APPLICATION OF THE PHOTOGRAMMETRIC AND THE GEOGRAPHIC INFORMATION SYSTEMS IN THE URBAN ENVIRONMENT: A CASE OF STUDY

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ABSTRACT:

The urban growth and the environmental relationship are several times joint as to the of the urban soil occupation as to the urban area development. The transformation of the several kinds of soil use and the human being activities related to them happen in all sections of the urban space. Therefore the development of the cities is not always followed by the substructure wanted which is going to roduce during a time environmental problems. The flood occurence is one of the environmental problems which has caused many damages to the inhabiting people from the cities. These problems are due to most of the time to the use and occupation of the soil without anandequated planning, besides the lack of state government management of pluvial water. In the city of Itajubá – MG, the flood has been drastic lately and because of it this study had been done with the objective of analysing the structure and the occupation of the soil integrated to the physical features of this landscape. At this rate, contributing to a more efficient planning, based on the environmental management which provides the citizen rights related to their worth life conditions.

1. INTRODUTION

The urbanization process has frequently been done making alterations in the drainage of pluvial water. Those changes occur due to factors as: water flow landing and lagoon; forest clearing, occupation of overflow reservoir areas; hydric resource accumulation of sand, as a result of soil soil erosion and the sewerage and rubbish soil impermeabilization, retification and water flow canalizing, urban system drainage(MOTA, 1999).

The general objective of this research is to take up environmental problems decurrent of the urban soil use in Itajubá, as flood and to make prognostic to contribute to the planning and urban space management.

The specific objectives are:

1. Evaluate the urban space structure, by the elaboration of a use soil map with its respectives classes of use.
2. Study the physical characteristics of the city together with the Urban Pluvial System, to contribute with the studies about the environmental problems related to the superficial drainage of the area.
3. The observation of the alterations occured in urban structure together the soil use and the historic analysis of the flood.

2. CHARACTERIZATION OF THE STUDY AREA

Itajubá city is a middle town from the south of Minas Gerais state which had in 1996 a population of 78,444 inhabitants.

The urban space of Itajubá has as plain coordinates UTM, the points 457.600 m E; 448.000 m E and 7.522.000 m N. The county has an area of 281 Km^2 and is located to 22^0 25'30" of south latitute and to 45^0 27' 20" west longitude. This Itajubá county sets bounds, to the north, with the counties São José do Alegre and Maria da Fé, to the east, with Delfim Moreira to the south, with Venceslau Brás and Piranguçú, to the west with Piranguinho(Guimarães, 1987).

The geomorphological feature where Itajubá is located in the Campos do Jordão Plateau,where the parts of the relieves, have high points, therefore only some sections keep thenselves semi-planing with convex slope small hills. The urban space of Itajubá is in an average high quota around 848m, although the county has high quota which varies around 800m to 1,300m. The climate in this region is tropical mesothermic-mild moist all year(the anual average climate varies around 18^0C to 19^0C, what is explained by the orography. It is the Cwb climate, according to Koppen classification. The average of the precipitation is around 1,400mm per year" (KAEFER et al., 1979). The driest period is also in july, which occurs the lowest temperatures around $16,5^0$C. The dry season is from May to September and the rainest period is frequently January.

3. METHODOLOGYCAL PROCEDURES

During the research, it had been used the systematic perspective proposed by BERTANLAFFY(1950) and the space to be analysed made by the city of Itajubá is crossed by the hydrographical basin(Sapucaí basin), in which the imputs and outputs of material andenergy occur among the others elements that integrate the system, and with the exterior. In the methodological procedure the following material was used: Topographic Map SF-23-Y-B-III-3, from the general coordinations and Planning Ministery-IBGE-Map of Brazil, scale 1: 50,000, 1971; Itajubá- MG city Map with the blocks and the pluvial drainage in the scale of 1: 10,000 of 1992, up-to-dated in 1999, made by Itajubá City Hall. Altimetric Map of Itajubá city-MG 1991, scale of 1: 20,000 made by the Itajubá City Hall; Map of the urban pluvial system 1992, up-to-dated in 1999 in the scale of 1: 10,000 made by Itajubá City Hall, Air pancromatic photographies scale of 1:800, from EMBRAFOTO acquired at CEMIG(Minas Gerais Eletric Central Station), computer programme as the Autocad R-14, the sufer 6, the IDRISI for windows 2.0 and the Corel Draw 7; South of Minas newspapers from 1945 to 2000, where important flood events in Itajubá had been described, data also were checked with field work as documents and interviews in the City Hall of Itajubá,

data from the SEBRAE workers of Minas Gerais, who work at Itajubá office; measurements of 2000 flood mark level left in several points of the city. All the maps were made in Autocad 14.

The photointerpretation was made with airphotos and the soil use map was gotten based on the methodological proposals of Pereira, Kurkidjian and Foresti (1989) besides Carrara(1992). The gotten classes were:1) Unifamiliar Residential, 2) Multifamiliar Residential, 3) Conventional Services, 4) Institutional Use, 5) Estate, 6) Empty Areas, 7) Areas with Native Vegetation(forests), 8) Industrial, 9) Water Channels and Courses, 10) Cattle Raising, 11) Transport, 12) Exposed Soil.

Declivity map was made having the abac as support. The data of the curve map of the city level in dwg file were worked in Surfer 6, elaborating the Digital Landfull Pattern and exporting the data the grd file to IDRISI, it was made a declivity map of the city. The Maps in Abac showed better the reality of the irregularities of the land if compared with the map made with IDRISI support. The declivity classes choice was based on the Cruz(1974) proposal for areas of big declivities. The classes are the following:**Class A:** <= 2%, **Class B**: 2< d< 5%, **Class C**: 5< d < 10%, **Class D**: 10 < d < 20, **Class E:** 20 <d< 30%, **Class F:** 30< d < 40%, **Class G** el >= 40%.

The geomorphological map of photointerpretation area was made from 59 air photos to get the geomorphological units following the Tricart (1965) proposal, Brazil (1983) and Guerra (1987) were: **1.1** Degraded relief(K); **1.2** Degraded relief (KA) (emphasis to the anthropical); **2** Accumulation relieves; **2.1** Accumulation of plain and Pluvial Terrace**; 2.2** Accumulation of Pluvial Plain; **2.3** Accumulation of Pluvial Terrace; **2.4** Pluvial Terrace; **2.5** Coluv Sloping; **2.6** Coluv Sloping and Pluvial Terrace; **2.7** Coluv Sloping and Accumulation of Pluvial Plain(RC+ATF); **2.8** Coluv Sloping and accumulation of Pluvial Terrace(RC+ATF); **2.9** Coluv Zone; **2.10** Torrential Accumulation as a fan shape; **2.11** Abandoned meanders. This map was data processed in Autocad R-14 and the data were sent to IDRISI 2.0. After elaborating the declivity map with IDRISI 2.0 these data were crossed and exported data to IDRISI 2.0 from the map with the geomorphological units of Itajubá. Besides, datas from the classes of the Declivity Map were also crossed with the data from the use of the soil map and with the data from the geomorphological units of Itajubá.

4. RESULTS AND DISCUSSION

The urban structure as well as the soil use, were set by the physical components of the natural landscaping and the attraction means(for example the production; flowing off through the roads and the railways), which occured during the years, up the occupation and consequently pushing the concentration of the population on the central region of the city and linear, along the principal river flow, Sapucai and its affluents. Through the observation of the field-work, a trend of the poorest population occupy the outskirt is noticied, on the up slope of the pluvial valleys which go through the city.

There are twelve classes of soil use in period of 1981 in Itajubá city. as followin: **Class 1 unfamiliar residential**: big concentration downtown and in the nearby districts, as the district Porto Velho, Varginha , Oriente, Morro Chic, Pinheirinho, Boa Vista and the Avenida District too; **Class 2 Multifamiliar Residential**: This is a very reduced class, only downtown; **Class 3 Conventional Services**: included hotels, Hospitals, Public offices(federal, stadual, municipal), banks; **Class 4 Institutional**: A part this class can be found downtown and also in other districts (Varginha District, Orient District, Cruzeiro, Porto Velho); **Class 5 Estate**: Beginning occupation areas, (Vila Poddis, Santa Luzia, Santa Rosa, Vila Rubens, Açude, Santos Dumont, São Sebastião, Cantina, Nossa Senhora de Fátima and Rebourgeon); **Class 6 Empty areas**: There are empty areas in several places of the city, although they can be seen much more in the weast part of the city(villa Podis, Industrial area and Nações); **Class 7 Areas with native vegetation (forests)**: few areas with this kind of vegetation and generally they are in the outskirts of the city; Class 8 Industrial: the industrial area, further west from downtown, in a outskirt area; **Class 9 Water channels and Courses**: the principal pluvial course which goes through the city in a southeast-northeast direction which name is Sapucai river having José Pereira, Água Preta, Anhumas and Piranguçu as its tributaries; **Class 10 Catlle Raisin**: they are located on the outskirts, and the production most of the time supplies the in marketing; **Class 11 Transport**: the roads BR-459 and the MG-290; **Class 12 Exposed Soil**: There are few examples(Santos Dumont District, Vila Rubens Açude, Varginha and Morro Chic).

Pedra Mamona District is the place where Sapucaí river is in a quota of altitude around 840 m. In the flood plain the declivity varies between the class A(0 to 2%) and the class B (2 to 5%). Along the Sapucaí river course through the Itajubá urban space there are the following relief shapes: Accumulation of Pluvial Terrace, Pluvial Terrace, Accumulation of Plain and Pluvial Terrace, Accumulation of Pluvial Plain and Abandoned meanders. The degrated can be noticied (Crystal-Clear pre-Cambrian), with the presence of slope with declivity around 10% to 40% aproximately. It is also noticied on itajubense landscape, a lack of vegetation not only in the urban space but also on the sloping and on the top of the hills which surround the city. Because of this, the sediment carried by the torrents will contribute to block the urban Pluvial system which becomes unable to keep the speed of the urban superficial drainage.

Analysing the crossing tabulation in the IDRISI of the class on the declivity map with the geomorphologic units of Itajubá, it is verified that the geomorphologic unit which has the biggest area is the degraded relief (crystal-clear), with 19,84 km^2 distribuited by all declivity classes, but on the **Classs D (10 – 20%) and E (20 – 30%)** the crystal-clear is much more representative occupying an area of approximatly 13 Km^2 . Other morphological units have showed in the city as an area of accumulation of the plain an the Pluvial Terrace with 7,60 Km^2, the area of accumulation of the Pluvial Terrace with 1,78 Km^2 , and the area of accumulation of the Pluvial Plain with 1,03 Km^2 and the Pluvial Terrace with 0,98 Km^2 . The districts of Cruzeiro, Estiva, Oriente, Rebourgeon, Santa Lúcia, Santo Antônio, Novo horizonte, Capetinga , Vila Poddis are examples of the districts with the declivity varying around 20% to 40% in some areas. In the analisis of the use of Urban Soil Map of Itajubá in 1981, if compared the city area which had been during this period with the urban limit area nowadays (1999), it can be verified that an elargement along the pluvial plain had been occuring but there had been a growth occupying the sloping areas with 30% or more of declivity inadequate to the structure and use of the urban soil. There are in some parts of

some districts in the urban space as, Novo Horizonte, Açude, Pinheirinho, Cruzeiro, Estiva, Oriente, Santo Antônio and Rebourgeon, where the declivity in some part of this districts is bigger (around 30% or more), the occupation is considered inadequated according to the Federal laws.

The analyses of the **table 1**, resulting from the crossing of the classes of declivity with the classes of the soil use, in Itajubá, class E of declivity (20 - 30%) occupies an area of 2,69 Km^2 and the class F of declivity (30 - 40%) occupies an area of 0,32 Km^2 in a total area of the city around 18,71 Km^2, in 1981. In the two classes of declivity it was considered the occupied area by the classes of the soil use. Residential Familiar, Residential Multi-familiar, Conventional Services, Institutional Use, Estate and Industrial. Then, the area occupied by the classes of use quoted in E and G classes of declivity is related to 2,76Km^2 of the urban space of Itajubá, in 1981. In the classes A and B of declivity, there is an area a11,14 $Km^{2,}$ which is 59% of the aproximatly total area of the city, in the classes Residential Familiar, Residential Multifamiliar, Conventional Services, Institutional Use, Estate and Industrial located on the space of the flood plain.

	1.1.1.1			Declivity Classes				
1.1.1.2 Use of Soil Classes	A (0-2%)	B (2-5%)	C (5-10%)	D (10-20%)	E (20-30%)	F (30-40%)	G (40-99%)	Totais (km^2)
Residential Unifamiliar	1,34	0,43	0,15	0,40	0,19	0,01	0	2,52
Residential Multifamiliar	0	0	0	0	0	0	0	0
Conventional works	0,12	0,05	0,03	0,02	0,01	0	0	0,23
Institutional	0,48	0,30	0,04	0,07	0,07	0	0	0,96
Estate	0,38	0,20	0,09	0,23	0,20	0	0	1,10
Empty Areas	4,36	1,85	0,77	1,83	1,23	0,14	0,03	10,21
Native Forest	0,21	0,07	0,07	0,35	0,59	0,11	0,03	1,43
Industrial	0,28	0,10	0,04	0,20	0,37	0,06	0,01	1,06
Water Flow- Course	0,27	0,10	0,02	0,02	0	0	0	0,41
Catlle- Breeding Areas	0,03	0,04	0,03	0,04	0,01	0	0	0,15
Transport	0,16	0,07	0,02	0,04	0,02	0	0	0,31
Exoposed Soil	0,23	0,07	0,01	0,02	0	0	0	0,33
Total (km^2)	7,86	3,28	1,27	3,22	2,69	0,32	0,07	18,71

Table 1 – Crossing of the declivity map class with soil use map – Itajubá – MG*. Source: Crossed of the data declivity class with class of the map use of the urban - Idrisi 2.0.* The urban area considerated - 1981.

The Urban Pluvial System, in the study area isn`t enough, mainly on the up sloping areas what increases much more the superficial drainage, carrying the sediments to the botton of the valleys of the pluvial drainage in this space. Analysing the releif conditions of the study area, a digital land pattern was observed and geomorphologic map of Itajubá, the relief shapes identified with the construction of this pattern, the geomorphologic units were confirmed. Among the units of relief two of them are prevailing and are related to the flood plain, where there are the abandoned meanders and the pluvial terraces, important aspect of this plain which was occupied by several districts of the city as part of Santa Rosa, Imbel, Nossa Senhora de Fátima, São Sebastião, Varginha, Pinheirinho, Medicina and a small part downtown, Vila Isabel, Vila Poddis and the most part of the districts, São Vicente, Avenida, Boa Vista, Vila Rubens, Santos Dumont, São Judas Tadeu and Industrial District. The most expressive releif shape in the class 1 of the use of soil (Residential Unifamiliar) is the degrated relief class which correspond to the crystal-clear and occupies an area of 17,76%. Senhora de Fátima, São Sebastião, Varginha, Pinheirinho, Medicina and a small part downtown, Vila Isabel, Vila Poddis and the most part of the districts, São Vicente, Avenida, Boa Vista, Vila Rubens, Santos Dumont, São Judas Tadeu and Industrial District. The most expressive releif shape in the class 1 of the use of soil (Residential Unifamiliar) is the degrated relief class which correspond to the crystal-clear and occupies an area of 17,76%. Senhora de Fátima, São Sebastião, Varginha, Pinheirinho, Medicina and a small part downtown, Vila Isabel, Vila Poddis and the most part of the districts, São Vicente, Avenida, Boa Vista, Vila Rubens, Santos Dumont, São Judas Tadeu and Industrial District. The most expressive releif shape in the class 1 of the use of soil (Residential Unifamiliar) is the degrated relief class which correspond to the crystal-clear and occupies an area of 17,76%. (Residential Unifamiliar) is the degrated relief class which correspond to the crystal-clear and occupies an area of 17,76%. The degraded relief is found in most part of the city although its occupation has been bigger during the last two decades (as slope) in the city (19,86Km^2). In the profile E – F (direction north-South) the direction of this one crosses Pinheiro district (José Pereira stream plain), part of São Vicente district with areas a little higher varying from 840 m to approximatly 880 m high, besides Medicina district with high varying from 860 m to 900 m. Visualizing the digital land pattern and the topographic profiles, one more contribution can be acquired in the avaliation about the aspects of the relief co- related to the occupation of Itajubá. Because of this, new analyses to conclude the study about the environmental problems of Itajubá is able to be done. The climate of the area CWb is also another factor that contribute to the flood occurence of orographic rains, frontal and conviction. On January 2000 there was one of the biggest flood with enourmous damage to the population and the district Nossa Senhora de Fátima, São Sebastião, Santos Dumont, Cantina, Pinheirinho, besides Boa Vista, Varginha, Porto Velho and Vila Rubens were drastically affected. The occurence of big flood on the riverside of the tributaries as Bicas and Santo Antônio river, for example, located upstream Itajubá can, contribute eventually to the overflowing of the biggest channel of the river in the urban space. In the beginning of January 2000, and the days 02, 03, 04, 05 and 06 rained a lot and the water stayed four days in the flood plain, contributing for the big damages .one that suffered more with

the flood of 2000. The flood (January 2000), in Pinheirinho District, varied from 1,90 m to 1,40 m. In the other districts as Nossa Senhora de Fátima, the higt points of flood vary from 2,90 m to 1,70 m, which shows that the occurence of 2000 brought many damages and suffering to the population in this area relatively occuppied.

To control the flood several structural and non- structural decisions were proposed by BARTH & POMPEU (1987) and by MOTTA(1999), these proposals complete by thenselves. Based on this proposals some decisions of flood control to Itajubá: **Emergencial decisions**: Setting up a program to deobstruction channel of Sapucaí river and its tributaries besides the channels, servers and ducts are part of the system urban drainage system of pluvial water, agroup of people to clean in all the region, streets and land; deobstruction of the bridges vain; checking and studying to correct the critical points of the drainage system; setting up a Comission of high Sapucaí Basin published in the government journal Minas Gerias state.
Long and short term decisions: Development of a Drainage Urban Plan; work realizations and actions with the goal of becoming better the water flowing, with the bridge widening which interfer in the drainage of water mainly in the rain seasons, in a Tropical Climate area (Cwb), convection rains, orographics and frontals; setting up the works to avoid the flood, with the objective of keeping the pluvial water back, in away that the drainage becomes slower. In this context some decisions have been done:**1.** piping of the slope streets with duts; **2.** on the pain areas small reservoirs have been built to collect rain water; **3.** the setting of reservoirs in buildings and houses; **4.** enlargement of the green areas in houses, buildings, sidewalks and lands; **5.** removal of rublish; **6.** periodical urban garbage gathering; **7.** maintenance of preservation areas as forests; **8.** aspects of drainage have been considering in the landscape projects in slope areas; **9.** inspection and cumpliment of the existent legislation, as well the urban plan regularization; **10.** an environmental programin school and midia; **11**. an alert plan to avoid the flood supported by FEPI with IGAM (MINEIRO INSTITUTE OF MANAGEMENT OF WATER); **12.** Setting a fluviometric and pluviometric network on Bicas reiver by Imbel, up to Delfim Moreira county. **13.** A study to setting up a network of small dam, to upstream Sapucaí river; **14**. investigations of the dredger work along the Sapucaí river and its tributaries; **15.** program of reforestation on the riverside and a work together the farmers of the region with the objective to teach them the best way to preserve the environment mainly along the water course of the Sapucaí Basin.

5. FINAL CONSIDERATIONS:

In itajubá urban space there are several physical characteristics of the landscaping as releif, climate and vegetation which together the declivity, the superficial drainage, the soil occupation, make the occurence of the flovd. in this area. Having a high declivity in some parts of the city, the vegetation is taken off from the slope areas, and the occupation of these nuv spaces with new estate areas were happening along the years without an orientation of the population or even without complying with the Federal Laws. Thus, besides a pluvial system which does not take in consideration the necessities of the urban areas, these discussed factors contribute to the existence of enveronmetal problems in the urban space of Itajubá (the flovds). Through this view of anylise, from several informations gotten along this research, its is very important to all the segment of the society the proposals done by this study and setting them on the urban space of Itajubá: **1)** The flovds are natural events and they will occur, but the problem must be discussed with the population, looking for an environmental education which may minimize the economical and social loses. **2)** The government must plan in an adequate way the urban space organization, and integrate the comunity with these problems. Thus, the management of the up Basin of Sapucaí river must be a work towards the population. According the observations not only the government but also the city as the habitat of the men become a place where the development and the preservation can run together. The enforcement of the structural and non-structural decisions, researched here, don't have the intention to exhaust the subject, but to contribuite to minimeze the flovd problems in Itajubá. The search for a defensible development which guarantees the welfase of the people and a true way to the community.

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