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THE PROXIMITY OF CITY - INDUSTRIAL ESTATE IN THE TOWN OF BATNA (NORTH EAST OF ALGERIA) MANAGEMENT OF MAJOR TECHNOLOGICAL RISKS THROUGH AN INTEGRATED APPROACH TO URBAN RESILIENCE

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Abstract: Urban resilience has become the subject of several scientific research in order to put the concept into operation as it is an important feature of a city's sustainability. Against this background, the proximity of industrial activity to the urban environment of the city of Batna, located in the North East of Algeria, has contributed to the rise of the concept of industrial risk, the prevention of which, demonstrates the fundamental role of urban resilience in the sustainable management of risk and urban disaster situations. This article is part of a Modeling of Application Data with Spatio-temporal features (MADS) approach for a territorialisation of integrated urban resilience with a view to meet the coordination needs amongst various highly interdependent actors and promote the development of integrated solutions that contribute to the city's resilience.

Key words: Batna, Industrial Area, Risk, MADS modelling, Urban Resilience,

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INTRODUCTION

In independent Algeria, the country has undergone a development strategy based on the setting up of a production apparatus characterized by a high integration capacity within gradually diversifying economic sectors. The rapid construction of a powerful industry was the main objective, the key priority, underlying all development policies (Mutin, 1980). This industrial activity has contributed to the emergence of the concept of industrial risks involving a large number of activities mostly associated with the manufacturing, use, storage or transportation of hazardous substances, either under the form of raw materials, products or waste entailing such properties as flammability, toxicity or explosiveness. Furthermore, the rapid and unbridled urbanization that affects risk areas is increasing the number of human, material, economic and

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environmental stakes, therefore worsening the vulnerability of the urban fabric and amplifying the devastating potential generated by major catastrophes (Herman, 2009; Laure and Emmanuel, 2005).

Located in the North-East of the country, the city of Batna is an appropriate case study on account of the urban sprawl casting together dangerous sites (industrial hazard sources), and, vulnerable, exposed areas of the city. The city's industrial estate was created outside the urban environment around 1974. Many hazardous facilities were built there. The city's urban sprawl has created a new neighbourhood located right in the middle of the industrial estate and the original urbanized areas, at the fringes of the factories hazard perimeter.

Nowadays, policymakers and land use planning professionals faced with industrial risk management issues need decision support tools for better management of catastrophic scenarios related to major risks.

The complexity of the interactions between the city, its urban services and technological risks finds an interesting response within the concept of urban resilience. This concept specifically allows meeting the challenges of the city's business continuity that should maintain its activity and recover quickly following a disruption.

This research focusing on the city of Batna aims to study the sustainability of industrial risks management by addressing the following issues:

How did the urban environment and the high risk industrial estate become contiguous, with major and widespread risk?

How can new geomatics technologies, including the Modeling of Application Data with Spatio-temporal features (MADS) contribute to improving urban resilience to industrial risks?

DESCRIPTION OF THE STUDY SITE

Encompassing an area of 2,852.41 ha, the city of Batna is located in the North-East of Algeria between latitude 35º34'23" and 35°31'26" North and longitude 6º7'59" and 6°13'31" East.

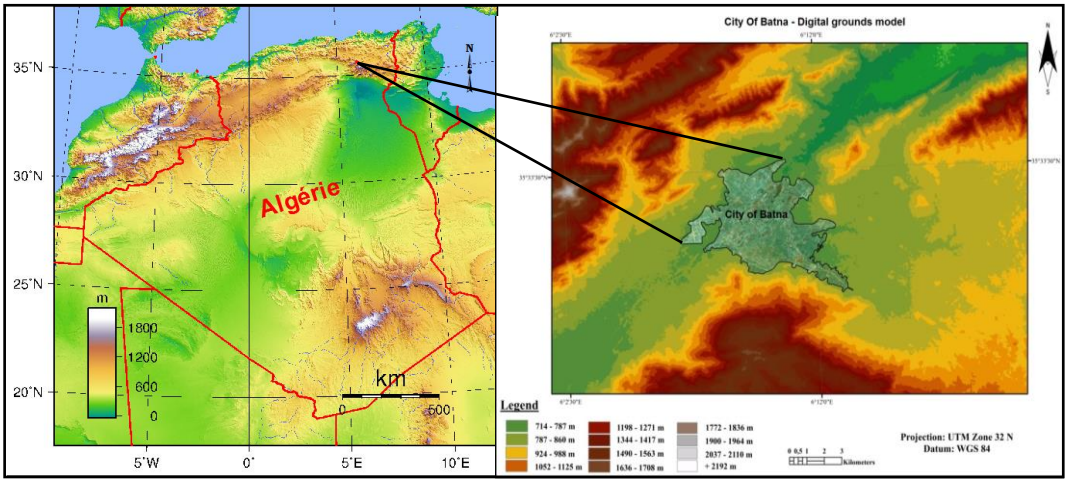

Figure 1. Location of the study area
Source: Habibi Yahyaoui

Positioned at the crossroads of cities such as Constantine, Biskra and Khenchela, Batna has acquired a polarising role. It was founded in 1844 in the middle of a natural bowl surrounded by jagged mountains from the Aures range, on a slightly sloping site, crossed by three major rivers and surrounded by rugged terrain; hence the label of "dish town".

This setting has played a major role in the urban sprawl of the city, its extension being faced by natural barriers, thus diverting the urban stretch into agricultural land and industrial areas created after the independence.

THE CONTEXT OF CITY AND INDUSTRIAL ESTATE PROXIMITY

The 1970s public industrial policies were marked by the establishment of several industrial estates outside the cities; many hazardous installations were initially set up outside built-up areas and away from residential districts. The city of Batna saw the implantation of its industrial estate in 1974, located in the North - East of the city.

Due to a lack of regulation relating to the management of major risks and urbanization on the one hand, and faced by demographic pressure and increased needs in terms of housing, neighbourhood facilities and urban infrastructure on the other, the policy of plastering over cracks and the increasing contiguity spawned the spreading outwards of the city, eventually reaching the factories in the industrial estate up to their danger perimeters, a movement enhanced by land development offers for disadvantaged population groups.

This lack of control of urbanisation has increased the vulnerability to industrial risks in the city, requiring new ways for decision support in terms of urban management and demonstrating the usefulness of upstream industrial risk integration, from the very first sketches of urban space design.

The classification of multi-date imagery of the american satellite LANDSAT allows us to illustrate and monitor diachronically the urban sprawl and the industrial estate smothering.

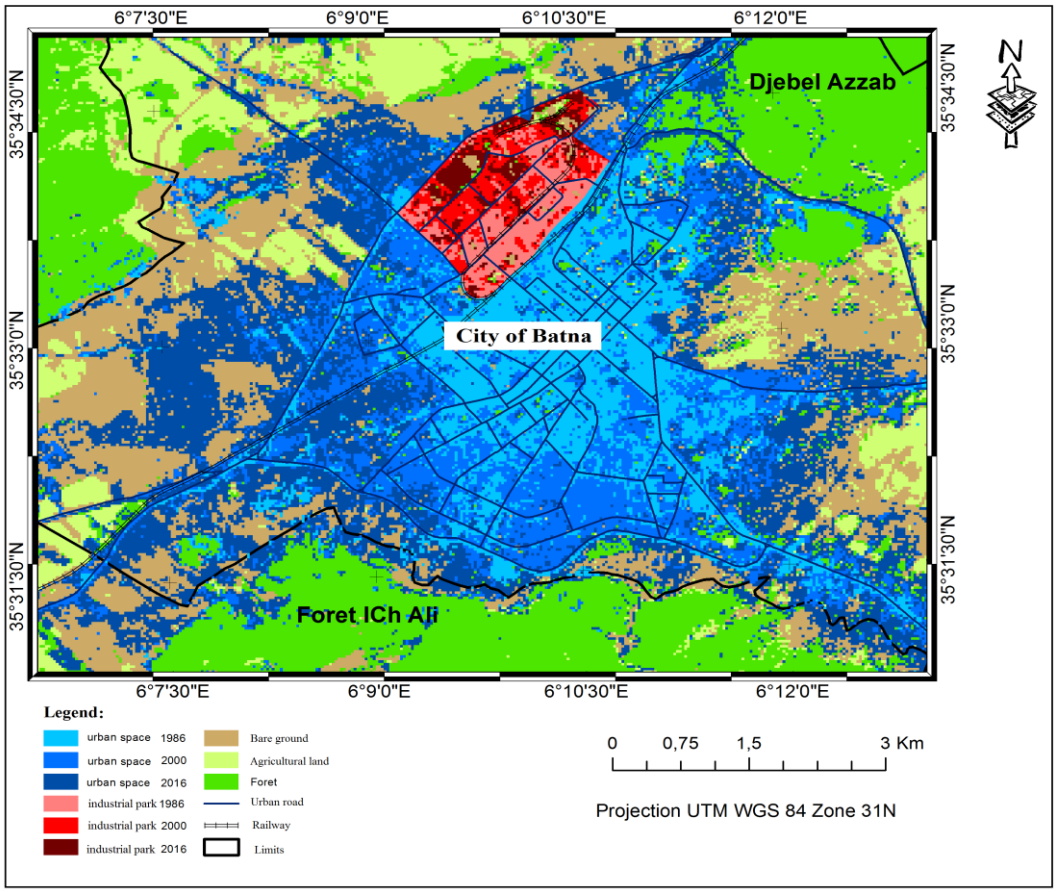

Figure 2. Diachronic monitoring of the urban sprawl phenomenon of the city of Batna
Source: Habibi Yahyaoui

TOWARDS AN INTEGRATED APPROACH OF URBAN RESILIENCE:

Industrial risk is an accidental event (fire, explosion ...) that may occur on an industrial site and have serious and immediate consequences on the staff, the surrounding population, property or the environment (DRM, 2014).

Today, the industrial area in the city of Batna is fully part of the urban fabric and this fact can result in an explosion that may cause varying degrees of damage and burns, depending on relative distance ranges.

Urban resilience to industrial risks resides in the inherent ability of an urban system to sustain shock or elude it. For this to happen, an organization may increase its resilience by acting both on the preparation, improvisation, emergency plans simulation and organizational learning.

Many theoretical definitions of resilience can be found in the scientific literature. Resilience can be perceived as "the ability to anticipate disruption, withstand it by successfully adapting to it, and recovering through restoring, as much as possible, the initial state prior the disturbance" (Marie et al., 2012, p. 5).

Therefore, urban resilience is a capacity that organizations deploy before the disturbance (in the phase of prevention and preparation), but also during the disturbance (in the response phase), and finally after the disturbance (in the recovery phase).

Consequently, urban resilience is defined as "the ability of a system to maintain or restore an acceptable level of functioning despite disruptions or failures". This definition encompasses three key concepts, namely:

- the system response to the crisis is perceived as a systemic approach;
- despite disruptions or failures, acceptability of disruptions or even system failures is necessary;
- the ability to maintain or recover before disturbances; the system adapts its management modes in order to be more resilient.

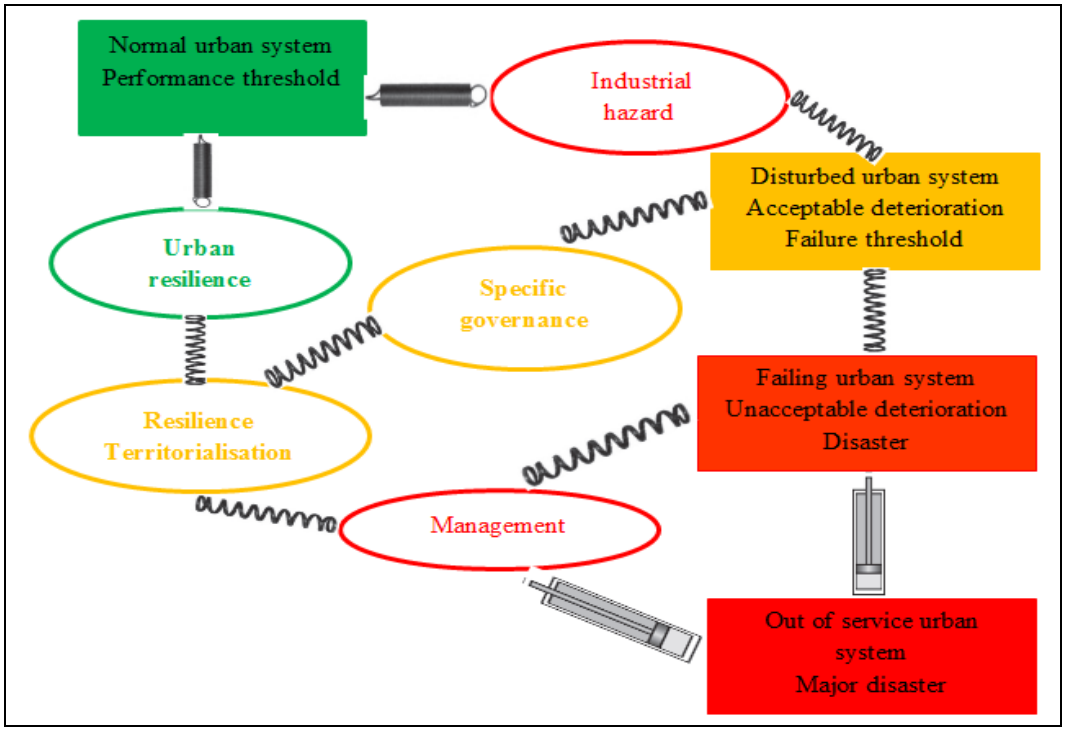

Figure 3. Mapping of urban resilience to industrial risk
Source: Habibi Yahyaoui

MODELLING OF APPLICATION DATA WITH SPATIO-TEMPORAL FEATURES - MADS

Urban resilience is perceived as the city's ability to absorb disturbance and recover its functions in its aftermath (Lhomme et al., 2010). On this understanding, the city is considered as a system in the sense that components (habitats, activities, infrastructure, populations, governance) interact to shape the urban system.

The main objective of integrated urban resilience management requires modelling of geographic objects, spatial relationships; for example, topological relationships, metric or even spatial aggregation relationship and the expression of temporality. MADS formalism (Modelling of Application Data with Spatio-temporal features). It was developed at the School of Computer Science's Database laboratory of the Swiss Federal Institute of Technology in Lausanne and offers an original method of modelling very focused on graphics. MADS is a conceptual entity-relationship model extended to the main concepts of object-oriented approach (complex structures, inheritance and methods) which also allows to model spatio-temporal applications (Parent et al., 2006).

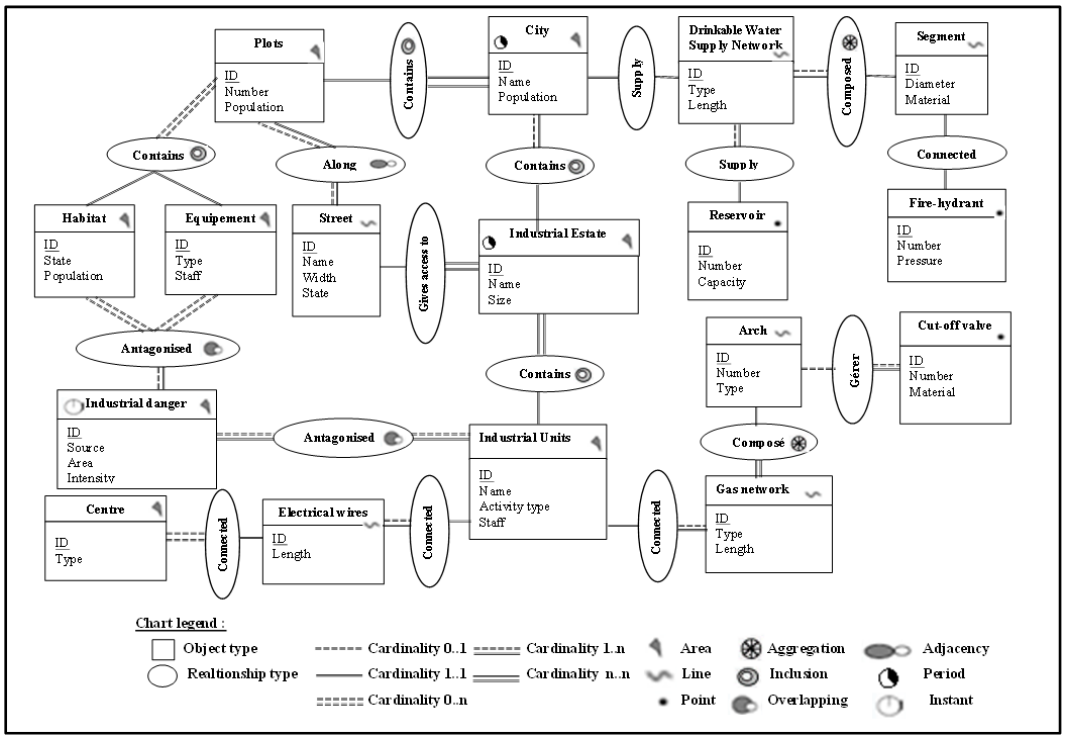

Figure 4. Conceptual Model of MADS data
Source: Habibi Yahyaoui

IMPROVING DISASTER MANAGEMENT THROUGH URBAN RESILIENCE INTEGRATION

The objective of the spatio-temporal modelling is not to define or evaluate the characteristics of urban resilience to industrial risks, but to build a process to develop a shared understanding and improve coordination amongst city administrators. Good governance of disaster situations requires technical and organizational resilience.

Organizational resilience

Organizational resilience is a strategy with a view to accelerate the return to normalcy through optimized management of means and resources as well as good accessibility. The scale of

the disaster, the complexity of interventions, the importance of interoperability and the operational response require a reorganization of the operational chain of command between the levels of decision through decision-making forecasting and operational effectiveness.

Evaluation of accidental impact on the site and the surrounding environment

Predictive mapping is the first step in the process of organizing relief for estimating damage and loss of life in the industrial unit and the surrounding environment. This assessment allows us to combine existing resources and the degree of risk.

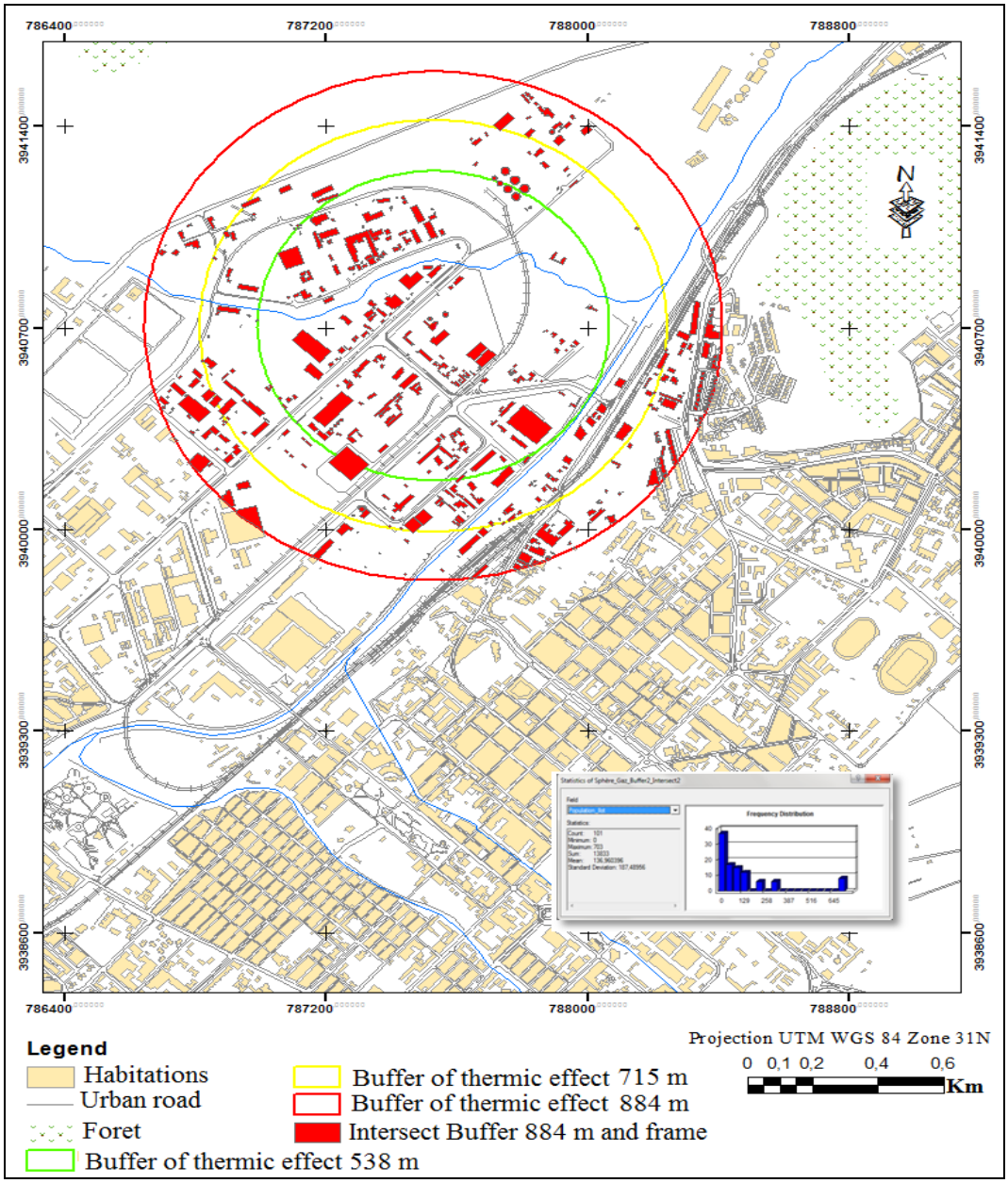

Figure 5. Projected damage map
Source: Habibi Yahyaoui

Intervention and evacuation of victims

Real time decision support through operational mapping enables to manage medical emergency for victims, which falls mainly on the city's civil protection services. The preparation and organization of emergency and intervention diagnosis can improve both the disaster handling and also reduce the recovery time to an acceptable situation. As a matter of fact, response and relief operations at a major industrial hazard location require good preparation in terms of documentation (guides, diagnosis aid help sheets for building emergency), skills and human resources available for civil security on the one hand and great access to urgent care facilities on the other. Network analysis allows us to explore this crisis management dimension by highlighting the spatial distribution of equipment, services and access means to health care in emergency situations.

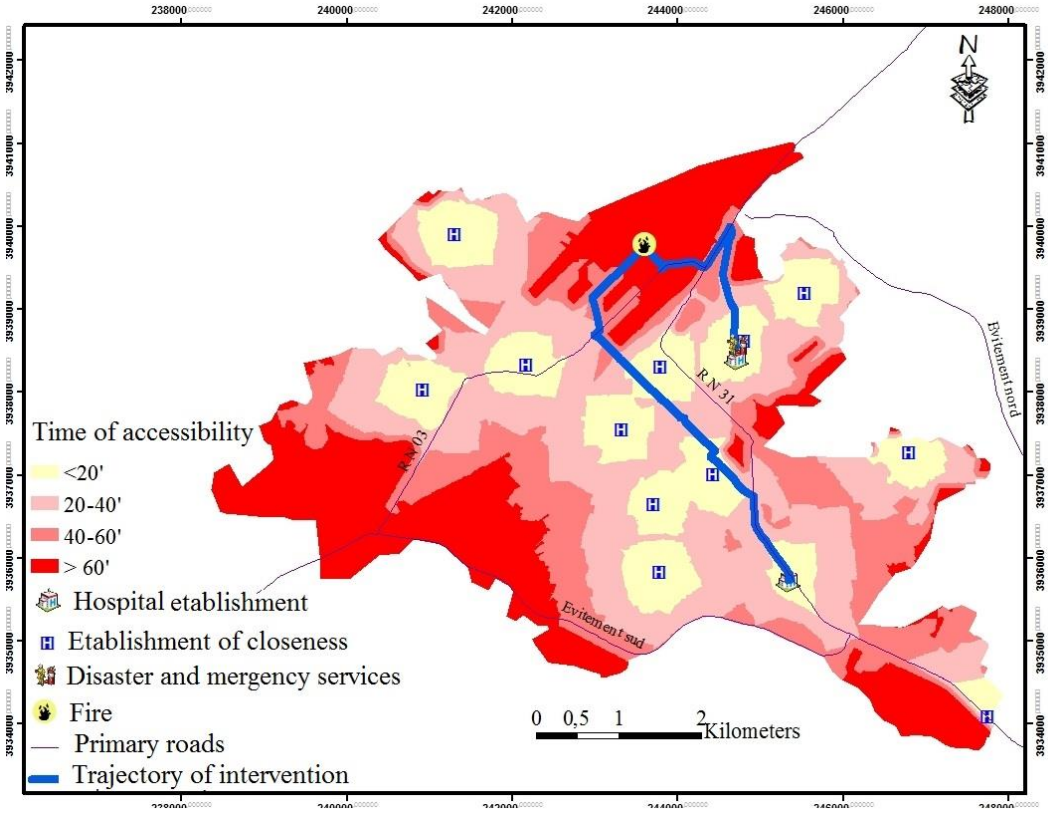

Figure 6. Spatial distribution map of health facilities by network analysis
Source: Habibi Yahyaoui

Technical resilience

Cities heavily dependent on technical systems confer the latter great importance in terms of risk spreading. To improve the resilience of cities, technical systems have already been identified as strategic (Lhomme et al., 2010). They act both as propagators of malfunction by their geographical extension and their interdependencies and are at the same time essential to reconstruction (Felts, 2005). They are the city's "nervous system" within which the slightest failure can have cascading effects on urban operation (Robert and Morabito, 2009. p.80).

Technical resilience is a technical strategy with a view to limit the degree of system disturbance through improved resilience and absorption; therefore a critical intelligence capable of removing all underestimation and any lack of preparation that could lead to a worsening of a non-

manageable situation. Furthermore, the integrated approach to urban resilience of local communities helps to demonstrate the domino effect and importance of technical networks in the spread of such a disturbance.

Domino effect

Domino effect is a chain reaction that increases the likelihood (or consequences) of a major accident, within the production units of the same enterprise or amid close plants. Each accident has several possible simultaneous aspects: explosion, fire, toxic emissions... It may prove necessary to consider some or other of these aspects as predominant in terms of relief efforts. It appears that poorly controlled interrelationships amongst different types of networks and within neighbouring industrial plants lead to vulnerabilities induced by domino effect. The technical resilience approach allows disregarding the precise facts of the initial failure mode and focusing on the impacts in terms of features (Robert et al., 2009).

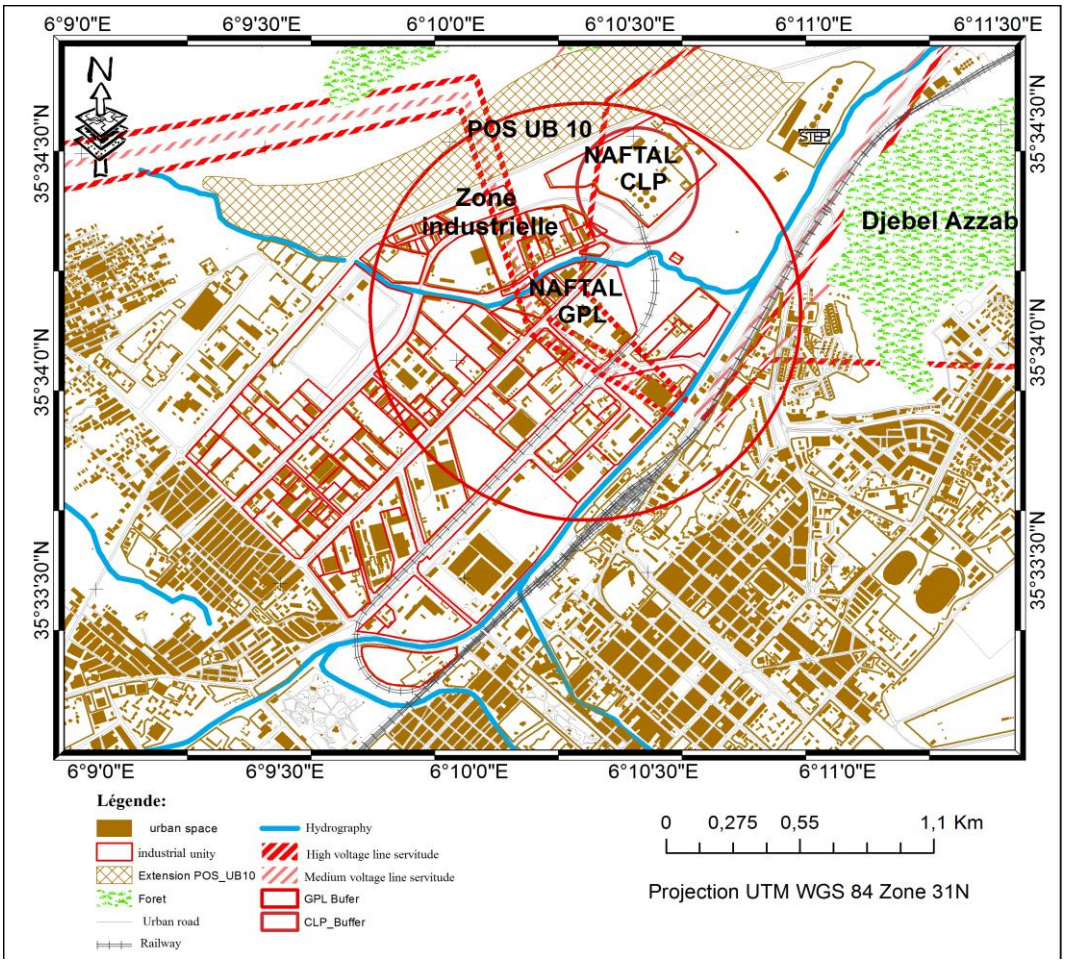

Figure 7. Map of the consequences of domino effect
Source: Habibi Yahyaoui

CONCLUSION

The urban policy adopted by the city of Batna's administrators has been causing the progressive and uncontrollable evolution of urban sprawl around the industrial estate; this proximity between the urban and industrial facilities classified as high risk may have created

insurmountable management problems of these risks. The analysis of the various potential consequences of an industrial hazard indicates that a population surrounding industrial plants is exposed to a large-scale major risk, displaying a very low urban resilience.

Territorialisation and operationalization of urban resilience to technological risk is rooted in the idea of the impossibility of zero risk of and the need for acceptance by the population, industrials and risk administrators in this city of a certain level of risk.

MADS modelling in a GIS environment is a tool for the operationalization of urban resilience thanks to its adequate tools for querying, analysing and displaying data. As a matter of fact, this tool allows us to share a real vision of the territory with all the risk management and intervention actors through a common representation of the urban space that needs to shift towards a sustainable urban development in the context of a territorial project. Moreover, the need to mobilize all prevention, emergency and disaster management actors requires the integration of time as an important parameter to maintain the spatial dynamics before, during and after the urban disturbances; this is the key to a full recovery.

The success of this urban resilience approach depends on the socio cultural resistance, which defines the culture of risk, acceptability and the response capacity of the population at risk. Therefore, urban resilience opens up prospects of a less technical and more social risk management approach. The answer would then come from the risk culture to develop. The development of the latter should be encouraged through a consultation procedure when setting up Technological Risk Prevention Plans (TRPP, equivalent to French: PPRT which stands for Plans de Prévention des Risques Technologiques). Moreover, the establishment of TRPP can have long-term effects on elected policymakers' culture of risk and on the recognition of the vulnerability of activities and constructions.

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