the monthly value of the different social contributions to the state, regional or local budgets etc. By analyzing such indicators one can gain data regarding the natural and social –geographical characteristics of certain areas of territory thus creating a classification of the risk areas.

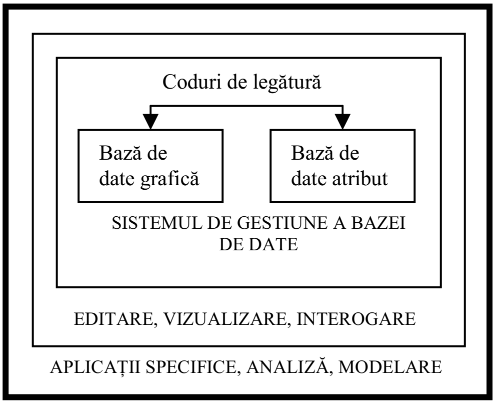


Fig. 3. ***The place of the database inside G.I.S***

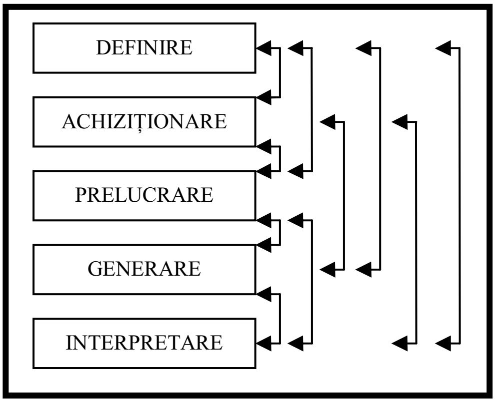


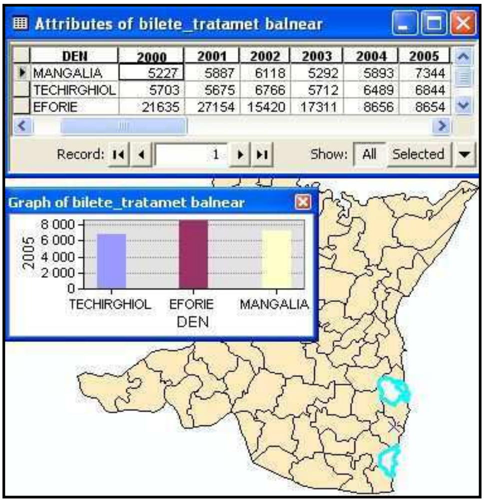
Fig.4. ***Feedbacks between the stages of GIS application***

The role of GIS is to store information, to interpret information, to integrate information in a specific model, to create correlations between different types of information etc. GIS also creates the connection between the quantitative attributes and the spatial ones, by attributing to each quantitative value a set of spatial coordinate identifiers (Fig. 3). G.I.S applications and database analysis for the sanitary domain was realized, in Romania, to county level. (Muresan F. et al. , 2006).

The use of G.I.S supposes certain work stages: identifying the problem, the acquisition of the necessary data, the preparation of the data and the exploitation of all the connex information; the creation of reports and spatial scenarios; the interpretation of results and the proposal of the optimum solutions.

However in reality there are only a few cases when these steps are followed in a linear fashion. It is needed thus a coming back stage during the study to the previous stages (Fig. 4).

A few aiding questions (Haidu I. and Haidu C., 1998) which could be asked during the stages presented above refer to: a) the type and source of necessary data and b) methods of data preparation and result interpretation.



a) The type and the source of the necessary data. The possible questions are: What kind of data are needed to analyze and solve the problem? Where and which is the primary information needed for reaching the desired result? Regarding the data typology it must be pointed out that there are <u>data variable in space</u> (the number of insured people at county, local etc level) and <u>data variable in time</u> reported in relation to certain spatial parameters such as the total number of population, the number of active population, the young force labor and the future contributions etc.

Fig.5. ***An illustration of the spatial – temporal variability of data***

As far as the source of information is concerned, in the field of social security the majority of the data are statistic in nature resulted after population surveys and questionnaires (the National Institute of Statistics); also the database of the social security institutions can be the most reliable source of information (CNPAS, ANOFM, MS, CNAS, MFP, ANAF).

An example of database that takes into account the double variability of the data is displayed in **fig.5**. The data refer to the number of tickets for the balneal treatment distributed through the state security system in the Romanian resorts (Mangalia, Techirghiol, Eforie) from Constanța county during 2000-2005.

b) Methods of data preparation and interpretation. The possible questions could be: *What procedures will be used for creating thematic layers and final maps?*

The most adequate methods for analysis must be used by using existing GIS extensions or by creating and integrating new ones which provide solutions for the problem in question. Here are a few examples: generating new attributes by querying the database, spatial uni-layer operations (the spatialization of the vectors of some indicators, density analysis), multiple spatial operations (vector overlay, matrix overlays, multi-criteria overlays etc).

3. POSSIBLE APPLICATIONS

The determination of some potential areas of applicability for GIS in the field of social security systems can be achieved by paying attention to some features: the identification (Which is the city with the most /least social security contracts); the tendency (Which changes related to the social security systems have occurred in the last ten years?); the causes (why has the number of pensioners has expanded in the last 15 years?); forecast (How will things look like in the next … ?).

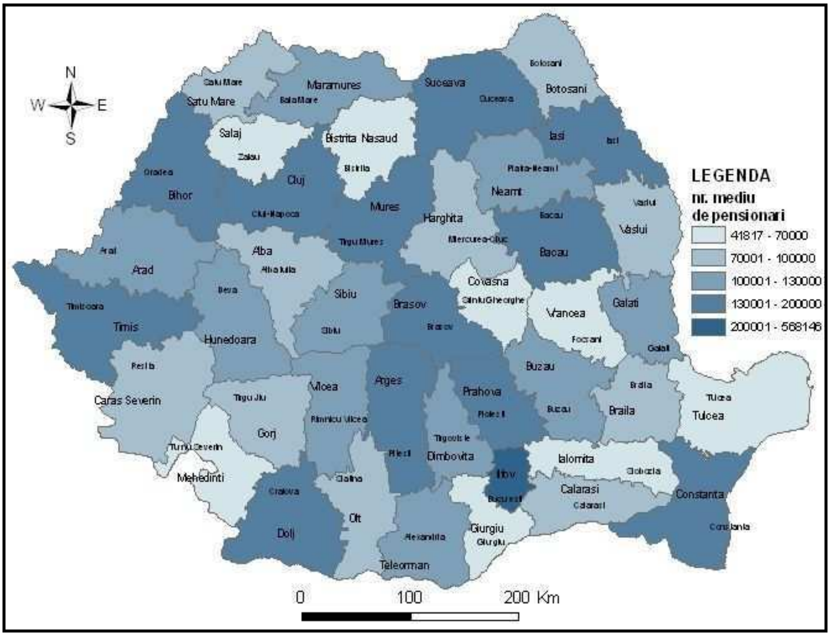


Fig.6 ***The mean number of social security pensioners at county level in 2005***

In order to evaluate the risks in the area of social security systems of a city and in order to assume some decisions it is necessary to create some sets of information in the form of layers referring to the: degree of pollution, the source of pollution, the age of the population, the specific of the works engaged by the population, the work conditions etc. If one is interested to analyze the unemployment rate in a county an identification of the localities with the most unemployed persons is needed. Also the causes which have lead to a diminishing of the investments in a city must be taken into account.

By using the data offered by CNPAS and the National Institute of Statistics the mean number of retired people was displayed spatially ta county level in 2005 (Fig.6). Another example of analysis at county level is offered by **Fig.7**, where one can see the spatial value of the social security pension in the 2005. By using certain data series with a certain spatial sequence one can obtain layers which can reveal alterations of the analyzed indicators.

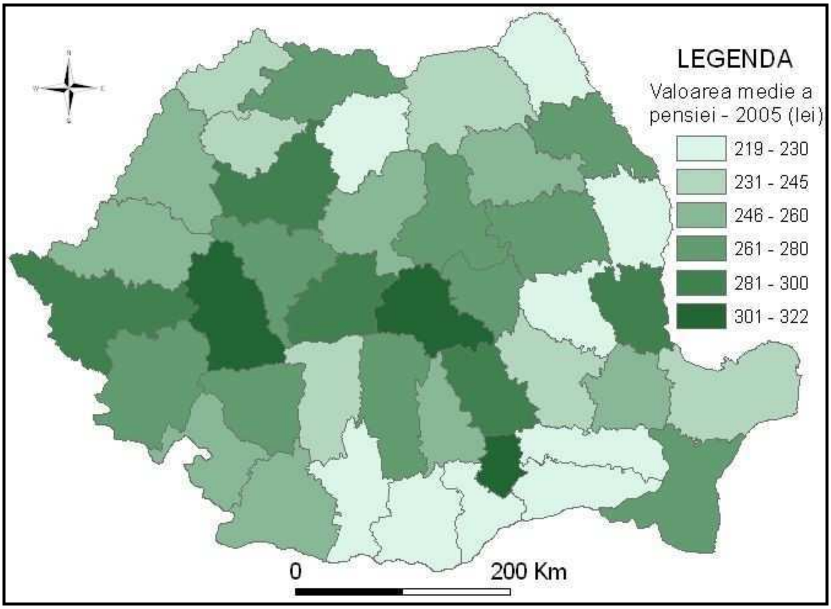


Fig.7. ***The mean distribution of the state social security pension value (lei/person) in 2005***

4. CONCLUSIONS

In the social security management activity, GIS systems could play an important role in the process of data storage, offering thus the possibility of accessing the spatial side of the parameters in the area of insurances. Considering what we presented above and in accordance with the CNPAS organizational chart (Fig.1) there are a few sectors where GIS could be used: the technology of information department, the direction of tax payers evidence, the direction of risk prevention and evaluation.

One of the great advantages in using GIS consists in locating and identifying the observed indicators and factors which lead to a certain situation. In order to have a diversification of its applications it would be important to integrate in GIS the used equations in the insurance activities creating thus new extensions.

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*** Institutul Național de Statistică

*** Legea nr.19/2000 privind sistemul public de pensii şi alte drepturi de asigurări sociale, cu modificările şi completările ulterioare (actualizată la 1 ianuarie 2006);

*** Legea nr.76/2002 privind sistemul asigurărilor pentru şomaj şi stimularea ocupării forței de muncă, cu modificările şi completările ulterioare;

*** Legea nr.346/2002 privind asigurarea pentru accidente de muncă şi boli profesionale, cu modificările şi completările ulterioare;

*** Legea nr.705/2001 privind sistemul național de asistență socială, cu modificările şi completările ulterioare

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MODERN SHORELINE CHANGES ALONG THE NILE DELTA COAST AS AN IMPACT OF CONSTRUCTION OF THE ASWAN HIGH DAM

M. Torab[1], M. Azab[2]

ABSTRACT

The major objective of this study is to detect the morphological changes of the Delta coast line during last 35 years, and to define coastal geomorphic features along the northern part of the Nile Delta. The Nile Delta coast was determined by comparing satellite images and historical charts with present-day conditions. The erosion and accretion shorelines are influenced by by transport processes, including sediment provenance from different sources: eroded Nile delta coast, relict sediments from the former Nile tributaries and mouths, and sediment supply by land valleys and from wind-blown sand.

Key Words: *Mediterranean Sea, Sea Level Changes, Nile Delta Coast, Aswan High Dam*

*

1. INTRODUCTION

The construction of the Aswan High Dam was started in storage Nile Water on 1964, and fully finished six years later. The construction of the Dam has changed the hydraulic regime of the river downstream. The erosion of the Nile Delta coast was first observed in 1898, but accelerated after the construction of the Dam. One of the major environmental problems of the Dam was the potential drop in river channel downstream of the Dam become silt-free water, and coastal erosion in the Nile Delta coast.

Before the construction of the Dam, silt used to be spread over land or carried to the delta coast. It is estimated that each year floods used to deposit 12 million tones of silt on land along the delta and Nile valley north of the High Aswan Dam . The reduction in soil fertility due to the loss of the nitrogenous component of the silt now has to be compensated for by the annual addition less than 13 thousand tones sediments (Frihy, 1988).

The study area is located on the northern coast of the Nile Delta, between Rosetta and Damietta mouths (Fig.1). It has a length of about 170 km., it consists of the following geomorphic units in addition to the barriers unit near the northern coastline of Sinai (out side of the study area) :

a. The mouths unit of Nile Delta braches in Rosetta and Damietta.
b. El Burullus lagoon unit.
c. The coastal plain unit.
d. The coastal dunes unit.
e. The coastal sabkhas unit.

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The morphological changes of the Nile Delta coast have been studied during last century such as: Lewis, 1931, Lafond, 1939, Aki, 1953, El-Ashry and Wantless, 1967, Zenkovich, 1967, Mohamed, 1968, Moussa, 1973, UNESCO DTR, 1973&19760, Frihy, 1975, Manohar, 1976, Misdorp and Sestini, 1976, El-Fishawi, 1977, Hamama, 1978, Rashed, 1978, Anwar et al.,1979, Abdela, 1987, Frihy, 1988, and El-Sayed, 2005.

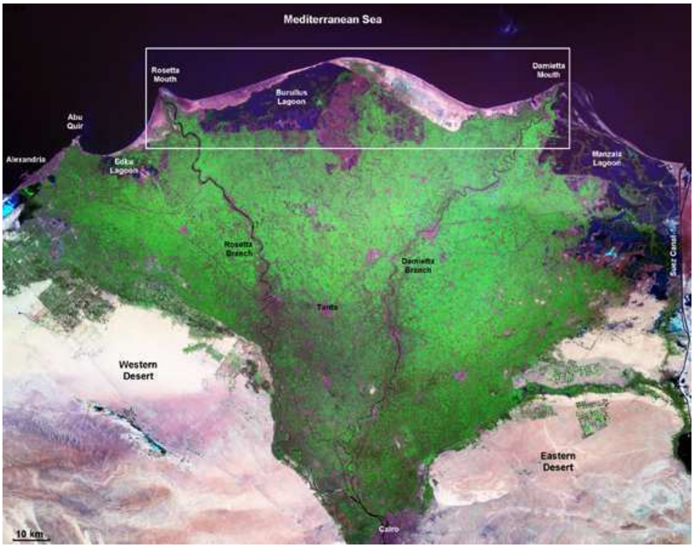

Fig.1. ***Location of study area***

The major objective of this study is to detect the morphological changes of the Delta coast line during last 35 years, and to define coastal geomorphic features along the northern part of the Nile Delta. Some of the modern changing shoreline positions along the Nile Delta coast were determined by the following methods:

1. Comparing two satellite images (Landsat TM: May1984 & Jul 2001 – Resolution 30m,7 bands), aerial photographs taken in 1955 and historical maps in 1900, 1925 and 1970 by using ERDAS IMAGINE 8.4 software .
2. Field observation of the study units.
3. Sediments samples has been collected for grain size analysis.
4. Analyze the collected data by GIS techniques.

2. RESULTS AND DISCUSSION

Every year before construction of the Aswan High Dam, water flooded from Nile during August-October through its branches (Rosetta and Damietta), but after building it a huge amount of water and alluvial sediments storage behind the Dam since 1964, the mean annual amount of Nile water is reduced from 34 billion cubic meters to less than ⅓ it's amount before construction the dam, the sediment load is reduce too from 60-180 million tons to less than 15 million tons after building it , which was the main source of accretion on the coast line and the two promontories of Rosetta and Damietta, but it has removed gradually from this date (Sharaf El Din, 1977). The present study shows that there are some morphological changes of the geomorphic units of the northern portion of the Nile Delta depicted as a result of construction of the High Aswan Dam (fig.2 & Tab.1):

The evaluation of the major topographic units between 1925-2001(km3)

Table 1

Topographic Unit	1925	1970	1984	2001
Data Source	Topographic Maps		Landsat TM images	
El Burullus lagoon unit	8658.5	5674.7	553.4	489.8
Lagoon islands unit	43.7	65.6	317.2	292
The coastal dunes unit	1085.6	704.3	1032.8	567
The coastal sabkhas unit	1173	736.4	265.1	59

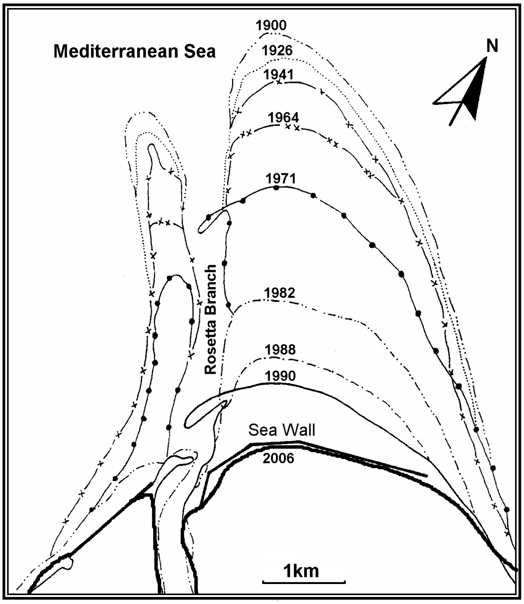

Fig.2. ***Major geomorphic units of The northern portion of the Nile Delta***

2.1. The mouths unit of Nile Delta braches in Rosetta and Damietta

2.1.1. Erosion of the Rosetta promontory began about 1900 after construction the Aswan Low Dam, the western and eastern sides of the mouth lost between 1900 – 1964: 879 and 1282 meters, it's average rate about 13.7 and 20 m/yr. The storage of water Nile started on 1964 at Lake Nasser in the front of the High Dam, it increased the erosion rate between 1964-2006 to 95.3 and 124.8 m/yr (tab.2 & Fig.3).

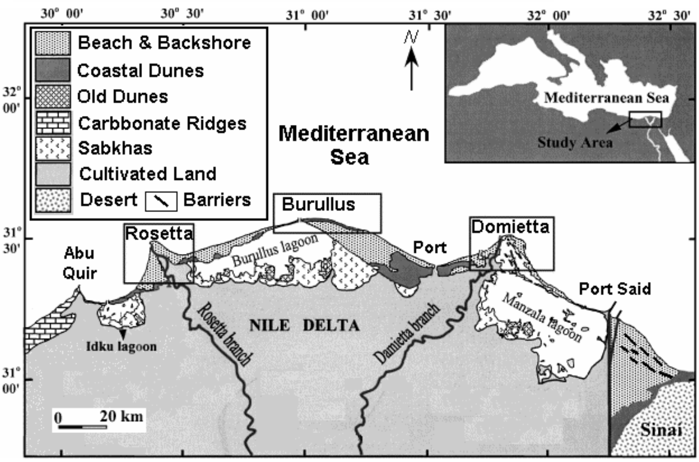

Fig.3. ***Morphological changes of The Rosetta mouth from 1900 to 2006 (After: Fanos, 1995)***

Annual rates of erosion on both western and eastern sides of Rosetta mouth (promontory) between 1900-2006

Table 2

Period		Western Side		Eastern Side	
		Erosion distance (m)	Erosion Rate (m/yr)	Erosion distance (m)	Erosion Rate (m/yr)
Before construction of the Aswan High Dam	1900-1926	243	9.3	396	15.2
	1926-1941	191	12.7	298	19.9
	1941-1964	445	19.3	588	25.6
	1900-1964 / Sub Total	**879**	**13.7**	**1282**	**20**
After construction of the Aswan High Dam	1964-1971	826	118	1555	222.1
	1971-1982	2796	254.2	1652	150.2
	1982-1988	381	63.5	826	137.7
	1988-1990	0	0	318	159
	1990-2006	0	0	890	55.6
	1964-2006 / Sub Total	**4003**	**95.3**	**5241**	**124.8**
Total Period		**4882**	**46**	**6523**	**61.5**

2.1.2. Coastline changes of Damietta promontory are similar to those of the Rosetta area. Erosion of the Damietta promontory started about 1900 too, it lost about 3.7 km between 1900-1991 averaged 40.7 m/yr. The average rates of the western and eastern sides between 1900 and 1973 was about 35 and 40 m/yr, but it increased to more than 100 m/yr after construction of The High Dam, although some protected walls and groins have been constructed during this period (Fig.4&5). The W/E currents accreted a 4.5 km long spit near the eastern side of the Damietta promontory, that spit appeared on 1983 aerial photos witch observed and recorded by (Frihy, 1988).

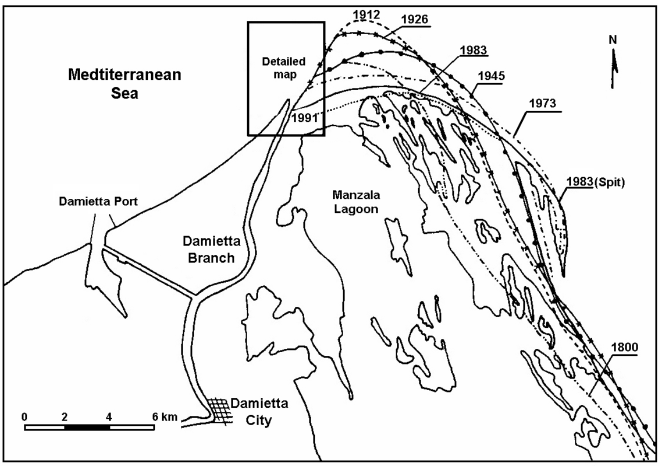

Fig.4. ***Morphological changes of the Damietta mouth from 1800 to 1991 (After: Fanos, 1995)***

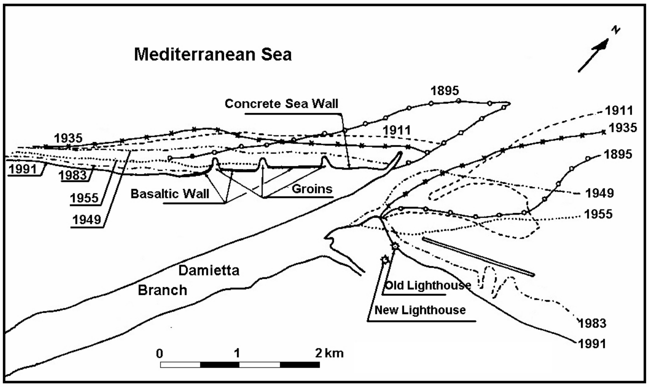

Fig.5. ***Detailed map of morphological changes of the Damietta mouth from 1895 to 1991 (After: Fanos, 1995)***

2.2. El Burullus lagoon unit: it is one of five shallow lagoons along the coastal plain of the Nile Delta (Maryut and Idku to the west of Rosetta Branch, El Burullus in the middle Delta coast and finally El Manzala and EL Bardawil to the west of Damietta Branch. The total area of El Burullus lagoon is reduce during last century from 5600 km3 (1925) to 317.2 km3 (1984) then to 197.8 km3 (2001) as a result of the human activities and land reclamation projects, specially after construction of the High Aswan Dam. Some years ago depth of that lagoon was varies between 0.5 and 3 meters, but now it becomes more shallow as a result of sediments accumulation by geomorphic processes and human activities. The total area of the lagoon islands is increase from 65.6 km3 (1925) to 292 km3 (2001) due to accumulate the deposits on the lagoon bottom.

2.3. The coastal plain unit

The Nile Delta coastal plain wasted by erosion more than 30.86 km2 between 1925 and 2001, most of these areas lies in the western sides of The Rosetta and Damietta promontories. The average of erosion increased from 91.4 during the period (from1925 to1984) to130.8 acres/yr during the modern period (1984-2001) as a result of storage the Nile water in Lake Nasser. In the other hand the coastal plain extended by accretion processes not more than 24.43 km2 from 1925 to 2001, and the average reduce from 93.7 acres/yr before 1984 to less than 30 acres/yr (Tab.3).

Morphological changes of the Nile Delta coastline sectors from 1925 to 2001 (in Acres)

Table 3

Sectors	**Erosion**		**Accretion**	
	1925-1984	1984-2001	1925-1984	1984-2001
Rosetta mouth	2952	1682	-	-
East of Rosetta mouth	-	-	1381	270
East of El Burullus lagoon	-	-	1338	152
West of El Burullus lagoon	-	-	1126	-
Damietta mouth	2450	541	-	-
West of Damietta mouth	-	-	1572	-
Separated areas	-	-	114	83
Sub total	5402	2223	5531	505
Annual rate	91.6	130.8	93.7	29.7
Total	**7625 Acre= 30.86 k.m.2**		**6036 Acre= 24.43 k.m.2**	

The coastline has been divided into 7 sectors from west to east (Fig. 5), witch show morphological changes of coastline between 1984 and 2001. The Nile Delta coastline is generally convex shape in three promontories at The Rosetta mouth, Burullus lagoon neck and The Damietta mouth, they separated with two concave wide bays, as a result of action of the NW prevailing wind, and W/E longshore currents effects, the eastern sides of these promontories are retrograded by coastal erosion, but accretion took place to the outer eastern sides of these promontories and bays.

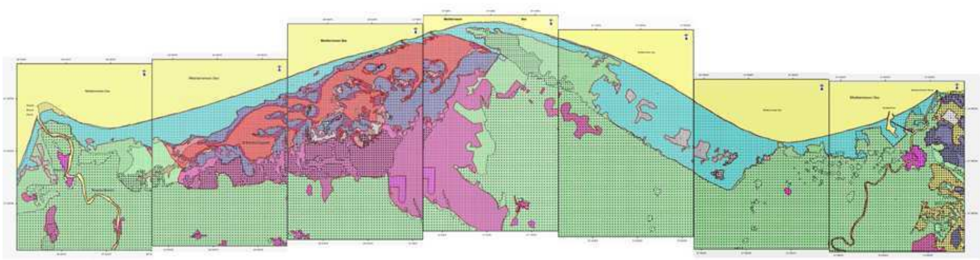

Fig.6. ***Morphological changes of the Nile Delta coastline between 1984-2001***

2.4. Grain Size analysis

14 beach samples were collected for grain size analysis, nine samples got from erosional beaches and five samples collected from accretional beaches. The statistical data (Fig. 7 & 8 and Tab.4) shows that most of the study area beaches are composed from coarse to very fine sand, but erosional beaches are contained more finer grains than accretional beaches, because the dynamic processes can transport fine grains more easy than coarse grains.

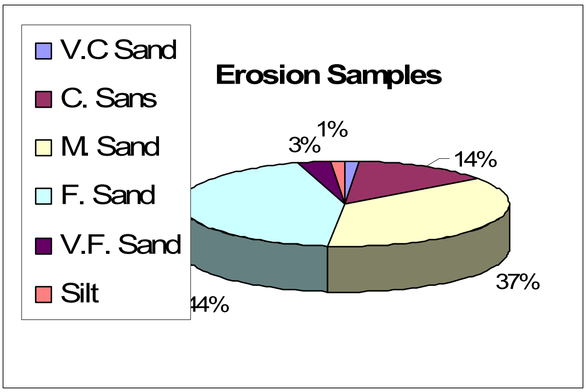

Fig.7. ***Size fraction of erosional beach samples***

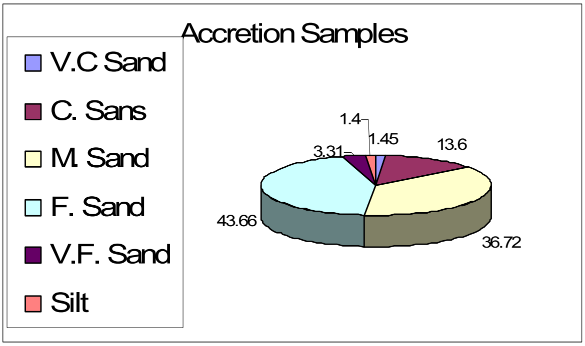

Fig.8. ***Size fraction of accretional beach samples***

Statistical characteristics of the sediments

Table 4

Beach type	Sample No.	Weight % of fractions					
		V.C. Sand	C. Sans	M. Sand	F. Sand	V.F. Sand	Silt
		-1:0	0:1	1:2	2:3	3:4	>4 Φ
Erosion	1	0.21	1.92	8.67	74.88	13.53	0.79
	4	0.19	3.63	14.15	69.52	11.93	0.58
	5	0.24	4.22	12.75	69.35	12.85	0.59
	6	0.28	3.95	13.94	66.52	14.83	0.48
	7	0.36	3.48	13.17	68.94	13.63	0.42
	8	0.25	3.21	12.28	66.99	16.74	0.53
	9	0.31	3.07	13.43	66.84	15.84	0.51
	10	0.21	2.86	14.53	68.19	13.67	0.54
	14	0.28	3.75	13.85	67.23	14.38	0.51
Average		**0.26**	**3.34**	**12.97**	**68.72**	**14.15**	**0.55**
Accretion	2	0.79	14.52	39.31	41.68	2.52	1.18
	3	1.38	13.84	35.83	44.52	3.17	1.26
	11	1.53	12.73	34.58	46.15	3.29	1.72
	12	1.72	13.17	36.37	42,98	4.17	1.59
	13	1.83	13.73	37.51	42.30	3.39	1.24
Average		**1.45**	**13.60**	**36.72**	**43.66**	**3.31**	**1.40**

3. CONCLUSIONS

The Nile Delta coast was determined by comparing satellite images and historical charts with present-day conditions. The analyses identify into two patterns: erosion and accretion shorelines. These two patterns are influenced by transport processes, including sediment provenance from different sources: eroded Nile delta coast, relict sediments from the former Nile tributaries and mouths, and sediment supply by land valleys and from wind-blown sand.

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THE USE OF GEOTOOLS LIBRARY IN DEVELOPING WEB GIS DASHBOARDS FOR PRESSURE SENSORS

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ABSTRACT

The purpose of this paper is to present a real life use of GeoTools library (the library used to build the open source GeoServer). We used GeoTools to develop web GIS software needed to display pressure sensors as points on a map and the values associated with them.

Keywords: *GIS, Open source GIS, Web GIS, GeoTools, Web sensor dashboard.*

*

1. INTRODUCTION

The purpose of the project was to build a web GIS dashboard to display water pressure sensors / values, in the city of Baia Mare. Pressure sensors dashboards had and still have a great need in businesses like water management, natural gas distribution and other. Our project was developed for S.C. VITAL S.A which is the company that manages and monitors the water distribution system. S.C.VITAL S.A. has a commitment to provide customers with a minimum level of pressure and they were thinking to increase the number of pressure sensors throughout the water system and they faced the following questions:

What kind of sensors should we use?

Should we use the same (old) architecture for pressure sensors?

Who are the users/employees for the new dashboard? Do we need to show the dashboard to other users/employees?

As result they decided to run the software on the internal network (Intranet) of the company and add GIS capabilities to it.

To do our data acquisition we came up with the same idea like the one used in the MIT – ORCA Project (http://web.mit.edu/orca/www/). We used a pressure transducer with a built in amplifier and the signal is A/D converted using a microcontroller, which then transmits the value to a database through a private network.

The idea for a web GIS monitoring system is not new but it suits well our needs and in the context of our community it's a new one (from our knowledge S.C. VITAL S.A. is the first company to implement something like this in our community). Probably in a few years new idea will emerge and will make this one old, but till then it's is the right approach from our perspective.

As we mentioned in our title, we used GeoTools library/toolkit to build our GIS component. The same GeoTools library is used in UDIG application (http://udig.refractions.net),

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NOAA/NCDC Java NEXRAD Viewer (http://www.ncdc.noaa.gov/oa/radar/jnx/), Balloon - Transports in Catalonia and other. GIS applications on the water resources were realized, for Romanian territory, by Oneci N. (2006) or Pancescu M. (2006).

2. WHAT WE USED

Main components of the project were:

– Amber WS 128 board was used to acquire data from the pressure sensors.

– **MySQL** database server used to store the data

– **GeoTools** "*is an open source (LGPL) Java code library which provides standards compliant methods for the manipulation of geospatial data, for example to implement Geographic Information Systems (GIS). The **GeoTools** library implements Open Geospatial Consortium (OGC) specifications as they are developed, in close collaboration with the GeoAPI and GeoWidgets projects*" (www.geotools.org).We used the library to build a small and light geo server.

Note: **GeoTools** is the library used to develop **GeoServer**.

– **OpenLayer** "*is a pure JavaScript library for displaying map data in most modern web browsers, with no server-side dependencies*" (www.openlayers.org).

– Geospatial vector data (SHP files) containing the city streets and limits.

– Custom made web application to integrate all the components presented above.

At this moment we will make a note. The pressure sensors position on the map is kept in the **MySQL** database and can be modified by the users with the appropriate rights. The stored data is used to dynamically create a layer in the web map.

2.1. Capabilities of Geotools Library

Because "data is the blood of any GIS project", GeoTools tries to support the following data formats:

DataStore (vector data)

- Shapefile - an ESRI shapefile (R/W)
- GML - Geography Markup Language (R)
- WFS - Features from an OGC Web Feature Server (RW)
- PostGIS - geometric objects for PostgreSQL (R)
- Oracle Spatial - Oracle's extension for spatial data (R)
- ArcSDE - ESRI's middleware for spatial databases (R)
- MySQL - support for the new geometry types
- GeoMedia - an Intergraph format (R)
- Tiger - Topologically Integrated Geographic Encoding and Referencing developed at the US Census Bureau (R)
- VPF - Vector Product Format, a data interchange format (R) (**work in progress**)
- MapInfo - MIF (Mapinfo Interchange Format) (RW) (**work in progress**)

Grid coverage (raster)

- ArcGrid - ArcInfo ASCII Grid format and GRASS ASCII Grid format (optionally compressed) (R/W)
- Image - can load images georeferenced with a world file (R/W)
- GeoTIFF - a georeferenced tiff image (R) (**work in progress**)
- WMS - OGC Web Mapping Server client (R) (**work in progress**)

3. HOW WE GOT HERE

S.C. VITAL S.A. had an older monitoring system that was built using a non GIS approach. In these days due to increasing computer power and the existence of open source GIS tools, a GIS approach was seen as being the right path to follow.

They had 2 options:

1. Buy a "of the shelf product".
2. Build a custom made solution.

The option to buy a commercial GIS system wasn't in the price range the company was able to pay, so they decided for the second one. With these in mind we came out with a solution that uses open source GIS tools and minimize the costs. We will not insist on what is open source GIS, what are its benefits and downsizes, because we fill it's much more important to present how we developed the software system.

With this paper we don't want to minimize in any way the importance of commercial GIS systems but to present what can be done using open source GIS tools.

GIS tools are a better way to display information because is closer to what people are used to deal with. In our case the users knows the streets where the pressure sensors are located. Having a complete view of the system and how the pressure sensors function they can make better decisions regarding their work.

The web approach came as an answer to the question "How to present the same dashboard to different users with different rights in different places?" This approach answered the above question because having an intranet application with GIS capabilities the users can be virtually anywhere in the world (by using VPN connections someone who is outside VITAL's internal network can connect and be part of it).

We thought is important to keep the backward compatibility of the system, so we also added in the application a non GIS pressure sensors dashboard (fig. 1).

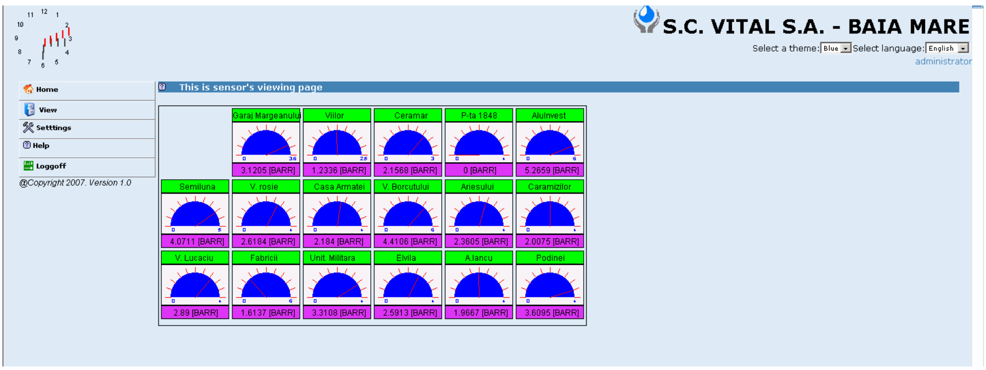

Fig. 1. ***[non GIS sensor dashboard]***

4. THE SOFTWARE

In this section we will present how the software is built and how it works.

The first step is to present the layout of the system (Fig. 2).

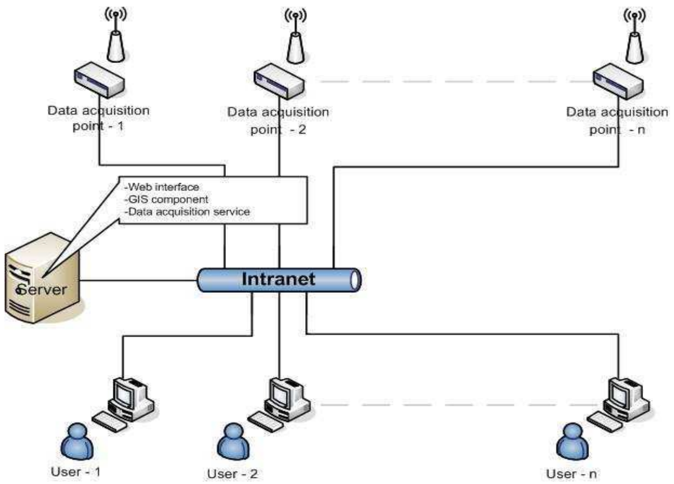

Fig. 2. ***[System layout]***

The main components are:

- **Acquisition systems –** which are designed to be able to measure pressure and return that information when asked. These acquisition systems work as independent systems and also run a small web server
- **Server service –** designed to question the acquisition systems for pressure values and store that information into a MySQL database. Fig. 3 and 4 presents how this component questions an acquisition system to get the data.

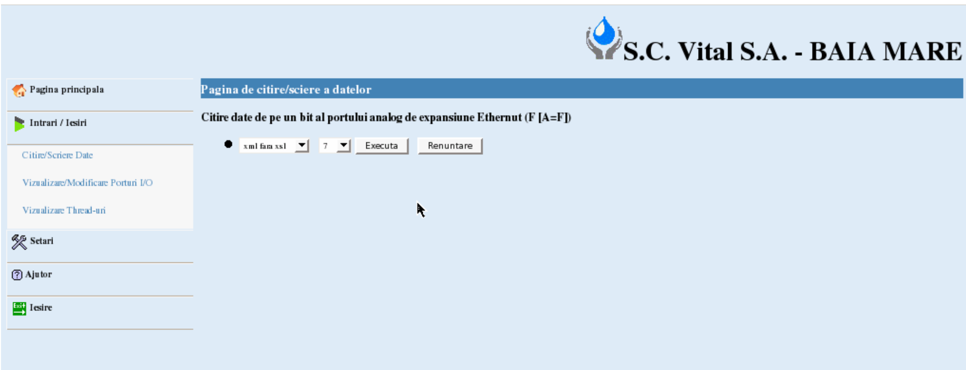

Fig. 3. ***[Data acquisition – the preliminary page for getting the pressure value]***

- **MySQL database –** which purpose is to store information.
- **GIS component –** is a library built on top of GeoTools to generate images from the vector or raster data (in our case just from vector data)
- **OpenLayer –** a JavaScript component used to display the map on the web browser.
- **VITAL application** – is the actual web software that links the GIS component, MySQL database and the users.

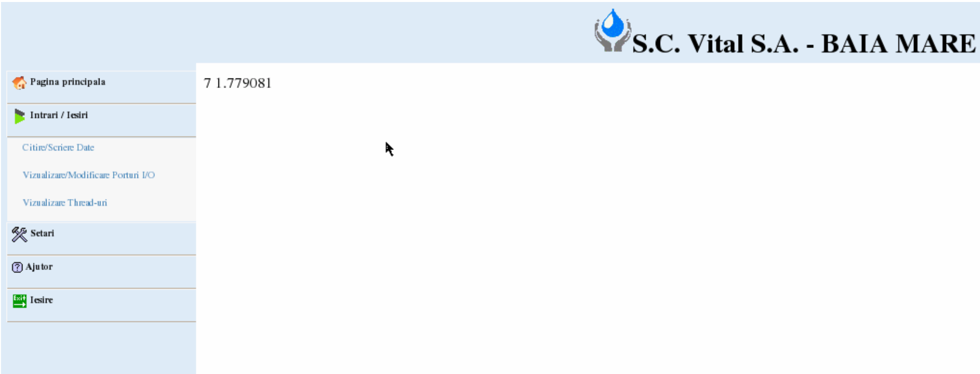

Fig. 4. ***[Data acquisition – the pressure value]***

4.1. How it works.

The users connect to the web interface through a login page (fig. 5).

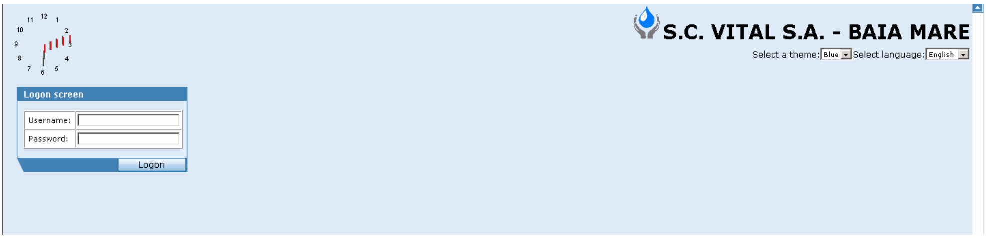

Fig. 5. ***[Login Page]***

Each user has associated rights, so some users can add information about pressure sensors and other can view information.

Once a user is connected into the application has three options (fig. 6).

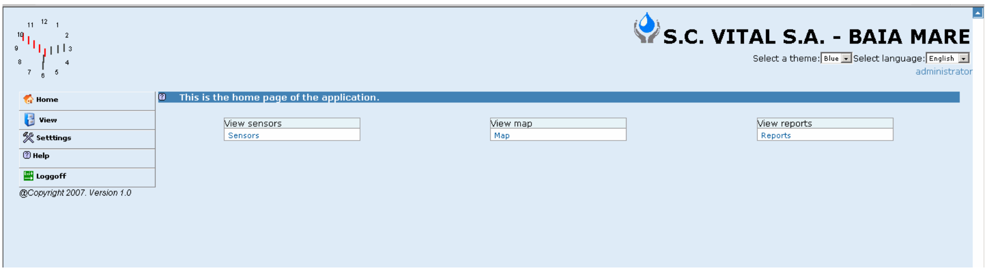

Fig. 6. ***[Home/Main page]***

The three options are:

1. View sensors – which are the old non GIS approach.
2. View map – which is the new GIS approach (fig. 7).
3. View reports – used to query the database about information.

Of course, down the road, some other options could be added here.

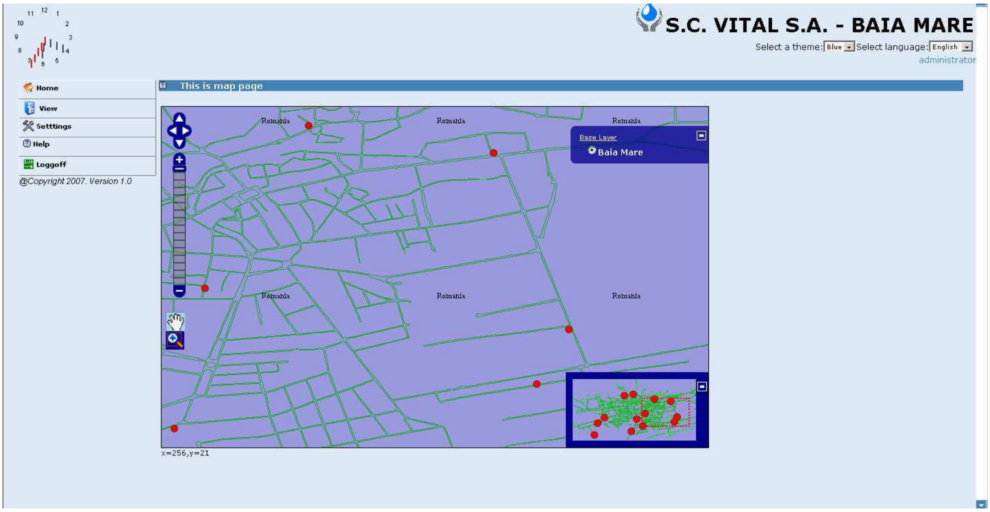

Fig. 7. ***[Map – GIS approach]***

One GIS query developed at this stage of the project is the following (fig. 8): when a user clicks a pressure point on the map a gauge will appear on the right side of the page. An improvement of the system, which is due for another stage, is to have the ability to display those gauges right on the map and the users are not gone have to click (unless they want detailed information about that pressure point).

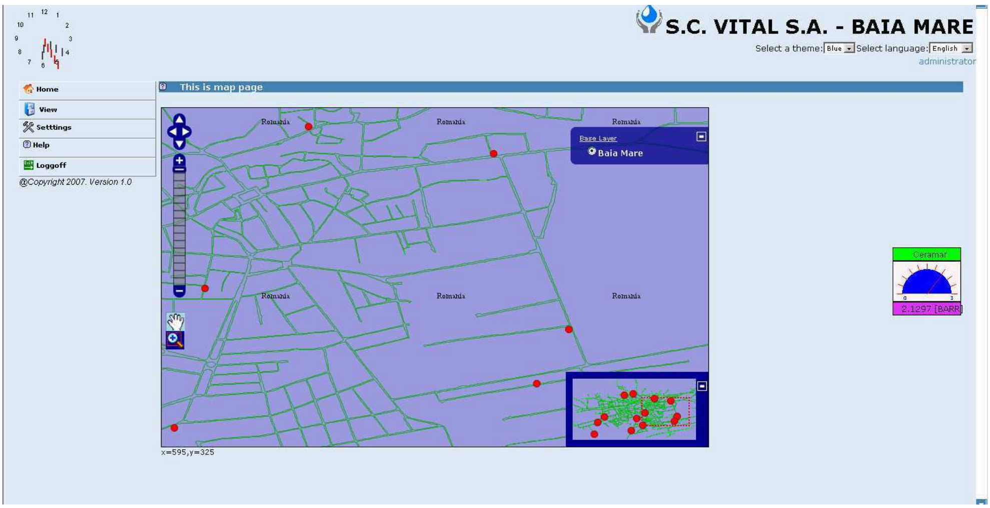

Fig. 8. ***[Map – GIS approach / gauge view]***

5. CONCLUSIONS AND FUTURE DEVELOPMENT

We think that a GIS approach for water pressure monitoring will bring ease in system exploitation because people tend to respond better to images. A downsize for a GIS approach is:

- better servers/computers to keep and deliver the GIS data
- possibly expensive GIS software
- having the data

Our solution tried to answer to some of the above questions and other. The first issue is answer by the fact that every day servers/computers became cheaper and cheaper. The second one is answer by open source GIS. The third one is a tricky one because depends on the company will (the managers to understand the need) to have that data. We answered to some other issues like:

- Can some users/employees see the pressures from outside company's premises? – we used the web approach, which allows users from outside to connect to internal network through a VPN connection.
- Can we restrict data based on user's roles?
- Can we change the position of one sensor on the map?
- Reporting – the software allows the appropriate users to see historical data for pressures sensors and compare that data in an ease to read format (graphics – fig. 9). These graphics will help in making every day decisions as well as for possible company developments.

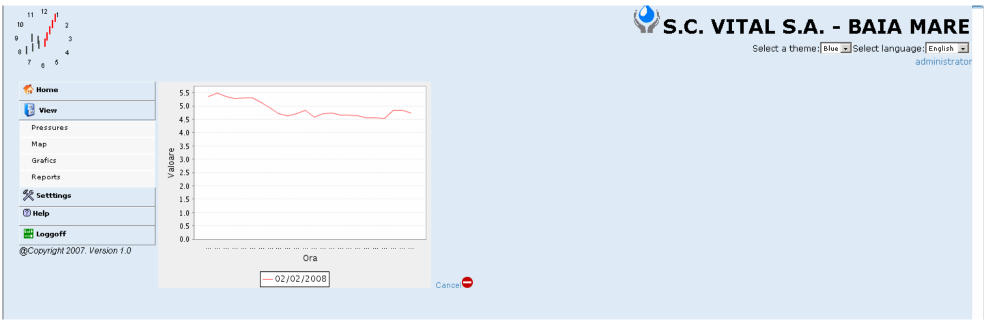

Fig. 9. *[Graphic for a pressure sensor]*

As we know in almost any field there is room for improvement and our field is not an exception, so we are aware of the possible improvements. One of those improvements could be dictated by the fact that S.C. VITAL S.A. is in expansion and will become a regional company with multiple local branches. A future development would be to have distributed systems which cooperate to present a unified GIS, but this approach raise some other issues and benefits that will not be discussed in this paper.

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LAND AND SOIL RESOURCES OF LOUISIANA, USA

D.C. Weindorf[1]

ABSTRACT

For years, researchers have used county or parish soil surveys when conducting fieldwork and research. Such surveys provided researchers with quick, easily accessible information (chemical, physical, taxonomic) in the field. The classification of soils has profound impacts on a variety of soil properties from land use to agronomic productivity. While initial soil survey work in Louisiana is complete, the inventory of soils in Louisiana is dynamic and subject to temporal change. The soil survey staff continues to produce soil series updates and continually works to update soil maps in response to changing land use and concepts of soil survey. For example, soil surveys were published for years on an individual parish basis. Yet such political boundaries do not conform to natural soil or land use patterns. As such, parish soil surveys often resulted in fragmentation of soils data along artificial (political) boundaries. Today, much greater emphasis is placed on mapping soils across parish boundaries using the concept of major land resource areas (MLRAs).

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1. GENERAL OCCURRENCE AND FEATURES

Louisiana consists of 112,822 km^2 (US Census Bureau, 2000) extending from the gulf coast inland some 610 km. Elevation of the state ranges from 163 m (Driskill Mountain – Bienville Parish) to -2 m (New Orleans)(US Geological Survey, 2008). The state is dissected by numerous river systems, most notably the Mississippi River, Red River and Ouachita River (ATLAS, 2008). These rivers have historically provided a major source of alluvial sediment to the state. Geology of Louisiana consists largely of Pleistocene terraces and Holocene alluvium associated with the major rivers (Figure 1). As flooding has been controlled through a series of dams, levees, etc., new sources of sediment deposition have been cut off and have contributed to subsidence, particularly along the coastline.

The climate of Louisiana is moist and subtropical. Average annual temperatures range from 63°F (17°C) in the northern part of the state to 71°F (22°C) along parts of the coast (Figure 2)(Soil Survey Staff, 2008a). Average annual rainfall ranges from 47 inches (119 cm) in the northwestern part of the state, to 71 inches (180 cm) in isolated areas north of Lake Ponchartrain (Figure 3)(Soil Survey Staff, 2008a). In the winter months, cold fronts advancing from north to south can cause sharp drops in temperatures, to include freezing temperatures throughout much of the state.

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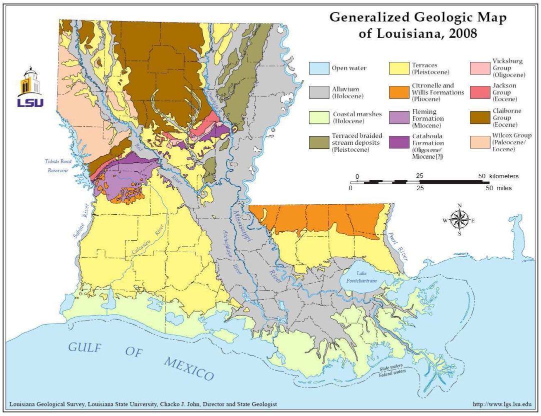

Fig. ***1 Generalized geologic map of Louisiana (Louisiana Geological Survey, 2008)***

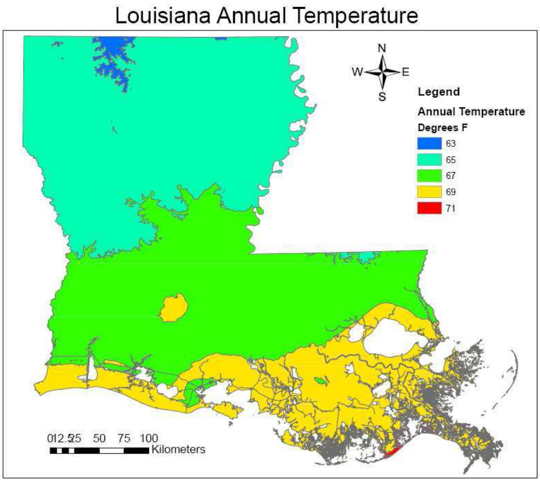

Fig. 2 ***Louisiana annua temperatures (Soil Survey Staff, 2008a)***

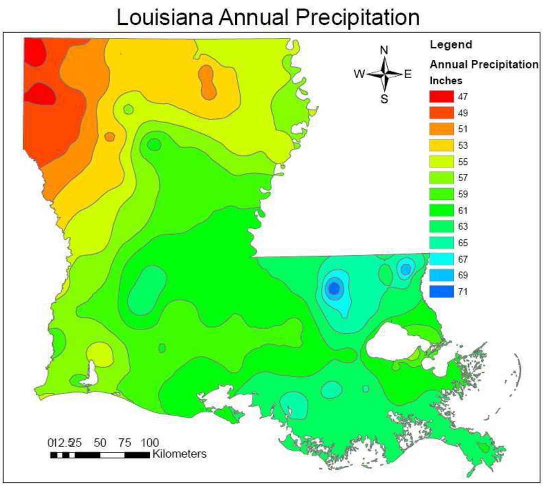

Fig. 3 ***Louisiana annual precipitation (Soil Survey Staff, 2008a).***

2. MAJOR LAND RESOURCE AREAS (MLRAS)

A previous guide to classification of soils in Louisiana (Amacher et al., 1989) cited work by Lytle (1968) and Lytle and Sturgis (1962) in defining six major soil areas in Louisiana: coastal plain, flatwoods, coastal prairie, loess hills, recent alluvium and coastal marsh. While these associations remain generally valid, they have been more precisely defined and differentiated by the Soil Survey Staff (2006) into eleven major land resource areas (MLRAs)(Figure 4). It should be noted that the following descriptions and interpretations describe the entire MLRA area, some of which exist beyond the border of Louisiana. The Soil Survey Staff (2006) define the MLRAs of Louisiana as follows:

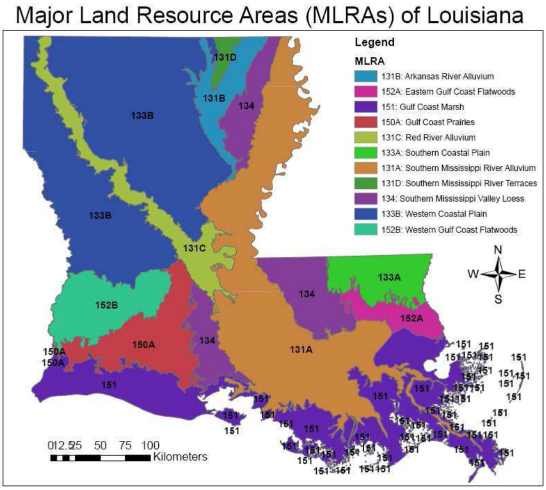

Fig 4. ***Major land resource areas of Louisiana (Soil Survey Staff, 2008a)***

131B – Arkansas River Alluvium

Louisiana constitutes 33 percent of this MLRA to include the town of Monroe, LA. Parts of Interstate 20 fall within this MLRA.

Physiography

This area is in the Mississippi Alluvial Plain Section of the Coastal Plain Province of the Atlantic Plain. It is on the alluvial plains along the lower Arkansas River in Arkansas and the Ouachita River in Louisiana and Arkansas. The landforms in the area are level or depressional to very gently undulating alluvial plains, backswamps, oxbows, natural levees, and terraces. Landform shapes range from convex on natural levees and undulating terraces to concave in oxbows. Landform shapes differentiate water-shedding positions from water receiving positions, both of which affect soil formation and hydrology. Average elevations start at about 50 feet (15 meters) in the southern part of the area and gradually rise to about 250 feet (75 meters) in the northwestern part. Maximum local relief is about 10 feet (3 meters), but relief is considerably lower in most of the area.

Geology

Bedrock in this area consists of Tertiary and Cretaceous sands formed as beach deposits during the retreat of the Cretaceous ocean from the midsection of the U.S. Alluvial deposits from flooding and lateral migration of the Arkansas and Ouachita Rivers typically lie above the bedrock. These sediments are sandy to clayey fluvial deposits of Holocene to late Pleistocene age and are many meters thick. The geologic surfaces are identified as the Arkansas Lowlands, which extend from the Yazoo Basin up the Arkansas River to the margin of the Coastal Plain, and the parts of the Tensas Basin west of Macon Ridge. The deposits on both of these surfaces are of Holocene age. In some areas late Pleistocene terrace deposits are within several meters of the present surfaces, but they do not crop out in the MLRA.

Soils

The dominant soil orders in this MLRA are Vertisols, Alfisols, Inceptisols, and Entisols. The soils in the area have a thermic soil temperature regime. They dominantly have an aquic soil moisture regime, smectitic clay mineralogy, and mixed sand and silt fraction mineralogy. They are very deep and generally are poorly drained to well drained and loamy or clayey. Nearly level Epiaquerts (Perry series), Vertic Hapludolls (Desha series), and Vertic Epiaquepts (Portland series) dominate the Holocene-age alluvial flats and backswamps. Nearly level to gently sloping Eutrudepts (Coushatta series), Udifluvents (Roxana series), and Vertic Epiaquepts (Latanier series) dominate the recent Holocene-age natural levees. Nearly level to gently undulating, sandy Udifluvents (Bruno series) and Udipsamments (Crevasse series) dominate the recent Holoceneage levee splays and point bars. Nearly level to gently undulating Epiaqualfs (Hebert series), Hapludalfs (Rilla and Sterlington series), and Argiudolls (Caspiana series) dominate the Holocene-age natural levees along the older meander scars.

Biological Resources

This area once consisted entirely of bottom-land hardwood deciduous forest and mixed hardwood and cypress swamps. The major tree species in the native plant communities in the areas of bottom-land hardwoods formerly were and currently are water oak, Nuttall oak, cherrybark oak, native pecan, red maple, sweetgum, eastern cottonwood, and hickory. The major tree species in the native plant communities in the swamps formerly were and currently are cypress, water tupelo, water oak, green ash, red maple, and black willow. The important native understory species are palmetto, greenbrier, wild grape, and poison ivy in the areas of bottom-land hardwoods and buttonbush, lizardtail, waterlily, water hyacinth, sedges, and rushes in the swamps. Some of the major wildlife species in this area are whitetailed deer, feral hogs, red fox, coyote, rabbit, gray squirrel, American alligator, water turtles, water snakes, frogs, otters, beavers, armadillo, crawfish, wild turkey, mourning doves, ducks, and geese. Fishing is mainly in oxbow lakes, rivers, and bayous. The species of fish in the area include largemouth bass, smallmouth bass, catfish, drum, bluegill, gar, and yellow perch.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 70%
Grassland – private, 2%
Forest – private, 22%; Federal, 1%
Urban development – private, 1%
Water – private, 3%
Other – private, 1%

Farms and scattered tracts of forested wetlands make up nearly all of this area. The farms produce mainly cash crops. Cotton, soybeans, milo, and corn are the main crops. In many areas furrow irrigation is used during droughty parts of the growing season. Throughout the area, catfish are produced commercially on farm ponds that are contained by levees. Migratory waterfowl are harvested throughout the area. Hardwood timber is harvested on some forested wetlands, and most forested areas are managed for wildlife. About 15 percent of this MLRA is not protected from flooding, and flooding occurs occasionally or frequently in these unprotected areas. Levees protect nearly all of the cropland from flooding. Most of the forested wetlands are not protected from flooding. Networks of drainage canals and ditches help to remove excess surface water from the cropland. The major resource concerns are control of surface water, management of soil moisture, and maintenance of the content of organic matter and productivity of the soils. Conservation practices on cropland generally include nutrient management, crop residue management, and alternative tillage systems, especially no-till systems. In many areas land leveling or shaping optimizes the control of surface water. Other major cropland management practices are control of competing vegetation and insects through aerial or ground spraying of herbicides and insecticides and fertility management programs that make use of chemical fertilizers.

152A – Eastern Gulf Coast Flatwoods

Louisiana constitutes 8 percent of this MLRA and Hammond and Covington, LA. A number of national wildlife refuges, state parks and a few state forests are found in this MLRA.

Physiography

Almost all of this area is in the East Gulf Coastal Plain Section of the Coastal Plain Province of the Atlantic Plain. This MLRA is a nearly level, low coastal plain crossed by many large streams. Elevation ranges from sea level to 80 feet (0 to 25 meters). Local relief is generally 10 to 20 feet (3 to 6 meters).

Geology

Pleistocene-age terraces consisting of ancient Mississippi River deposits of unconsolidated fine sand, which grades to coarser sand and gravel at depth, are at the surface in the western end of this area in Louisiana. Recent silt, sand, and gravel deposits fill the valleys along most of the major rivers in the area.

Soils

The dominant soil orders in this MLRA are Alfisols, Ultisols, Entisols, Spodosols, and Histosols. The soils in the area dominantly have a thermic or hyperthermic soil temperature regime, an aquic or udic soil moisture regime, and siliceous mineralogy. They generally are deep or very deep; are somewhat poorly drained to very poorly drained; and are loamy, mucky, or sandy. Alaquods (Chaires and Leon series) and Psammaquents (Scranton series) formed in sandy marine sediments on flats and in depressions. Haplosaprists formed in organic deposits in swamps and depressions (Dorovan and Pamlico series) and in marshes and swamps (Lafitte and Maurepas series). Sulfihemists (Handsboro series) and Sulfaquents (Axis series) formed in saltwater and brackish water marshes. Quartzipsamments (Newhan and Corolla series) and Psammaquents (Duckston series) formed on dunes and in interdunal swales on barrier islands. Glossaqualfs (Guyton series) and Hydraquents (Arat and Levy series) formed in alluvium on flood plains. Endoaqualfs (Meadowbrook and Wekiva series) and Albaqualfs (Tooles series) formed in loamy marine sediments on flats and flood plains and in depressions. Endoaquults (Myatt series) and Paleudults (Stough series) formed in mixed fluvial and marine sediments on flats and stream terraces. Paleaquults (Plummer and

Bayou series) and Paleudults (Escambia and Ocilla series) formed in loamy and sandy sediments on marine terraces.

Biological Resources

This area supports pine forest vegetation and freshwater, brackish water, and saltwater marsh vegetation. Longleaf pine and slash pine are the major trees. Chalky bluestem, Indiangrass, and several species of panicum make up the understory. Palmetto, gallberry, and waxmyrtle are the dominant woody shrubs. Roseau, common reed, bulltongue, maidencane, cutgrass, and alligatorweed characterize the freshwater and intermediate water vegetation. Marshhay cordgrass, saltgrass, and Olney bulrush characterize the brackish water vegetation. Saltgrass, marshhay cordgrass, smooth cordgrass, and black needlerush are included in the saltwater vegetation. Some of the major wildlife species in this area are whitetailed deer, feral hog, gray fox, red fox, bobcat, raccoon, skunk, opossum, otter, rabbit, squirrel, turkey, bobwhite quail, and mourning dove. The species of fish in the area include largemouth bass, channel catfish, bullhead catfish, bluegill, redear sunfish, spotted sunfish, warmouth, black crappie, chain pickerel, gar, bowfin, sucker, spotted trout, croaker, striped mullet, flounder, and red drum.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 1.3%
Grassland – private, 1.9%
Forest – private, 55.6%; Federal, 11.5%
Urban development – private, 10.4%
Water – private, 12.0%; Federal, 3.0%
Other – private, 4.3%

Very little of this dominantly forested area is in farms. Much of it is in large holdings owned by pulp and paper companies. Pulpwood and lumber are the principal forest products. Some of the forestland is grazed. Some areas are in State and national forests or are used as game refuges or as military training sites. Only a very small acreage is cropped or pastured. Corn, peanuts, tobacco, and soybeans are the major crops. The major soil resource concerns are water erosion, maintenance of the content of organic matter and productivity of the soils, surface compaction, and management of soil moisture. Conservation practices on forestland generally include forest stand improvement, forest trails and landings, prescribed burning, riparian forest buffers, forest site preparation, bedding, establishment of trees and shrubs, and management of upland wildlife habitat. The most important conservation practice on pasture is prescribed grazing. Overseeding of pastures with small grains and/or legumes during winter commonly supplements forage production. Haying also provides additional feed during the long winters. Conservation practices on cropland generally include systems of crop residue management, cover crops, crop rotations, water disposal, subsoiling or deep tillage, pest management, and nutrient management. Critically eroding areas and areas where animals congregate must be monitored regularly and treated promptly.

151 – Gulf Coast Marsh

Louisiana constitutes 95 percent of this MLRA including the towns of Gretna, Chalmette, Marrero and New Orleans, LA. Interstate 10 and U.S. Highway 90 cross the area. The New Orleans Naval Air Station is in this MLRA. A number of national wildlife refuges and State parks occur throughout this area.

Physiography

Vermilion Bay splits this area into an eastern half and a western half. The eastern half is in the Mississippi Alluvial Plain Section of the Coastal Plain Province of the Atlantic Plain. The western half is in the West Gulf Coastal Plain Section of the same province and division. The land east of Vermilion Bay, part of the Mississippi River Delta, has a ragged shoreline. The land west of Vermilion Bay has a smoother shoreline. Low, narrow sandy ridges characterize much of the area. There are many rivers, lakes, bayous, tidal channels, and manmade canals. Elevation generally ranges from sea level to about 7 feet (2 meters). It is as much as 10 feet (3 meters) on beach ridges, canal spoil banks, and natural levees and as much as 165 feet (50 meters) on salt dome islands. Some areas that are protected by levees have subsided below sea level.

Geology

The surface of this area is primarily Mississippi River clay, silt, and fine sand deposited over the past 2 million years. The eastern half of the area, part of the Mississippi River Delta, is underlain by a mixture of Recent alluvial material and Pleistocene-age marine sediments. The area west of Vermilion Bay is underlain by older alluvial and marine sediments. Salt domes, natural gas, and petroleum deposits are below the surface in this area.

Soils

The dominant soil orders in this MLRA are Entisols and Histosols. The soils in the area dominantly have a hyperthermic soil temperature regime, an aquic soil moisture regime, and smectitic mineralogy. They generally are very deep, very poorly drained, and clayey. Hydraquents (Bancker, Creole, Larose, and Scatlake series) formed in clayey sediments in coastal marshes. Haplosaprists formed in organic deposits over alluvium (Allemands, Clovelly, and Lafitte series) or entirely in organic deposits (Kenner and Timbalier series).

Biological Resources

This area supports freshwater and saltwater marsh vegetation consisting of grasses, sedges, rushes, and other plants. Alligatorweed, spikerush, maidencane, cutgrass, and bulltongue characterize the freshwater vegetation. Roseau, common reed, bulltongue, and marshhay cordgrass characterize the intermediate water vegetation. Marshhay cordgrass, saltgrass, and Olney bulrush characterize the brackish water vegetation. Saltgrass, marshhay cordgrass, smooth cordgrass, and black needlerush are included in the saltwater vegetation. Some of the major wildlife species in this area are whitetailed deer, alligator, nutria, raccoon, otter, muskrat, swamp rabbit, cottontail rabbit, mink, mottled duck, bobwhite quail, mourning dove, meadowlark, lark bunting, and crawfish.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 16%
Grassland – private, 6%
Forest – private, 8%
Urban development – private, 3%
Water – private, 33%
Other – private, 30%; Federal, 4%

Most of this area supports marsh vegetation and is used for wildlife habitat. The area is almost treeless. Much of the area is uninhabited. The area is in the fertile and productive estuarine complex that supports the marine life of the Gulf of Mexico. The area provides wintering ground for millions of migratory ducks and geese and habitat for many fur-bearing animals and for alligators. A significant acreage west of Vermilion Bay is firm enough to support livestock and is grazed by cattle in winter. A small acreage of freshwater marsh is drained by pumping systems and is used for pasture or for rice. The major resource concerns are determined by land use and marsh type. Flooding is a major concern in New Orleans. The concerns in areas of native marsh include maintenance of the salinity level in the soils, ingress and egress of freshwater or saltwater, and the content of organic matter in the soils. The concerns on pasture and cropland include maintenance of the content of organic matter and control of the salinity level in the soils. Erosion caused by overland water from high rainfall or a storm surge in the Gulf is a concern in areas where the native vegetation has been altered. Conservation practices on cropland include systems of crop residue management, which help to control erosion and maintain the content of organic matter in the soils. Timely tillage and planting can help to maintain tilth and the supply of soil moisture and control salinity. The practices on pasture include prescribed grazing, brush and pest management, prescribed burning, and watering facilities. Management of upland and wetland wildlife habitat is needed.

150A – Gulf Coast Prairies

Louisiana constitutes 17 percent of this MLRA to include the towns of Crowley, Eunice, and Lake Charles, LA. Interstate 10 and highways 90 and 190 are in the eastern part, in Louisiana.

Physiography

This area is in the West Gulf Coastal Plain Section of the Coastal Plain Province of the Atlantic Plain. It is characterized by nearly level plains that have low local relief and are dissected by rivers and streams that flow toward the Gulf of Mexico. Elevation ranges from sea level to about 165 feet (0 to 50 meters) along the interior margin.

Geology

This area is mostly a strip of land that is about 50 to 80 miles (80 to 130 kilometers) wide and runs along the Gulf of Mexico. The sedimentary rocks at the surface are of Pleistocene age. They were laid down during the last 2 million years. The deposits are deltaic and lagoonal clays and loams derived from older rocks to the west. At the western edge of this area, mostly within Texas, the sediments are older and more weathered and contain more sands. At the eastern edge, mostly within Louisiana, a cap of mixed loess and alluvium occurs on most soils. The loess was derived from the flood plain along the Mississippi River. Some Tertiary deposits occur along the interior edge of this MLRA. The weight of the recent deposits has caused them to tilt towards the Gulf of Mexico, so successively older deposits crop out from the coastal edge to the interior edge of the area. Salt domes, natural gas, and petroleum deposits are commonly below the surface throughout this area. Recent deposits of alluvial sand fill the valleys of the Brazos and Trinity Rivers and the other large rivers in the area.

Soils

The dominant soil orders in this MLRA are Alfisols, Mollisols, and Vertisols. The soils have a hyperthermic soil temperature regime in the southwestern part of the area and a thermic soil temperature regime in the northeastern part. The soils in the MLRA generally have an ustic soil moisture regime and smectitic mineralogy. Drainage ranges from well drained in very gently sloping and gently sloping soils in convex areas to very poorly drained in soils in enclosed depressions. Soils that formed in early Pleistocene sediments, generally occurring north of Interstate 10, are very deep and have a loamy surface layer and subsoil and siliceous mineralogy. Soils that formed in late Pleistocene sediments, generally occurring south of Interstate 10, are very deep and have a loamy or clayey surface layer and a clayey, very slowly permeable subsoil. Aqualfs and Udalfs (Crowley, Aris, and Vidrine series) are dominant in Louisiana. Uderts and Udalfs (League, Lake Charles, Laewest, Hockley, Katy, and Telferner series) are dominant in the eastern and central parts of the area. Usterts and Ustolls (Banquete, Cranell, Orelia, and Victoria series) are dominant in the western and southwestern parts.

Biological Resources

This area was originally a natural grass prairie with hardwood trees along the rivers and streams. Little bluestem, Indiangrass, switchgrass, and big bluestem are the dominant species. A few groves of live oak dot the landscape. Some of the major wildlife species in this area are white tailed deer, raccoon, opossum, rabbit, fox, coyote, squirrel, armadillo, nutria, quail, and mourning dove. Migratory waterfowl, such as ducks and geese, and neotropical migratory songbirds winter in this area. The species of fish in the area include bass, channel catfish, and bream.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 32%
Grassland – private, 39%; Federal, 1%
Forest – private, 5%
Urban development – private, 16%
Water – private, 5%
Other – private, 2%

Most of this area is in farms. Rice, soybeans, grain sorghum, cotton, corn, and hay are the chief crops. About two-fifths of the area is rangeland or pasture. The forested areas, consisting chiefly of hardwoods, border the rivers and streams that cross the MLRA. Urban development is rapidly expanding onto agricultural land throughout the area.

The major soil resource concerns are wind erosion, water erosion, maintenance of the content of organic matter and tilth of the soils, and management of soil moisture. Increasing salinity is a problem in some areas. Conservation practices on cropland generally include systems of crop residue management, which help to control erosion and maintain the content of organic matter in the soils. Timely tillage and planting can help to maintain tilth and the supply of soil moisture. Conservation practices on pasture and rangeland generally include prescribed grazing, fences, watering facilities, and nutrient and pest management.

131C – Red River Alluvium

Louisiana constitutes 86 percent of this MLRA to include the eastern half of the city of Shreveport and the towns of Alexandria and Bossier City, LA. Interstate 20 crosses this area and intersects Interstate 49 in Shreveport. Small areas of the Kisatchie National Forest are along the southwest edge of this MLRA.

Physiography

Almost all of this area is in the West Gulf Coastal Plain Section of the Coastal Plain Province of the Atlantic Plain. The southern end is in the Mississippi Alluvial Plain Section of the same province and division. This MLRA is on the alluvial plain along the lower Red River in Louisiana. The landforms in the area are level or depressional to very gently undulating alluvial plains, backswamps, oxbows, natural levees, and terraces. Landform shapes range from convex on natural levees and undulating terraces to concave in oxbows.

Landform shapes differentiate water-shedding positions from water-receiving positions, both of which have a major effect on soil formation and hydrology. Average elevations start at about 40 feet (12 meters) in the southern part of the area and gradually rise to about 270 feet (80 meters) in the northwestern part. Maximum local relief is about 10 feet (3 meters), but relief is considerably lower in most of the area.

Geology

Bedrock in this area consists of Tertiary and Cretaceous sands formed as beach deposits during the retreat of the Cretaceous ocean from the midsection of the U.S. Alluvial deposits from flooding and lateral migration of the Red River typically lie above the bedrock. These sediments are sandy to clayey fluvial deposits of Holocene to late Pleistocene age and are many meters thick. In some areas late Pleistocene terrace deposits are within several meters of the present surfaces, but they do not crop out in this MLRA. The geologic history of the area is greatly influenced by a large logjam that formed in the Red River channel in the middle part of the area during the late 18th century and the early 19th century. At the time of its largest extent, the logjam obstructed the river and its tributary outlets for a distance of 160 miles downstream from the Arkansas State boundary. Backwater flooding, reformation of natural levees, and crevasse splays caused by this logjam played a major role in covering large parts of the area with a mantle of recent clayey to sandy material. Destruction of the logjam in the late 1800s resulted in the drainage of many large lakes that had formed.

Soils

The dominant soil orders in this MLRA are Vertisols, Entisols, Inceptisols, and Alfisols. The soils in the area have a thermic soil temperature regime. They dominantly have an aquic soil moisture regime, smectitic clay mineralogy, and mixed sand and silt fraction mineralogy. They are very deep and generally are poorly drained to moderately well drained and loamy or clayey. Nearly level Epiaquerts (Moreland series) and Vertic Endoaquepts (Yorktown series) dominate the Holoceneage alluvial flats and backswamps. Nearly level to gently sloping Endoaquepts (Coushatta series), Udifluvents (Severn and Roxana series), and Vertic Epiaquepts (Latanier series) dominate the Holocene-age natural levees. Nearly level to gently undulating, coarse-silty over clayey Udifluvents (Caplis series) and sandy Udifluvents (Kiomatia series) dominate the Holocene-age levee splays and point bars. Nearly level to gently undulating Hapludalfs (Gallion and Rilla series) and Argiudolls (Caspiana series) dominate the Holocene-age natural levees along the older meander scars.

Biological Resources

This area once consisted entirely of bottom-land hardwood deciduous forest and mixed hardwood and cypress swamps. The major tree species in the native plant communities in the areas of bottom-land hardwoods formerly were and currently are water oak, Nuttall oak, cherrybark oak, native pecan, red maple, sweetgum, eastern cottonwood, and hickory. The major tree species in the native plant communities in the swamps formerly were and currently are cypress, water tupelo, water oak, green ash, red maple, and black willow. The important native understory species are palmetto, greenbrier, wild grape, and poison ivy in the areas of bottom-land hardwoods and buttonbush, lizardtail, waterlily, water hyacinth, sedges, and rushes in the swamps. Some of the major wildlife species in this area are whitetailed deer, feral hogs, red fox, coyote, rabbit, gray squirrel, American alligator, water turtles, water snakes, frogs, otters, beavers, armadillo, crawfish, wild turkey, mourning doves, ducks, and geese. Fishing is mainly in oxbow lakes, rivers, and bayous. The species of fish in the area include largemouth bass, smallmouth bass, catfish, drum, bluegill, gar, and yellow perch.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 37%
Grassland – private, 20%
Forest – private, 30%; Federal, 1%
Urban development – private, 5%
Water – private, 5%
Other – private, 2%

Farms and scattered tracts of forested wetlands make up nearly all of this area. The farms produce mainly cash crops. Cotton, soybeans, milo, and corn are the main crops. Sugarcane is a major crop in the southernmost part of the area. In many areas furrow irrigation is used during droughty parts of the growing season. Throughout the area, catfish are produced commercially on farm ponds that are contained by levees. Migratory waterfowl are harvested throughout the area. Hardwood timber is harvested on some forested wetlands, and most forested areas are managed for wildlife. About 22 percent of this MLRA is not protected from flooding, and flooding occurs occasionally or frequently. Levees protect nearly all of the cropland from flooding. Most of the forested wetlands are not protected from flooding. Networks of drainage canals and ditches help to remove excess surface water from the cropland. The major resource concerns are control of surface water, management of soil moisture, and maintenance of the content of organic matter and productivity of the soils. Conservation practices on cropland generally include nutrient management, crop residue management, and alternative tillage systems, especially no-till systems. In many areas land leveling or shaping optimizes the control of surface water. Other major cropland management practices are control of competing vegetation and insects through aerial or ground spraying of herbicides and insecticides and fertility management programs that make use of chemical fertilizers.

133A – Southern Coastal Plain

Louisiana constitutes a mere 1% of this MLRA near the town of Bogalusa, LA in the extreme eastern part of the state.

Physiography

This area extends from Virginia to Louisiana and Mississippi, but it is almost entirely within three sections of the Coastal Plain Province of the Atlantic Plain. The northern part is in the Embayed Section, the middle part is in the Sea Island Section, and the southern part is in the East Gulf Coastal Plain Section. This MLRA is strongly dissected into nearly level and gently undulating valleys and gently sloping to steep uplands. Stream valleys generally are narrow in their upper reaches but become broad and have widely meandering stream channels as they approach the coast. Elevation ranges from 80 to 655 feet (25 to 200 meters), increasing gradually from the lower Coastal Plain northward. Local relief is mainly 10 to 20 feet (3 to 6 meters), but it is 80 to 165 feet (25 to 50 meters) in some of the more deeply dissected areas.

Geology

This MLRA is bordered on the west and north by the “fall line.” This line of waterfalls marks the western and northern extent of the unconsolidated Coastal Plain sediments. It is an erosional scarp formed when this area was the Atlantic Ocean shore in Mesozoic time. The MLRA is underlain by eroded igneous and metamorphic bedrock. Rivers and streams draining the Appalachians deposited a thick wedge of silt, sand, and gravel east and south of the fall line as delta deposits in the Atlantic Ocean. These Jurassic and Cretaceous river sediments were eventually exposed as the Coastal Plain uplifted and the sea level changed. When the sea level rose again, the Coastal Plain was submerged and covered by a thin layer of Cretaceous sands in the eastern half of the area. In the western part of the area, the water was deeper and limestone, dolomite, and calcareous sands were deposited. As the Coastal Plain continued to uplift and the sea level dropped again, Quaternary material consisting of unconsolidated clay, silt, sand, and gravel was deposited over the Tertiary sand and carbonates. Subsequent changes in the sea level created terraces in these younger deposits along many of the streams and rivers draining this area. Much of the MLRA has a "benched" appearance because of the cycles of erosion and deposition that occurred as the area was exposed and submerged numerous times in its geologic history.

Soils

The dominant soil orders in this MLRA are Ultisols, Entisols, and Inceptisols. The soils in the area dominantly have a thermic soil temperature regime, a udic or aquic soil moisture regime, and siliceous or kaolinitic mineralogy. They generally are very deep, somewhat excessively drained to poorly drained, and loamy. Hapludults formed in marine sediments (Luverne and Sweatman series) and mixed marine sediments and alluvium (Smithdale series) on hills and ridges. Kandiudults formed in marine sediments (Dothan, Fuquay, Norfolk, and Orangeburg series) and mixed marine and fluvial sediments (Troup series) on hills and ridges. Fragiudults (Ora and Savannah series) and Paleudults (Ruston series) formed in mixed marine and fluvial sediments on uplands and stream terraces. Fluvaquents (Bibb series) and Endoaquepts (Mantachie series) formed in alluvium on flood plains. Quartzipsamments (Lakeland series) formed in sandy eolian or marine material on uplands. Paleaquults (Rains series) formed in marine and fluvial sediments on terraces.

Biological Resources

This area supports mixed oak-pine vegetation. Loblolly pine, longleaf pine, slash pine, shortleaf pine, sweetgum, yellow-poplar, red oak, and white oak are the major overstory species. Dogwood, gallberry, and farkleberry are the major understory species. Common sweetleaf, American holly, greenbrier, southern bayberry, little bluestem, Elliott bluestem, threeawn, grassleaf goldaster, native lespedezas, and low panicums are other understory species. Some of the major wildlife species in this area are whitetailed deer, turkey, rabbit, squirrel, bobwhite quail, and mourning dove. The species of fish in the area include bass, bluegill, and channel catfish.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 17%
Grassland – private, 8%
Forest – private, 61%; Federal, 3%
Urban development – private, 6%
Water – private, 3%
Other – private, 2%

Timber production, cash-grain crops, and forage production are important in this MLRA. Soybeans, cotton, corn, and wheat are the major crops grown throughout the area. Pastures are grazed mainly by beef cattle, but some dairy cattle and hogs are raised in the area. The major resource concerns are water erosion, maintenance of the content of organic matter and productivity of the soils, control of surface water, artificial drainage, and management of surface compaction and soil moisture. Conservation practices on cropland generally include systems of crop residue management, cover crops, crop rotations, water disposal, subsoiling or deep tillage, pest management, and nutrient management. The most important conservation practice in pastured areas is prescribed grazing. Pastures commonly are overseeded with small grains and/or legumes to supplement forage production during winter. Haying also helps to provide supplemental feed during the long winters. Critically eroding areas and areas where animals congregate should be monitored and treated.

131A – Southern Mississippi River Alluvium

Louisiana constitutes 32 percent of this MLRA including the towns of Lake Providence, Morgan City, and Houma, Louisiana. The cities of Baton Rouge and New Orleans, Louisiana, are just outside this area. Parts of Interstates 10 and 20 cross this MLRA.

Physiography

This area makes up most of the Mississippi Alluvial Plain Section of the Coastal Plain Province of the Atlantic Plain. It is on the alluvial plain along the lower Mississippi River, south of its confluence with the Ohio River. The landforms in the area are level or depressional to very gently undulating alluvial plains, backswamps, oxbows, natural levees, and terraces. The parts of the MLRA south of Baton Rouge, Louisiana, are on a deltaic plain. Landform shapes range from convex on natural levees and undulating terraces to concave in oxbows. These shapes differentiate water-shedding positions from water receiving positions, both of which have a major role in soil formation and hydrology. Average elevations start at sea level in the southern part of the area and gradually rise to about 330 feet (100 meters) in the northwestern part. Maximum local relief is about 15 feet (5 meters), but relief is considerably lower in most of the area.

Geology

Bedrock in this area consists of Tertiary and Cretaceous sands formed as beach deposits during the retreat of the Cretaceous ocean from the midsection of the U.S. Alluvial deposits from flooding and lateral migration of the Mississippi River typically lie above the bedrock. These sediments are sandy to clayey fluvial deposits of Quaternary age and are many meters thick. The Yazoo, Tensas, and Atchafalaya Basins and the modern deltaic plain are in areas of Holocene deposits. The St. Francis Basin, in the northwestern part of the MLRA, and some surfaces surrounded by the Yazoo Basin, in the central part of the MLRA, are in areas of Wisconsin Stage deposits of Pleistocene age. Some small areas in the western part of the MLRA are covered by a thin mantle of pre-Wisconsin, Quaternary-age loess deposits.

Soils

The dominant soil orders in this MLRA are Alfisols, Vertisols, Inceptisols, and Entisols. The soil temperature regime is thermic in most of the MLRA. It is hyperthermic, however, south of Baton Rouge, Louisiana. The soils in the MLRA dominantly have an aquic soil moisture regime, smectitic clay mineralogy, and mixed sand and silt fraction mineralogy. The soils are very deep, dominantly poorly drained and somewhat poorly drained, and dominantly loamy or clayey. Nearly level Epiaquerts (Sharkey series), Vertic Epiaquepts (Tunica series), and Vertic Endoaquepts (Dowling series) dominate the alluvial flats and backswamps of Holocene to late Pleistocene age. Nearly level to gently sloping Endoaquepts (Commerce series), Udifluvents (Robinsonville series), and Fluvaquents (Convent series) dominate the natural levees of Holocene age. Nearly level to gently undulating, sandy Udifluvents (Bruno series) and Udipsamments (Crevasse series) dominate the levee splays and point bars of Holocene age. Nearly level to gently undulating Endoaqualfs (Dundee series), Hapludalfs (Dubbs series), and

Epiaqualfs (Tensas series) dominate the terraces of Pleistocene age.

Biological Resources

This area once consisted entirely of bottom-land hardwood deciduous forests and mixed hardwood and cypress swamps. The major tree species in the native plant communities in the areas of bottom-land hardwoods formerly were and currently are water oak, Nuttall oak, cherrybark oak, native pecan, red maple, sweetgum, eastern cottonwood, and hickory. The major tree species in the native plant communities in the swamps formerly were and currently are cypress, water tupelo, water oak, green ash, red maple, and black willow. The important native understory species are palmetto, greenbrier, wild grape, and poison ivy in the areas of bottom-land hardwoods and buttonbush, lizardtail, waterlily, water hyacinth, sedges, and rushes in the swamps. Some of the major wildlife species in this area are whitetailed deer, feral hogs, red fox, coyote, rabbit, gray squirrel, American alligator, water turtles, water snakes, frogs, otters, beavers, armadillo, crawfish, wild turkey, mourning doves, ducks, and geese. Fishing is mainly in oxbow lakes, rivers, and bayous. The species of fish in the area include largemouth bass, smallmouth bass, catfish, drum, bluegill, gar, and yellow perch. Crawdads are a commercial species in the southern end of this MLRA.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 70%
Grassland – private, 2%
Forest – private, 15%; Federal, 3%
Urban development – private, 3%
Water – private, 6%
Other – private, 1%

Most of this area is in farms, which produce mainly cash crops. Cotton, soybeans, milo, and corn are the main crops, and sugarcane is a major crop in the southernmost part of the area. Furrow irrigation is used in many areas during droughty parts of the growing season. Rice is grown in some land-leveled, flood irrigated areas. Catfish and crawfish are produced commercially on farm ponds that are contained by levees. The catfish are produced throughout the MLRA, and the crawfish are produced in the southern part of the area. Migratory waterfowl are harvested throughout the area. Hardwood timber is harvested on most forested wetlands, and most of the forested areas are managed for wildlife. About 29 percent of this MLRA is not protected from flooding, and flooding occurs occasionally or frequently in these unprotected areas. Levees protect nearly all of the cropland, urban land, and grassland from flooding. Most areas of forested wetlands are not protected from flooding. Networks of drainage canals and ditches help to remove excess surface water from the cropland. The major resource concerns are control of surface water, management of soil moisture, and maintenance of the content of organic matter and productivity of the soils. Conservation practices on cropland generally include nutrient management, crop residue management, and alternative tillage systems, especially no-till systems that reduce the cost of tillage. In many areas land leveling or shaping optimizes the control of surface water. Other major cropland management practices are control of competing vegetation and insects through aerial or ground spraying and fertility management programs that make use of chemical fertilizers.

131D – Southern Mississippi River Terraces

Louisiana constitutes 12 percent of this MLRA, including the town of Bastrop, LA.

Physiography

This MLRA is in the Mississippi Alluvial Plain Section of the Coastal Plain Province of the Atlantic Plain. It consists dominantly of Pleistocene-age, level to gently sloping terraces along the Mississippi River. Slopes generally range from level to gently sloping but are steep along terrace escarpments. Channel scars are evident in some areas. Elevation is generally 50 to 250 feet (15 to 75 meters) on the terraces.

Geology

Bedrock in this area consists of Tertiary and Cretaceous sands formed as beach deposits during the retreat of the Cretaceous ocean from the midsection of the U.S. Alluvial deposits from flooding and lateral migration of the rivers crossing this area typically lie above the bedrock. These sediments form Pleistocene-age alluvial terraces. Silty alluvium underlies most of the area. Clayey sediments are in old channel scars. The Pleistocene terraces are part of the Prairie Terrace complex. A minor portion of the area is in the Deweyville and Montgomery terrace formation. These terraces have a base of red alluvium capped by one to several meters of brownish alluvium.

Soils

The dominant soils in this MLRA are Alfisols. They have a thermic soil temperature regime, an ustic or aquic soil moisture regime, and mixed mineralogy. They are very deep and formed dominantly in silty alluvium. They generally are moderately well drained to poorly drained. Gently sloping Hapludalfs (Goodwill series) are on natural levees and low terraces. Gently sloping to level Hapludalfs (Immanuel and Stuttgart series) and Fraglossudalfs (Grenada series) are on broad interfluves and along terrace escarpments. Level Endoaqualfs (Idee series), Albaqualfs (Dewitt series), Glossaqualfs (Ethel series), Epiaqualfs (Lagrue), and Fragiaqualfs (Henry series) are on low terraces and natural levees. Nearly level and level Endoaqualfs (Tichnor and Forestdale series) are on low terraces, natural levees, and flood plains. Nearly level Dystrudepts (Oaklimeter series) are along drainageways and on flood plains.

Biological Resources

This area supports hardwoods and pines. The Grand Prairie area, in Arkansas, originally supported tall prairie grasses interlaced with hardwood timber. Cherrybark and Shumard oak are widely distributed. Yellow-poplar, white ash, cottonwood, and black walnut are important species on the flood plains. Loblolly pine and shortleaf pine are on a wide variety of sites, mainly the eroded soils on uplands and ridges. Other hardwood species that commonly grow in this area are white oak, basswood, sweetgum, water oak, American elm, blackgum, sycamore, sassafras, southern red oak, chinkapin oak, American beech, and hickory. Some of the major wildlife species in this area are whitetailed deer, coyote, bobcat, beaver, raccoon, skunk, armadillo, mink, cottontail, turkey, mourning dove, ducks, and geese. The species of fish in the area include channel catfish, largemouth black bass, crappie, and bluegill.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 42%
Grassland – private, 4%
Forest – private, 46%; Federal, 1%

Urban development – private, 3%
Water – private, 3%
Other – private, 1%

Scattered tracts of forests and farms make up nearly all of this area. Rice, soybeans, and wheat are the main crops. In most areas furrow or flood irrigation is used throughout the growing season. Hardwood timber is harvested on some forested wetlands, and most forested areas are managed for wildlife. Bait fish are produced commercially in ponds that are contained by levees. Migratory waterfowl are harvested throughout the area. The major soil resource concerns are management of soil moisture, erosion control, and maintenance of the content of organic matter and productivity of the soils. Depletion of ground water through excessive pumping is a major concern in the Grand Prairie area. Conservation practices on cropland generally include nutrient management, crop residue management, and alternative tillage systems, especially no-till systems that reduce the need for tillage. In many areas land leveling or shaping optimizes the control of surface water. Other major cropland management practices are control of competing vegetation and insects through aerial or ground spraying of herbicides and insecticides and fertility management programs that make use of chemical fertilizers.

134 – Southern Mississippi Valley Loess

Louisiana constitutes 15 percent of soils in this MLRA to include Baton Rouge, Opelousas, Lafayette, and New Iberia, Louisiana. Interstates 49 and 10 cross the area.

Physiography

This area is in the Coastal Plain Province of the Atlantic Plain. Most of the part of the area east of the Mississippi River is in the East Gulf Coastal Plain Section of the province. Parts of the western edge of the area, the part of the area in Arkansas, and the isolated part in northern Louisiana are in the Mississippi Alluvial Plain Section. The farthest southwest part in Louisiana is in the West Gulf Coastal Plain Section. The sharply dissected plains in this MLRA have a loess mantle that is thick at the valley wall and thins rapidly as distance from the valley wall increases. Valley sides are hilly to steep, especially in the western part of the area. The intervening ridges generally are narrow and rolling, but some of the interfluves between the upper reaches of the valleys are broad and flat. Stream valleys are narrow in the upper reaches but broaden rapidly downstream and have wide, flat flood plains and meandering stream channels. Elevation ranges from 80 to 600 feet (25 to 185 meters). Local relief is mainly 10 to 20 feet (3 to 6 meters), but it can be 80 to 165 feet (25 to 50 meters).

Geology

This area is mantled with loess, which varies in thickness. The area is underlain by unconsolidated sand, silt, and clay, mainly of marine origin. Crowley's Ridge is underlain by Pliocene sand and gravel. The seas extended up the present-day valley of the Mississippi River in Tertiary time, when these sediments were deposited by rivers draining the surrounding uplands. Throughout Quaternary and Recent time, the valley floor received fine grained sediments each time the Mississippi River flooded. After these sediments dried, winds picked them up and deposited them as loess in the higher areas on each side of the valley. There are five known periods of loess deposition in the area. The surface deposit is the Peoria Loess, which is of Late Wisconsin age (about 10,000 years ago). Pre-Peorian Loess, which is of Middle Wisconsin age (about 20,000 to 40,000 years ago), occurs in some areas. This loess is thinner than the Peorian Loess and is generally redder or darker. Loveland-Sicily Island Loess, which is of pre-Wisconsin age (85,000 to 130,000 years ago), is at the surface in some areas in the southern part of this MLRA. It has a well developed reddish paleosol (buried soil). Two other loess deposits have been described on Crowley's Ridge. They have been identified as Marianna Loess and Crowley's Ridge Loess. These deposits are not exposed at the surface. They have well developed paleosols.

Soils

The dominant soil orders in this MLRA are Alfisols, Entisols, Inceptisols, and Ultisols. The soils in the area are very deep or deep, are medium textured, and have a thermic soil temperature regime, a udic soil moisture regime, and mixed mineralogy. Well drained, nearly level to very steep Hapludalfs (Memphis series) are on uplands. Nearly level to steep, well drained Hapludalfs (Memphis, Coteau, and Feliciana series), moderately well drained and somewhat poorly drained Fraglossudalfs (Olivier, Grenada, and Calloway series), moderately well drained Fragiudalfs (Loring series), and well drained Eutrudepts (Natchez series) formed in thick deposits of loess. Nearly level to gently sloping, somewhat poorly drained Epiaqualfs (Patoutville series), moderately well drained Fragiudults (Gigger, Toula, and Tangi series), well drained to somewhat poorly drained Hapludalfs (Colyell and Dexter series), and well drained Paleudults (Lytle series) formed in deposits of loess 2 to 4 feet (1 meter) thick. Nearly level and very gently sloping, somewhat poorly drained and poorly drained Glossaqualfs (Calhoun, Encrow, and Frost series), somewhat poorly drained Glossudalfs (Egypt series), somewhat poorly drained Hapludalfs (Satsuma series), and somewhat poorly drained Argiaquolls (Jeanerette series) formed in a thin mantle of loess over loamy alluvium or mixed loess and loamy alluvium. Deep, gently sloping, well drained Eutrudepts (Weyanoke series), somewhat poorly drained Fragiudults (Bude series), and somewhat poorly drained Fraglossudalfs (Fluker series) formed in silty material or in a mantle of loess and the underlying late Pleistocene loamy terrace material. In the eastern part of the area, where the loess mantle thins, well drained Paleudalfs (Lexington series), moderately well drained Fragiudalfs (Dulac and Providence series), well drained Hapludults (Brandon and Silerton series), and well drained Paleudults (Smithdale series), all of which are gently sloping to steep, are on ridgetops and side slopes. Well drained Dystrudepts (Ariel series), moderately well drained Udifluvents (Collins series), moderately well drained Dystrudepts (Oaklimeter series), and somewhat poorly drained Fluvaquents (Gillsburg series) are on flood plains.

Biological Resources

This area supports hardwood-pine vegetation. Cherrybark oak, Shumard oak, white oak, post oak, southern red oak, and southern magnolia are widely distributed. Loblolly pine and shortleaf pine are the dominant pines. Yellow-poplar, white ash, swamp chestnut, cottonwood, sweetgum, and black walnut are important species on the flood plains. Loblolly pine and shortleaf pine are on a wide variety of sites, mainly the eroded soils on uplands and ridges. Other hardwood species that commonly grow in this area are white oak, basswood, sweetgum, water oak, American elm, blackgum, sycamore, sassafras, southern red oak, chinkapin oak, American beech, and hickory. Beech-magnolia-holly forests are dominant on narrow ridges and in steep ravines in the Tunica Hills of Louisiana. Some of the major wildlife species in this area are whitetailed deer, red fox, gray fox, raccoon, opossum, skunk, muskrat, cottontail, gray squirrel, fox squirrel, bobwhite quail, and mourning dove. The species of fish in the area include largemouth bass, bluegill, and bullhead.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 36%

Grassland – private, 13%
Forest – private, 38%; Federal, 2%
Urban development – private, 7%
Water – private, 2%
Other – private, 2%

Most of this area is in farms. A small acreage is federally owned. About one-third of the area is cropland, but the proportion varies greatly from county to county, depending on the soils and the topography. This is largely a cash-crop area. Cotton, corn, rice, soybeans, and wheat are the major crops. Strawberries are important in Louisiana. Feed grains and forage are grown on dairy farms. Less than 15 percent of the area is pasture or hayland. About two-fifths is forest of mixed pine and hardwoods. Lumber is the major forest product, and some pulpwood is harvested. The present trend is toward the conversion of pasture and forest to cropland. Some areas are used for urban development, which is expanding near the metropolitan areas. The major soil resource concerns are water erosion, maintenance of the content of organic matter and productivity of the soils, and management of soil moisture. Water erosion is a hazard in sloping areas that are bare because of tree harvesting. Conservation practices on forestland generally include systems of tree residue management and reforestation. Conservation practices on cropland generally include crop residue management, which increases the content of organic matter in the soils, and applications of lime in areas of low pH. Many of the soils remain wet or have a high water table for some or most of the year. Measures that improve drainage should be applied, or the crops adapted to the wet conditions should be selected for planting.

133B – Western Coastal Plain

Louisiana constitutes 31 percent of this MLRA and includes Minden, Ruston, West Monroe and Shreveport, Louisiana. The area includes parts of Interstates 20 and 49.

Physiography

This area is in the West Gulf Coastal Plain Section of the Coastal Plain Province of the Atlantic Plain. It consists of level to steep uplands that are intricately dissected by streams. Broad flood plains and terraces are along some streams. Elevation ranges from 80 to 650 feet (25 to 200 meters), increasing gradually from southeast to northwest. Local relief is generally less than 30 feet (9 meters).

Geology

Tertiary and Cretaceous marine sediments underlie most of this area. Tertiary units include the Wilcox and Midway Groups, the Claiborne Group, the Jackson Group, the Catahoula Formation, and the Willis Formation. They consist of interbedded sandstone, siltstone, and shale and unconsolidated sands, silts, and clays. The Reklaw and Weches Formations in the Claiborne Group form the Redland area in east Texas. The Cretaceous marine sediments of the Fleming and Oakville Formations are of minor extent in the area. They consist of calcareous clays and marls. Sand, silt, and clay alluvium is under the flood plains and terraces along the major drainages.

Soils

The dominant soil orders in this MLRA are Alfisols and Ultisols. The soils in the area dominantly have a thermic soil temperature regime, a udic or aquic soil moisture regime, and siliceous, mixed, or smectitic mineralogy. They generally are very deep, well drained to poorly drained, and loamy or clayey. Hapludults formed in residuum (Cuthbert and Kirvin series) and marine sediments (Sacul series) on hills and ridges. Paleudults formed in marine sediments (Bowie and Malbis series) and mixed marine sediments and alluvium

(Ruston series) on uplands. Endoaquults (Amy series) formed in old alluvium on stream terraces. Fragiudults (Savannah series) formed in mixed marine sediments and alluvium on uplands and stream terraces. Hapludalfs (Eastwood and Woodtell series) formed in marine sediments on hills and ridges. Glossaqualfs formed in alluvium on flood plains and stream terraces (Guyton series) and in old alluvium on stream terraces (Wrightsville series).

Biological Resources

This area supports pine-hardwood vegetation. The dominant trees are loblolly pine, shortleaf pine, sweetgum, southern red oak, white oak, flowering dogwood, and post oak. American beautyberry, greenbrier, hawthorns, and berry vines are included in the woody understory. Little bluestem and pinhole bluestem are the dominant herbaceous species. Other major grasses include beaked panicum, longleaf uniola, spike uniola, and yellow Indiangrass. The plant community has many species of low-growing panicums and paspalums and perennial forbs. The major wildlife species in this area include white-tailed deer, coyote, beaver, raccoon, skunk, opossum, muskrat, mink, cottontail, squirrel, weasel, armadillo, and mourning dove.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 2%
Grassland – private, 18%
Forest – private, 65%; Federal, 4%
Urban development – private, 6%
Water – private, 3%; Federal, 1%
Other – private, 1%

The forested areas in this MLRA are used for the production of lumber and pulpwood. The cleared land is used mostly for pasture and hay. Where the water supply is adequate, such crops as corn, grain sorghum, oats, soybeans, peanuts, rice, and vegetables are grown. The major resource concerns are water erosion, wetland restoration, and water supplies for livestock. Conservation practices on cropland generally include buffer strips, which help to control erosion and runoff. They also include the proper use and timing of irrigation.

152B – Western Gulf Coast Flatwoods

Louisiana constitutes 41 percent of this MLRA and includes Singer, Sulfur, and Oberlin, Louisiana, are in this MLRA. Interstate 10 is just south of this area. The Sam Houston Jones State Park is in the part in Louisiana.

Physiography

This area is in the West Gulf Coastal Plain Section of the Coastal Plain Province of the Atlantic Plain. The area is nearly level to gently sloping and has low local relief. Elevation ranges from 80 to 330 feet (25 to 100 meters).

Geology

The entire area is underlain by unconsolidated clay, silt, sand, and gravel deposited by ancient rivers in late Tertiary and Quaternary time. Recent silt, sand, and gravel deposits fill the valleys along most of the major rivers in the area.

Soils

The dominant soil orders in this MLRA are Alfisols and Ultisols. The soils in the area dominantly have a thermic soil temperature regime, an aquic or udic soil moisture regime, and siliceous or smectitic mineralogy. They generally are very deep, moderately well drained to very poorly drained, and loamy or clayey. Glossaqualfs formed in loamy and clayey sediments on stream terraces (Caddo and Evadale series), in loamy marine sediments on uplands (Waller series), and in alluvium on flood plains and stream terraces (Guyton series). Glossudalfs (Messer series) formed in loamy marine sediments on mounds and ridges. Vermaqualfs (Sorter series) formed in old alluvium on uplands. Hapluderts (Kaman series) formed in alluvium on flood plains. Paleudults (Kirbyville and Malbis series) formed in loamy marine sediments on uplands.

Biological Resources

This area supports pine-hardwood forest vegetation characterized by longleaf pine. Sweetgum, blackgum, post oak, blackjack oak, and southern red oak are the principal hardwood species. Hawthorns, myrtle, and shining sumac make up the woody understory. Mid and tall grasses are dominant in open areas. Little bluestem, pinhole bluestem, big bluestem, switchgrass, and Indiangrass are the principal grasses. Longleaf uniola, Virginia wildrye, Florida paspalum, beaked panicum, and several low-growing panicums and paspalums are the principal grasses in shady areas. Lespedezas, tickclover, wildbeans, and several composites are the principal forbs in the area. Some of the major wildlife species in this area are whitetailed deer, coyote, fox, nutria, raccoon, skunk, cottontail, gray squirrel, fox squirrel, mink, armadillo, wood rat, white-footed mouse, eastern harvest mouse, cotton mouse, golden mouse, hispid cotton rat, hispid pocket mouse, marsh rice rat, turkey, quail, and mourning dove. Other major species include cottonmouth moccasin, broad-banded water snake, coral snake, hognose snake, canebrake rattlesnake, pigmy rattlesnake, copperhead, Louisiana milk snake, speckled kingsnake, rough green snake, buttermilk snake, five-lined skink, broad-headed skink, green anole, smooth softshell turtle, three-toed box turtle, red-eared turtle, Mississippi mud turtle, marbled salamander, smallmouth salamander, Fowler’s toad, East Texas toad, spring peeper, eastern tree toad, northern cricket frog, northern leopard frog, and bullfrog. The species of fish in the area include spotted bass, largemouth bass, crappie, catfish, bullhead, carp, and bluegill.

Land Use

Following are the various kinds of land use in this MLRA:

Cropland – private, 1%
Grassland – private, 12%; Federal, 1%
Forest – private, 74%; Federal, 3%
Urban development – private, 7%
Water – private, 1%
Other – private, 1%

The forestland in this area consists principally of pine and pine-hardwood forests. Much of the forested acreage is owned by large corporations, and lumber and pulpwood are the chief forest products. Cleared areas are used mostly for pasture. The major pasture grasses are bahiagrass and coastal bermudagrass. Only a few small areas are used for crops. Many small subdivisions are being developed throughout the area, especially in the vicinity of Houston and Beaumont, Texas. The major soil resource concerns are water erosion, maintenance of the content of organic matter and productivity of the soils, and soil moisture management. When areas are bare after a tree harvest, water erosion is a hazard on sloping land. Conservation practices on forestland generally include forest stand improvement, forest trails and landings, prescribed burning, riparian forest buffers, forest site preparation, bedding, establishment of trees and shrubs, and management of upland wildlife habitat. The soils in this area are low in content of organic matter and productivity. Measures that increase the content of organic matter are needed. Applications of lime in areas of low pH help to maintain or improve productivity. Many of the soils remain wet or have a high water table for some or most of the time during the year. Measures that improve drainage or adapt the land use to the wet conditions are needed.

Soils of Louisiana

In 2008, 315 soil series were being used in Louisiana (Soil Survey Staff, 2008c)(Table 1). Among these series, 54 benchmark soil series were mapped in the state (Soil Survey Staff, 2008c) (Table 1). Benchmark soils occupy large extents, hold key positions in soil classification, and are important in determining the properties and interpretations of soils in a large area (Soil Survey Staff, 1993). Alfisols, Entisols, Inceptisols, Histosols, Mollisols, Ultisols, and Vertisols are found in the state (Table 1).

The state soil of Louisiana is the Ruston series (Fine-loamy, siliceous, semiactive, thermic Typic Paleudult). The Ruston soil contains both albic and argillic horizons with an ochric epipedon (Soil Survey Staff, 2008c). It occupies 733,714 acres (296, 924 ha) in the state and widely supports woodland vegetation consisting of hardwoods and southern pine (Soil Survey Staff, 2008d).

Taxonomic classification scheme of common soil series in Louisiana. Benchmark soil series are in bold

Table 1

Order: Entisols

Suborder	Great Group	Subgroup	Series
Aquents	Fluvaquents	Aeric	**Falaya**, Vacherie
		Thapto-Histic	Westwego
		Typic	Bibb, Cypress, Gueydan, Placedo
		Vertic	Sostien
	Hydraquents	Typic	Arat, Balize, **Barbary**, Creole, Gentilly, **Larose**,
		Sodic	Bancker, Scatlake
	Psammaquents	Typic	Osier
Fluvents	Udifluvents	Aquic	Cocodrie
		Oxyaquic	Caplis
		Typic	Bruno, Morganfield, Nugent, Ochlockonee, Robinsonville, Roxana, Severn
Psamments	Quartzipsamments	Aquic	Lotus
		Typic	Bigbee, Alaga
	Udipsamments	Aquic	Felicity, Iuka
		Typic	Cheniere, Crevasse, Peveto

Order: Alfisols

Suborder	Great Group	Subgroup	Series
Aqualfs	Albaqualfs	Aeric	Mamou, Springfield, Tenot
		Typic	**Crowley**, Zachary
		Vertic	Anacoco
	Endoaqualfs	Aeric	Dupuy, Galvez
		Mollic	Loreauville
		Typic	Amagon, **Dundee**, **Forestdale**, Ged
	Epiaqualfs	Aeric	Acadia, Acy, Essen, Frozard, Groom, **Hebert**, Patoutville, Solier
		Typic	Rigolette
		Vertic	Baldwin, Kaplan, Midland, Tensas
	Glossaqualfs	Aeric	Bursley

		Oxyaquic	Acadiana
		Typic	Basile, Besner, **Caddo**, **Calhoun**, **Fountain**, Frost, Gilbert, **Guyton**, Kinder, Leton, Merryville, Mowata, Waller, **Wrightsville**
	Natraqualfs	Glossaquic	Lafe
		Glossic	Bonn, Brimstone, Deerford, **Foley**, Verdun
	Vermaqualfs	Typic	Gessner
Udalfs	Fragiudalfs	Aquic	Bude
		Oxyaquic	**Loring**, **Providence**
		Typic	Gigger, Libuse
	Fraglossudalfs	Aquic	**Calloway**, Fluker, Necessity, Olivier
		Oxyaquic	**Grenada**, Pineisland
	Glossudalfs	Aquic	Egypt, Fred, Vidrine
		Fragic	Duralde
		Haplic	Elysian, Messer
		Oxyaquic	Kleinpeter
	Hapludalfs	Albaquic	Cadeville, Corrigan
		Aquic	Goldman
		Glossaquic	Colyell, Coteau, Frizzell, Glenwild, Satsuma, Vick
		Oxyaquic	Glenwild, Rexor
		Typic	Gallion, Kisatchie, **Memphis**, **Rilla**, Sterlington
		Ultic	Dexter, Dossman, Feliciana, Kenefick, Lexington, Liddieville, Meth, Sugartown
		Vertic	**Eastwood**, Herty, Iota, Mckamie, Natchitoches, Oula, Rayburn, **Woodtell**
	Paleudalfs	Aeric	Falkner
		Aquic	Duson, Muskogee, Tippah
		Arenic	Larue, **Wolfpen**
		Glossaquic	Abita, Glenmora, Keithville, **Kolin**, Metcalf
		Glossic	**Bernaldo**, Evangeline
		Lamellic	Flo
		Psammetic	Bienville
		Rhodic	Nacogdoches
		Typic	Attoyac, Bistineau, Darbonne
		Vertic	Boswell, Forbing, Gore

Order: Ultisols

Suborder	Great Group	Subgroup	Series
Aquults	Albaquults	Typic	Leaf
	Endoaquults	Aeric	Haggerty, Zenoria
		Typic	Myatt
	Paleaquults	Typic	**Smithton**
Udults	Fragiudults	Glossaquic	**Pheba**
		Glossic	Prentiss
		Typic	Ora, **Savannah**, Shatta, Tangi, Toula
	Hapludults	Aquic	Mollicy, **Sacul**
		Typic	Bassfield, Bearhead, Cahaba, Darley, **Kirvin**, Latonia, **Mahan**, Olla, Smithdale, Sweatman
	Kandiudults	Arenic	Lucy
	Rhodudults	Typic	Ruple
	Paleudults	Aquic	Angie, Bodcau, Gurdon, Harleston, **Sawyer**
		Arenic	Boykin, **Briley**, Letney, Trep
		Fragiaquic	Stough

		Lamellic	**Betis**
		Oxyaquic	Brule, **Kirbyville**
		Plinthaquic	Beauregard, Saucier
		Plinthic	**Bowie**, Doucette, Malbis, Pinetucky
		Typic	Blevins, Dubach, Lytle, Mclaurin, Niwana, **Ruston**, Sailes, Warnock

Order: Inceptisols

Suborder	Great Group	Subgroup	Series
Aquepts	Epiaquepts	Fluvaquentic	**Cancienne**, Newellton
		Typic	Una
		Vertic	**Portland**, **Tunica**, Urbo, Yorktown
	Endoaquepts	Aeric	Hackberry
		Fluvaquentic	Mhoon, Rosebloom, Waverly
		Fluventic	Arkabutla, Carville, **Commerce**, Convent, **Mantachie**
		Typic	Mermentau
		Vertic	**Dowling**, **Fausse**, Harahan, Rita
Udepts	Dystrudepts	Fluvaquentic	Sardis
		Fluventic	Cascilla, Jena, **Ouachita**
	Eutrudepts	Dystric	Weyanoke
		Fluventic	Coushatta, Norwood
		Oxyaquic	Bruin
		Rendollic	Keiffer, **Sumter**
		Typic	Natchez

Order: Histosols

Suborder	Great Group	Subgroup	Series
Saprists	Haplosaprists	Fluvaquentic	Kenner
		Terric	**Allemands**, Bellpass, Carlin, **Clovelly**, Delcomb
		Typic	Lafitte, Maurepas, Timbalier

Order: Mollisols

Suborder	Great Group	Subgroup	Series
Aquolls	Argiaquolls	Typic	Andry, Jeanerette
Udolls	Argiudolls	Aquertic	Sonnier
		Aquic	Armistead
		Oxyaquic	Morey
		Typic	Caspiana, Mer rouge

Order: Vertisols

Suborder	Great Group	Subgroup	Series
Uderts	Dystruderts	Aquic	Bayoudan, Bellwood, **Vaiden**
	Hapluderts	Aquic	Buxin, Hornbeck, Lebeau
		Chromic	Morse
		Watsonia	Leptic
		Oxyaquic	**Latanier**, **Moreland**
Aquerts	Dystraquerts	Chromic	**Alligator**, Ashford, Litro, Mayhew, Oktibbeha
	Epiaquerts	Aeric	Bossier
		Chromic	Gramercy, **Perry**, **Schriever**, **Sharkey**
		Typic	Iberia, Judice

3. CONCLUSIONS

Louisiana displays a wide variety of soils and natural resources throughout the state. Dynamic geology, climate and cultural practices have added to the diversity of natural resources found in the state. While initial soil sampling in Louisiana is complete, the Soil Survey Staff continue to produce updates to established soil survey data in an effort to keep soils information current in the face of changing land use, soil series, and concepts in soil pedology.

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