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GIS for Vulnerability to Natural Hazards

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***Abstract*:** *A natural hazard is a dangerous threat untimely event due to natural phenomena (landslides, earthquakes, floods etc.) All the manifestations of forces of nature are called phenomena. We are speaking then of natural risks when these problems are threatening, with varying degrees, human activities, causing significant damage to human life, property and the environment. The need to consider natural hazards in land use planning tasks has become a major concern.*

During these past years, the town of Constantine (Algeria) has been hit by frequent natural disasters, with the most recent ones endangering the lives of people and causing priceless damage, faced with such a situation the company of adequate measures, capable of exercising effective prevention, is essential. In addition to the seismic risk, for which prevention still needs to be improved, Algeria must also face gravity processes such as landslides. By their suddenness, they can put people in danger and destroy entire buildings involving the evacuation of entire neighbourhoods where the financial impact is significant on the state budget and local government.

The main interest of the present paper is the feasibility of a plan for prevention of natural disasters related to landslides based on a cartographic approach to the vulnerability of land to potential risks in this area by using the code ArcGIS, and eventually lead to a Zoning risk that would be considered for inclusion in the Master Plan of Urban Planning and Land Use Plan and provide support for decisions taken by local authorities for the selection of sites.

Keywords: *Geotechnical hazards, landslides, ArcGIS, vulnerability.*

1. Introduction

The risk of slip is a space event, related to the ground, and the chart is always its privileged support. The cartography and the database try to answer the following questions:

- Where can occur a landslide?
- When and at which speed that it will arrive?
- Which type of movement?
- Which is the safety margin?
- Which will be dimensions of the slip?
- Which will be its extension (downstream or upstream)?

2. Historical of the Prevention Plans of the Risks

The cartographic studies are made on various scales, the studies with large scales being field of the local authority. One can distinguish three classes from scale: lower than 1/100000, higher than 1/10000 and between these two limits (Vaunat 1997) [1]. In France the scales employed are the 1/25000 and the 1/5000. (Chart of state major and registers) (Leroi 1996) [2]. In Norway the state has a role of prevention; it indexes the risks and formulates councils. It carries out works of prevention; the detailed studies are with the load of the municipalities as well as the renovation work. The scales employed are the 1/25000 and the 1/5000 (Berggren 1992) [3]. In Sweden, the State studies the risk on a scale territory and the municipalities assume the responsibility for the detailed recognition. The government grants a help if the risk is imminent (Ahlberg et al. 1988) [4]. In Hong-Kong, (200 islands, 1050 km2), Geotechnical Control Office makes the analysis of the risks relating to the ground and strongly related to pluviometers. A network of pluviometric stations very dense is the

essential component of the alert device. Many statistical studies made it possible to establish a chart of classification of the grounds, connected to the use of the grounds and the limitations attached to their use. Many analyzes of stability are also charted. The scales employed are the 1/20000 and the 1/2500 (Brand 1988) [5], (Fell et al. 1996) [5]. In Italy, several national plans were undertaken to chart all the movements of ground, either by area or by route. The scales employed are the 1/400000, 1/100000 and the 1/10000. Since 1908, a program had listed all the cities to be rebuilt, program which did not have many continuations (Canetti 1988) [6]. On Quebec, the law imposes the realization of charts of risks, which are important considering the geological nature of the grounds (sensitive clays). In Brazil, the town of Rio de Janeiro has an inventory charted of the landslides as well as charts of risk (Barros 1992) [7]. In Romania, a multi criteria approach allowed the implementation of cartography thanks to a SIG (Rosenbaum et al. 1996) [8]. Because of the laws existing for the majority of the countries, and the impulse given by UNESCO, (decade of the natural risks), the need for management and decision is essential in almost everywhere. The manager of the territory cannot be satisfied any more with descriptions and wants increasingly powerful tools to be able to make relevant and equitable decisions. In Algeria, the gallop growth of demography, the anarchistic urbanization, and the all disordered state environmental pollution of the ecosystems make worsen the width and the frequency of the catastrophes underlines “Symbiosis” in its last edition.

According to the Plan of the United Nations for the Environment, the median number of victims is 150 times higher in the countries in the process of development than in those developed. The specialized magazine in environment estimates that in the case of Algeria, it is more than urgent to pass “from a fight plan or rehabilitation to a strategy of prevention of the catastrophes”. “Symbiosis” refers to a recent conference on the prevention of the risks to quote the Minister for Town and country planning and the environment, CHÉRIF RAHMANI, who insisted on a better sensitizing of the public to the risks caused by the environmental dangers, natural and technological. It should be noted that pollution by hydrocarbons is a topic which particularly held the attention of the specialists.

In three years, Algeria was shaken by the floods of the district of BAB EL OUED of Algiers in 2001; the earthquake of ZEMMOURI-BOUMERDES in 2003 and the chemical accident (gas) which has occurred in the industrial park of SKIKDA in 2004 and the landslides of Constantine 2005.Les public authorities are still frequently stripped as regards forecast, of prevention and of management of natural phenomena to the sometimes dramatic consequences (landslides, muddy castings, cliff collapses, falls of blocks, collapses of underground cavities etc.) the operation has aimed at improving the knowledge acquired for several years in the various aspects of the engineering of the natural risks: identification, characterization, forecast of the behavior of the phenomena, definition of the tools of cartography and risk management related to the movements of ground in comparison of the people, the works, the networks and the threatened goods. Generally the main risk is characterized by many victims, high costs of property damages, environmental impacts: the vulnerability measures these consequences.

The major risk is thus the confrontation of a risk with stakes. Thus the company as the individual must be organized to face there. An event potentially dangerous hazard is not a major risk that if it applies to a zone where human stakes, economic or environmental are in presence. Two criteria characterize the major risk:

- a weak frequency: the man and the company can be all the more inclined to be unaware of it the catastrophes are not very frequent;
- an enormous gravity: many victims, important damage with the goods and the environment.
- hazard: probability of appearance of a phenomenon given on a given territory, during a given base period. The risk is characterized by (3) three elements according to the case, such as for example: description of the phenomenon, space definition (starting point and spreading) and appreciation of the temporal occurrence (not very probable rupture in the 5 years).
- Stake: People, goods, equipment or environment threatened by the risk and likely to suffer damages or damage.

Any citizen with right to information on the risks to which it is subjected, like on the means of protecting itself some.

The risk term includes all kinds of risks including natural hazards. The prevention plan of the risks approved is worth constraint of public utility and imposes limits on the property right and the right to use the ground (Code of town planning); PPR also is essential on the POS (Plane of occupation of the grounds) to which it must be annexed, and intervenes in the delivery of permit building.

3. The Town of Constantine (Algeria)

3.1. History

Since about thirty years, the town of Constantine (East Algeria), located on much escarped, broken grounds and seismically active, episodically knew serious problems of slips. The latter parallel to appeared a fast and anarchistic urbanization around the site of the old town. These movements worsened at the time of the stormy rains of 1986-1987, of July August 1994 and September 1998. Indeed, the majority of the landslides are reactivated during the winters when average pluviometer varies 306mm with 733mm.

Moreover, the out datedness of the buried networks of the cleansing and drinking water has sudden damage, non-localized, having involved escapes which support the lubrication of surfaces of separation, worsening this manner the problem.

Since 1998, expertise's carried out by international and national specialists on the unit in the sites led to conclusions recommending of the studies very targeted on each site in order to stabilize, when that is possible, the movements of the ground and to instrument each zone at ends of prevention (Paulsen et al. 1998) [9].

We present in this article, the various sites touched by this phenomenon, on the one hand, and having an important data bank and on the other hand, some typical cases of slips anthropic following a fast and anarchistic urbanization represent.

In 1999, on the whole of the urban area (old and new urban fabric), sixteen (16) sites presenting a strong potential of slip were listed.

The urban area of Constantine of a surface of 5001 ha presents ten zones of slips (figure1) representing an entire surface of 165 ha is 3.3% with a great concentration of inhabitants of about 16%.

The landslides which watch for the town of the bridges and make him incur a real and imminent danger of a catastrophe with large scales. These movements are very old and are reactivated when the opportunity arises which are in figure 2. The town of Constantine, object of this article, is relatively well documented. The objectives of this work are:

- The synthesis of the data of this city.
- The evaluation of the characteristics geological, topographic, hydrogeological and geotechnical and vulnerability of the frame of this city.
- The development of a model of reference compared to the close zones.

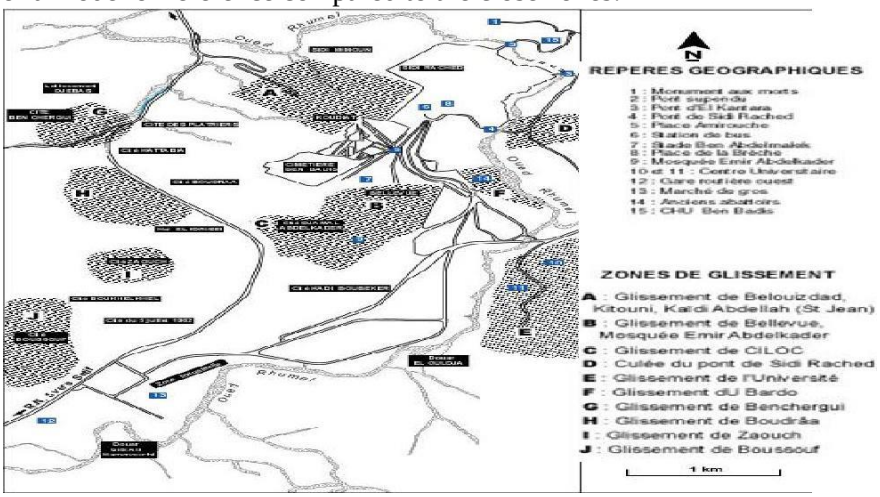

Fig. 1: Principal zones off slipways located in the urban perimeter (Constantine) [10].

3.2. Geology

The geological units (figure 2) which level in the area are:

- The rock of Constantine,
- Me-pliocène marly,
- Recent deposits of Quaternary and filling materials lay out by the human activity.

The two last units, little or not consolidated, are at the origin of the slips of Constantine.

The rock of Constantine: They are massive limestone's of Cénomanien age in Turonien on which the old town was built. Tectoniquement this rock is presented in the form of a horst faulted to side SE monoclinal having continued to unequally raise in `' keys of piano" during the Quaternary one.

Marne's Me-Pliocene: This calcareous series is overcome by a thick layer of marnes black of Campanien age having a low schistosity sometimes. As the slope of the substratum on which these marnes rests is important slips appear with the favour of exceptional natural phenomena the such for example pouring rain and the earthquake of 1910 and 1947 respectively which involved serious damage with the abutment Is Bridge of SIDI RACHED. These units level on the east coast of RHUMEL. North of the Boumerzoug junction and with the South of the Rock including the upper part of the abutment Is of Pont SIDI RACHED. Conglomerates and sands of the Quaternary one: Parallel to the tectonic movements of rising of the rock, a powerful series of continental layers settled. It acts from top to bottom of an alternation of conglomerates and sandy clays red:

- Gravels with blocks which can reach 0,5 m^3 of volume embedded in a muddy silty clay sandy clay: Thickness 0 to 3 m.
- A more compact whole of water limestones, pisolitic travertines, limestones and sands passing with silts and vases presenting remains of Vertebrate associated with a paleolitic industry. Thickness 0 to 10m.
- Red clay plating of decalcification. Thickness 0 to 1 m.
- Formed alluvial sand deposits and silts are localized on the level of the bed of RHUMMEL. Their thickness is variable.
- The embankments resulting from the human activity are very widespread in the area. A large fill exists close to the Western termination of the Bridge SIDI RACHED. The movements of ground noted on these levels were the cause of the damage which affects the neighbouring constructions and roads: the station of the buses KRIKRI in is an example. More serious still, a former garbage dump, poses a considerable risk at the houses built upstream and the downstream of this one.

The whole of these continental formations, little or no consolidated, are very sensitive to instabilities of the slopes and the landslides (Deleau 1967, Vila 1977, Lahondere 1987) [11-12-13].

3.3. Morphology

The town of Constantine developed on a very escarped and broken topography of TELL CONSTANTINOIS. The site is dominated by the rock of Constantine which is presented in the form of a calcareous escarpment with an abrupt Western bank. The altitude of the rock is roughly 625m. While running out towards North. The WADI RHUMEL cuts the rock in a spectacular throat formed by karstification (figure4). RHUMEL with the bridge of EI MILIA reaches approximately 360m. Creating an uneven maximum of 265 m in the area of our study.

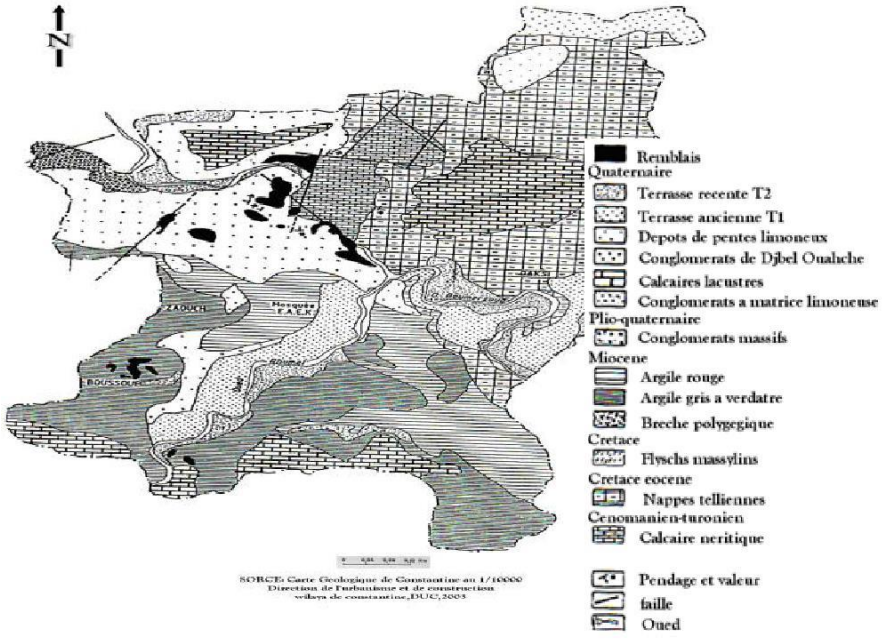

Fig. 2: Geological map of the commune of Constantine [15].

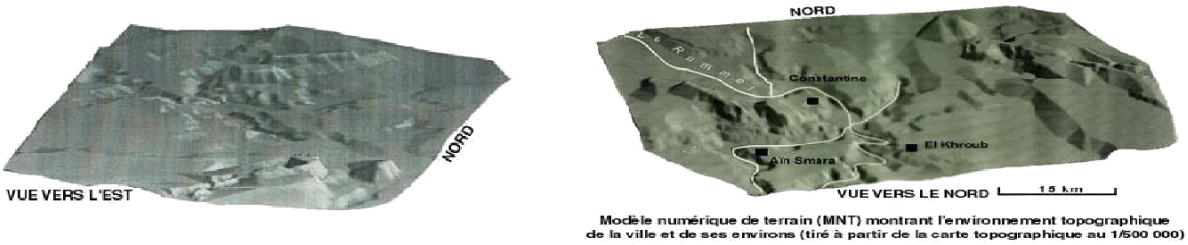

Fig. 3: Morphology of Constantine and its area (Belouar 2005) [14].

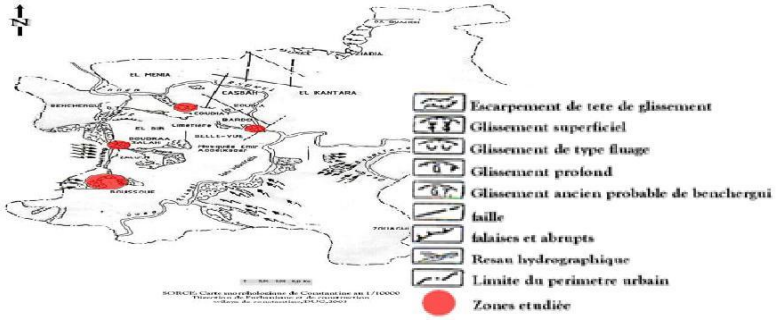

Fig. 4: Geomorphological chart of the commune of Constantine [15].

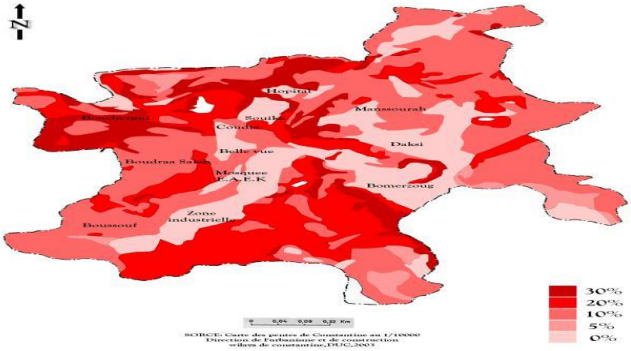

Fig. 5: Chart of the slopes of the commune of Constantine [15].

The risks identified on the area of Constantine are primarily related to structural factors such geology, topography, the structure (faulted or not), hydrology and the parameters geotechnical and others worsening such as the human action (anarchistic urbanization, excavations in foot of the slopes, failing drain of waste water), seasonal precipitations without to speak about certain parameters to take into account when it is about an old or new movement

The analysis of these factors starting in these zones will make it possible to define zones of presumptions in these sites or these factors are very important of share the vulnerability and the stakes (built and goods and equipment) as shown in the figure 6 (it is the case of only one site to knowing Boussouf).

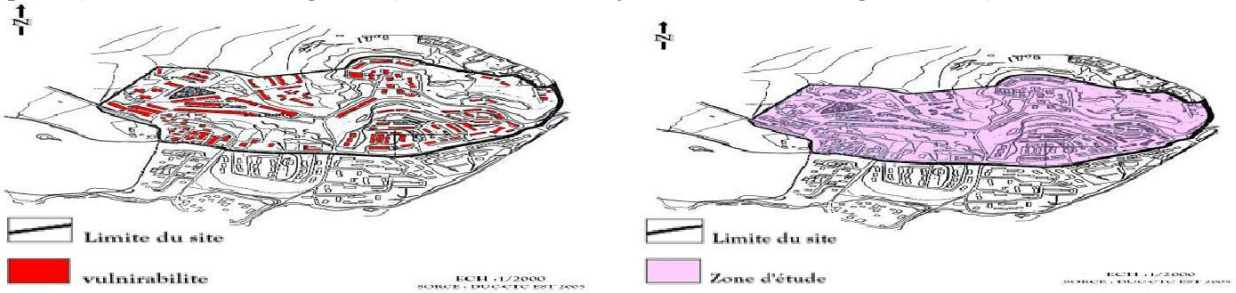

Fig. 6: Plan of BOUSSOUF site a: vulnerability b: distributions of the small islands [15].

3.4. Zoning of a potentially unstable area

The goal is the determination of cartography for the area to be used like background document joint in the master line of installation and the plan of occupation of the grounds in order to avoid the errors of appreciations

of the slopes (Fabre et al. 1998) [16]. Methodology suggested is based on a qualitative analysis of the determining factors (Belouar et al. 2005) [17-18]. problems of the movements of ground. Work consists with:

- Inventoried all the sites of the area touched by this phenomenon.
- To analyze the various studies carried out before on these sites.
- To develop the determining factors according to the compilation of the data.
- To draw up the charts of risks and stakes

To define the risk of the movements of ground like zone of appearance of a phenomenon on a studied area (chart of zoning).

starting from the data collected for each zone, put in form and inventoried on a basis of data within the laboratory of materials and durability of constructions of the University of Constantine for all the sites of the city and in close cooperation with the laboratory of the research unit of civil engineering U.R.G.C of geotechnical of the National institute of Sciences Applied I.N.S.A of Lyon one can illustrate this by a cartographic representation while using the superposition of the charts for obtaining of a geotechnical zoning. To extract the determining factors by the data analysis; To quantify the probability of the risk movements of ground and to chart the distribution of it.

4. The Chart of Zoning

Thus if one makes the transposition of the data collected, inventoried and put in form on the charts and applying the method of estimate of the possible hazard of instability in a sector considered, gives for the case chosen, following zoning as the figure 7 shows it. The examination of the chart shows three zones. It is noticed that the zones which present a possible hazard or declared are primarily related to the level of the marl formations. Sectors likely to be arranged on the condition of carrying out work of stabilization of the ground and to ensure a mode of foundation which must absolutely take into account the risk of swelling. For another sector one meets sandy muddy argillaceous formations where the risks are weak, and their installation does not pose a priori any constraint of a physical nature.

This geotechnical zoning gives a general aspect of the sector considered, which makes it possible to avoid the large practical errors. But on the level of the specific execution, the specific study remains irreplaceable.

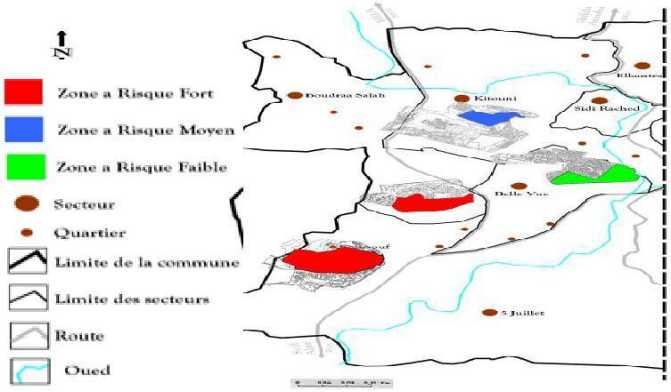

Fig. 7: chart of geotechnical zoning of some cities of Constantine

5. Conclusion

We have, through this paper presented a cartographic approach which offers a private interest to locate the zones exposed to the movements of ground and to give a qualitative evaluation of the risk.

The site of the town of Constantine admirably lent itself to the development of the method suggested because of the good knowledge of the various sectors prone to evolutionary movements and abundance of information geological, topographic, hydrogeological, geotechnical as well as the knowledge of the frame

Through model suggested by using the code Arc GIS treating the zone of BOSSOUF, we could locate the potentially unstable grounds. Moreover, Arc GIS makes it possible to create a broad database for if required leading to a zoning of the risk which would be taken into account to integrate it in the Master line of the Urban

development and the Plan of Occupation of the ground and to bring a decision-making aid taken by the local authorities for the choice of the sites.

Arc GIS has an important application for civil engineering projects like involve the management, analysis and integration of large amounts of geographic information to ensure success.

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