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The Performance of the Urban System Face of the Industrial Risks Case Study the Old Downtown of Skikda City

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Abstract

Zero risk has never existed and will not exist in the near future, even if through innovative technologies and ingenious processes to reduce the risky effects of this approximate industrial activity juxtaposed to the city. The coexistence of the city with these industrial risks can be the solution, going back to the concepts of urban resilience; a city that survives and can face threats and industrial risks, that is why it is primordial to reinforce the control of the urban space with all its dimensions. This paper aims to verify the resilience of the urban space of the old downtown of Skikda. The research process is based on the construction of a system of indicators that correlate and reflect the performance of the case study. The selected indicators that characterize the urban space are: human concentration, accessibility, spatial channels of absorption of large mechanical and human flows in case of evacuation, and finally, to try to demonstrate their relationship with the increase or reduction of the crisis in case of an industrial accident.

Through the correlation of the different indicators, we were able to detect a fragility and a great vulnerability of the old downtown of Skikda, which brings us directly back to a limited and very reduced rate of resilience in the face of a permanent risk juxtaposed to the city, so the behavior of the old downtown in case of an industrial accident will be disastrous and will directly increase the rates of risk.

Key word: Industrial risk, urban resilience, urban morphology, city of Skikda.

INTRODUCTION

Many cities in the world are exposed to high technological risks; some can be managed through urban spatial configuration; the behaviour of the city in case of a technological accident can change consequently to the urban forms. Their impact on exacerbating industrial risks is important and directly relates to the city's vulnerability. The city of tomorrow will surely be a sustainable city that minimises environmental constraints.

The proposed case study is the city of *Skikda*, which is characterised by its position next to an unstable petrochemical industrial zone, with the absence of sufficient protection and winds that would bring death in the case of an accident. Therefore, the city is exposed to an important industrial risk.Many studies dealt with the subject of the city with surrounding industrial risks, but few studies were interested in the behaviour of the cities towards those risks. Meanwhile, the main question is: How and by what means can the quality and performance of the urban space cope with industrial risks?

This study tries to identify the behaviour of the city in the case of industrial risks; mainly the relationship between urban form, spatial configuration, and industrial risk.Industry has long been seen as a vehicle for developing and enriching

cities and countries, and an important source of employment, however, it has also other negative sides such as noise, pollution and risks(Matheu 2002), Today, the industry appears less as a producer of wealth than as a source of risk, as (Beck, Bernardi, and Latour 2001)states « *in the second half of the 20th century, from a wealth-producing society to a risk-producing society »*.

Events keep reminding us of the production of industrial accidents all over the world, for example, the explosion of the A.Z.F. factory in Toulouse in 2001, where French Prime Minister Lionel Jospin declared:*«It is no longer possible, 'after Toulouse', to think in the same way as before about industrial risk... It is no longer possible to think in the same terms as before about the relationship between industry and the city in our society»*(Momal 2003).

The most common and widely used definition of an industrial risk is the one quoted by the French Ministry of Land Management and Environment in 1990, which defined a major industrial risk as an accidental event that occurs on an industrial site resulting in immediate and serious consequences for personnel, neighbouring populations, property, or the urban and natural environment.

Industrial ecology has made a significant contribution to the environmental management tools undertaken over the past decade. However, it should be noted that most of this contribution has been at the level of individual products and companies.

However, in the case of cities in almost all developing countries, this approach is absent, so other approaches and solutions must be considered to minimise the hazards of all industrial activities in the urban environment.

Resilience is a concept with positive connotations, which plays a role as a strategic aid to urban risk management, the more resilient a city is the less vulnerable it is, increasing resilience reduces the damage of the hazard. Therefore, we prefer to focus on tools to increase resilience rather than on how to prevent a hazard from occurring. Implementing a resilience strategy means accepting the disaster, but reducing its effects(Dauphiné and Provitolo 2007). As an illustrative example of urban resilience, check the influence of the quality of the urban space on the behaviour of its occupants to minimise its negative impact and strengthen its resilience.

According to Pigeon (2005)«*Urbanisation tends to effectively increase the risks influencing both the hazards and the different parameters of vulnerability*», That is why it is essential to strengthen the control of urban space with all its physical and immaterial dimensions and to create a vision of spatial and functional coherence.

The relationship between urban resilience and the sustainable city is both relevant and unclear, but also very strong because they have the same field of intervention: the city (Folke et al. 2002). By definition, the sustainable development of urban areas is based on a balance between three main axes: economic, social and environmental. In the same sense, we can structure the analysis of the vulnerability of urban areas around these three axes.

As mentioned previously, the less vulnerable urban space is, the more resilient it is; urban resilience makes cities more responsive to devastating phenomena and,therefore, safer cities. A resilient city is a sustainable city.Indeed, the performance of the urban system has a direct correlation with its urban resilience to industrial risks. The interconnections between the systems and the different urban units in this phase are very important. This is the reason why working on the networks and urban structure and their connections is a preventive way to prepare and anticipate as soon as possible(Boyer 2015).

We can think urban connectivity on several and different scales, previously mentioned on the city scale. However, interconnections at the neighbourhood scale are as important as the previous one.All this guides us to select urban indicators that directly correlate and influence the resilience of the urban space of the city, and we quote:

Human Concentration

Population density is an indicator of the concentration of inhabitants and flows, it is considered the most obvious factor of vulnerability (Blancher, Paquiet, and Zampa 1996).

In fact, the human stake is the most important indicator in the vulnerability equation, the density of the population exposed to the hazard and its concentration tends to increase its vulnerability,i.e. reduce the resilience of the population in the urban space.

Urban Structure

According to Baudet-Michel and Aschan-Leygonie (2009)« *The morphology of the urban space (the density of the street grid, the density and height of the buildings, the density of green spaces). This variation of the morphology of the urban space is likely to make vary the consequences of the hazard».*Urban configuration intervenes to better manage any urban fabric and its occupants; for example, the city of Paris; Its structure has been changed by the Prefect of Paris through the famous Haussmannian breakthroughs (rectilinear breakthroughs).

These operations of radical interventions which lasted more than 20 years were claimed and concretized for sanitary, and security reasons, and management of human flows in case of riots or war; that is why the urban structure must be conceived to answer these basic functions; displacement, and circulation, and also the absorption of a great human and mechanical flow and channel it in case of necessity. This vision of positive reactivation of urban space in the face of constraints and threats has been well-defined to date by the concept of urban resilience.

Accessibility

Accessibility is a key factor in managing crises in urban areas. Difficulties in access, or even the interruption of mobility to and between city districts, can create a crisis within a crisis by multiplying the effects of a disaster.

METHODS AND MATERIALS

The research method is based on the verification of the urban resilience levelthrough the construction of a system of indicators, which aims to verify the efficiency of the urban environment in the face of a possible technological hazard and how human and material damage can be reduced through an adequate spatial configuration.

Thus, the system of indicators is multidimensional, it covers issues of sustainable development.The indicators are designed in such a way as to instruct a debate between the different urban factors that intervene in the management and absorption of damage in the event of an industrial accident in cities.

The construction of the system of indicators is oriented towards a discourse between the factors characterising the urban space, the human concentration and the accessibility; without neglecting the spatial channels of absorption of the great mechanical and human flows in case of evacuation.

Our research and verification of resilience indicators will be carried out in two stages:

Stage 1: The state of vulnerability of the city; This stage aims to select a study area in relation to its vulnerability and also in relation to the importance of the issues it faces, and then to apply and verify the various indicators mentioned above.

Stage 2: verification of the level of resilience in the selected area. The application of the different indicators which enter into dialogue and correlation in order to verify the resilience of the selected study area.

Stage 1:The City's State of Vulnerability

Vulnerability summarises the distinct elements and parameters that make a system (stakes) more or less fragile to external aggression (hazards) which can be natural or anthropic (related to human activity). (Thaler et al. 2019)stated that industrial risks are linked on the one hand to the peripheral location near major communication routes (noise pollution, air quality, transport of dangerous materials, high-voltage lines, etc., e.g. Val d'Argent, Argenteuil, and on the other hand to the proximity of areas of activity and therefore employment (industrial risks of all kinds: toxic leakage, explosions, spills, etc., e.g. the explosion at the AZF factory in Toulouse).

According to (d'Ercole et al. 1994)« *Vulnerability appears in some papers as a system, articulated around many variables, natural and human, whose dynamics in time and space can generate more or less dangerous situations for an exposed society* » That is, the system of vulnerability turns around several variables that can be summarised as the container and the contained; space as the container and society and its institutions as the contained.

The objective of this first step is to determine which areas are the most exposed to industrial risks, and which areas may be the most affected in case of a crisis. The verification of the vulnerability and coexistence of cities exposed to high industrial risks is done through the correlation of several indicators:

- Stability and safety of the industrial activity: we will check the stability in relation to its history of incidents in the last decade.

- Distance: distance is an important factor in the management and control of risks that industrial activities can generate; logically, the further away the source of danger is, the safer the city is
- Topography: we consider the topography in our approach as a natural obstacle and protection; a physical buffer between the city and the source of danger (unsafe industrial activity)
- Prevailing winds: this is a double-edged sword; the winds can direct any dangerous gas product to the direction of the prevailing winds; i.e. towards the city (unfavorable high-risk situation) or the opposite.

Stage 2. Verification of Indicators

The method of evaluating urban space by indicator is a recognised scientific method and can give results in the case of industrial risk management in urban space.

In the following, we will verify the vulnerability rate of the correlating indicators previously mentioned which enter into dialogue, to better identify the resilience of the urban space in the city of *Skikda* which faces the hazards of anthropic nature.

By looking at the content and the container,the research can directly move on to the second stage, which is the selection and verification of the indicators that can enter and influence the resilience and the behaviour of the urban space in the face of industrial risk.

The selected indicators are:

Human Concentration

The equation of vulnerability is based on 2 key factors; the human stake and the hazard; that is why: the greater the concentration of inhabitants in an urban area, the greater the damage in case of an accident.

The evaluation of the human concentration will be done through statistics projected on the map of the city, then the verification of the occupancy rate per dwelling (TOL) and superimposing it with the state of the constructions, all that will give us a clear vision of this indicator.

As a source of information on the old buildings in the old center of the city of Skikda, the report of the CTC (abbreviation of a state institution whose title is: technical control of construction) will be very useful; thus, annexed to the state of the buildings the statistics on the concerned population.

Urban Structure

Carrying the evaluation of theurban structure through the analysis of the following elements: firstly, the urban void which consists of the empty volumes of the city, characterised by voluntary layouts, or simply the progressive implantation of the building.Secondly, the building which intervenes in the structure of the space as a generator of the urban void its role influences the functionality of the space through its typology (housing, equipment), location, and attractiveness to users.

The cartographic supports of the study area provided by the documents of the CTC report (Technical Construction Control) as well as the report of the PDAU (Urban Masterplan) of the city will be very useful for the research, not only as illustrative documents of the statistical and spatial information but also as means to facilitate the exposition of the analyzed urban phenomena.

Accessibility

It is important to remind that the city is essentially dynamic. Its functioning is the result of the fluidity of the many interconnections of urban networks and systems. A disaster can therefore severely impact these different flows with effects of punctual discontinuities that can go as far as a possible paralysis of entire sections of the city and its activities, as well as its relationship with its geographical environment. To facilitate the vital resumption of activities in the city after a disaster (Boyer 2015).

This spatial context of vulnerability is determined from two spatial criteria: accessibility and exposure to hazards, in the case of risk management in the urban space we generally speak of the possibilities of external intervention of specialised

services (fire brigade, forces of order, army, humanitarian institutions) and also, the possible exit of evacuation in case of an accident on the one hand and the possibilities of accessibility of the different entities of the city.

The evaluation of accessibility in the study area will be carried out through the analysis of the different axes penetrating the city using the urban masterplan and superimposed with the topographical obstacles.

The more access possibilities are available with an easy topography, the more resilience will increase and the possibility of overcoming an industrial crisis will be greater.

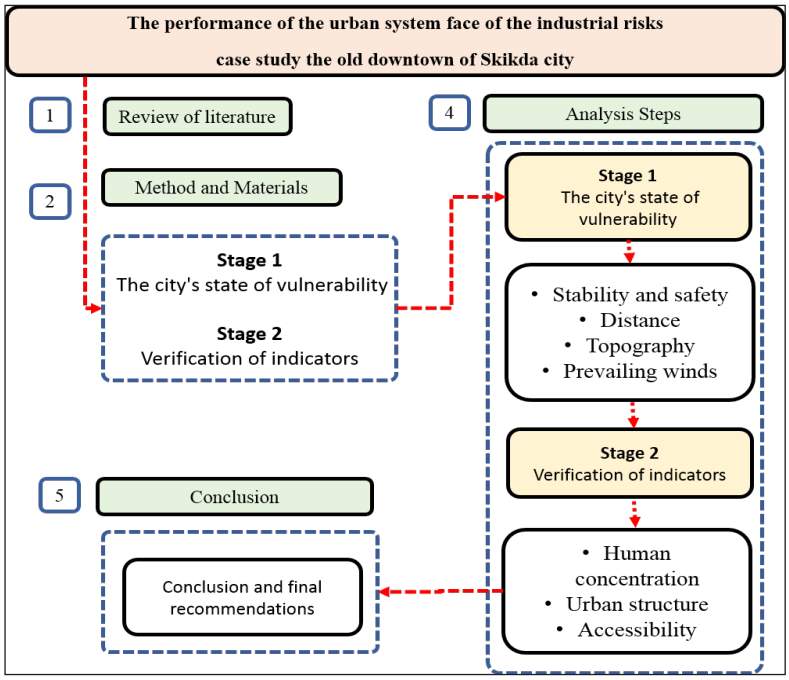

Figure 1. Research framework

Case Study Presentation

Skikda, formerly Philippeville, a coastal town in eastern Algeria, was chosen to host the Eastern Petrochemical Complex, the country's second-largest industrial hub. The choice of the city of Skikda was implemented by order n° 70-13 of 22 January 1970 (See Fig.2).

This industrial pole of national and international importance is dominated by the petrochemical complex, equipped with various installations and specialised in the treatment of natural gas and oil. It is strongly involved in the effort and development of the Algerian economy.

Figure 2. Location of Skikda City (Google 2022)

The launch of the petrochemical pole in the city of Skikda was at a time when the notion of industrial risk did not exist, hence urbanisation was carried out under conditions that did not take into account the impact of industrial activity on man and the environment.

The industrial zone of Skikda occupies an important surface of more than 1200ha with a coastal line of 5.4 kilometres, it is located 4 kilometres east of the city of Skikda, in addition to its danger, it constitutes a major obstacle to the urban extension in the east of the city, not only it occupies the best agricultural sites but it is classified as being the principal source of pollution.

In addition to this industrial zone on the east of the city, several physical constraints characterise the city's space, namely a tormented site, steep slopes, sensitive areas, an uncomfortable situation which forces recent urbanisations to settle in the southern part towards *El Hadaiek* and the edges of *Oued Saf-Saf*.

RESULTS AND DISCUSSION

Stage 1. The Vulnerability of the Site

As a first step in assessing the vulnerability of any site juxtaposed with industrial activity, several factors are correlated, the most direct factors:

- The instability of the industrial activity

- The location of the sources of industrial risk in the city

- The topography and prevailing winds of the site

By projecting that on our case study, and relying on a previous study (Ghani, Tayeb, and Lakhdar 2015)The city of Skikda is juxtaposed to a large and medium stable petrochemical activity and with the absence of sufficient topographic obstacles, consequently, the vulnerability of the city of Skikda is important and flagrant.

Industrial risks in the city of Skikda are a lesson in social geography, an illustration of the coexistence of the petrochemical industry on the one hand and the city on the other(Ghani, Tayeb, and Lakhdar 2015).Thus, our urban environments are not prepared for industrial risks, to this end, the city of Skikda demonstrates the need to carry out prevention, and management and planning work, to better manage the city, and reduce risk rates.(See Table 1)

Table 1. The final result of the indicators of the vulnerability of a city to industrial risk sources (Ghani, Tayeb, and Lakhdar 2015)

	Level 1	**Level 2**	**Level 3**
Stability and safety of the industrial activity		Moderately stable	
The distance between the city and the industrial activity			Juxtaposed
Topography		Medium protection	
Prevailing winds			unfavourable

Through this verification of the vulnerability of the city of Skikda and these results (table.7), it can be detected that the most fragile and vulnerable area is the old city centre of Skikda; given the importance of these stakes about the presence of risk related to industrial activities, this selection of the study area was made in relation to the following criteria:

- The proximity to industrial activity
- Insufficient physical obstacles
- Accessibility
- The importance of the issues and their vulnerability:

a) The age of its urban morphology (built environment, urban structure, materials, size)

b) The human concentration and the activities of attraction (administrations, shops, tourism..)

Stage 2. Verification of Indicators

Human Concentration

Concerning our case study, the population density in the city centre of Skikda is 370 inhabitants/hectare(See Fig. 3), which is considered a high density, especially because the buildings date from the colonial era and are in a disastrous general state (Aissa 2011).

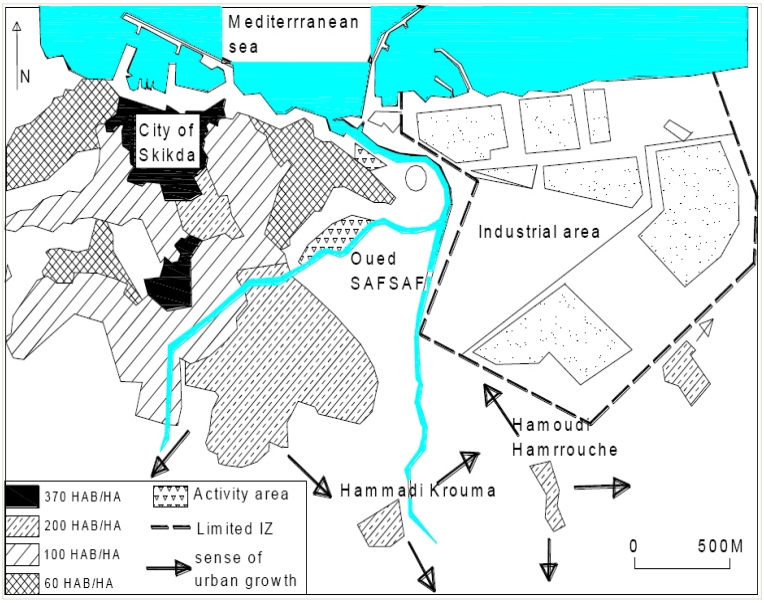

Figure 3. Concentration of inhabitants by area (Aissa 2011)

The overall population is 22027 residents in the old town until 2012, and the number of occupied dwellings is 3759 with an occupancy rate per dwelling(TOL) of 5.86(CTC 2012b), without disregarding the commercial and administrative attractiveness of the old centre. That is to say, population concentration is not only the number of permanent residents, but the real number of human concentrations is much larger; it includes permanent residents and occasional and temporary users of the space.

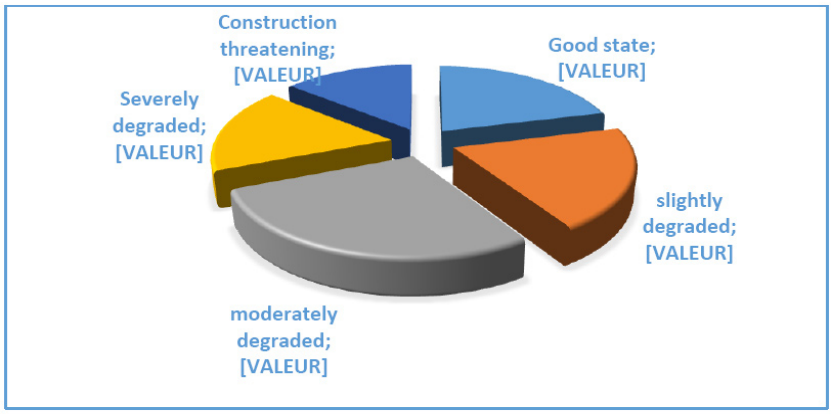

Figure 4. Rate of degradation of buildings in the old city centre(CTC 2012b)

The state of most of the buildings is declared as dangerous(See Fig.4), in addition to the buildings with high population density and the over-occupation of these buildings, the human concentration indicator is set at level3, the vulnerability and fragility of the population stake are important, consequently, its resilience to the industrial risk is very low.

Table 2. Human concentration

	Level 1	**Level 2**	**Level 3**
Human concentration			Failed

Urban Structure

A- Urban Void

In the case of Skikda, a checkerboard pattern regularly traced and structured the void, the planimetry of the ground can define the urban void (in plan), concave spaces are the negative part of the city.

The plan view reveals the diversity of voids and their hierarchies. They are differentiated according to their nature, streets, and squares, then, according to their scale and morphology, the planimetric reading of the case study is quite clear; a checkerboard plan with a spatial hierarchy which favours a soft fluidity is safe (See Fig.5), but the reality is relevant, with a simple visit on site we notice a great imbalance caused by a great attractiveness of the main axis of the centre as well as the secondary roads perpendicular to it. Some streets play a more important role than the main boulevard despite their modest size.

Figure 5. The building density of the downtown of Skikda city(DUC 2006)

The topography of the site, which is very uneven, has a negative influence on the urban structure; the slope of certain secondary streets perpendicular to the main boulevard can exceed 10%. The morphology of the streets and their dimensions are partially narrow (the boulevard 12-20m, the secondary streets 3-6m) to the over-density of human settlements.

Concerning the large spaces of gathering and pleasure in the urban space, it was underlined that the checkerboard plan of the colonial era does not favour the integration of this type of space; the gardens, the squares and the plazas.The displacement is concretized by the streets and lanes is the dominant function of the urban void. (See Fig. 6)

In the old city of Skikda, two large public squares were cleared:

- A public square called *COUR* which is located in the centre of the old city, this space was created after the demolition of the Church of the colonial time, unfortunately, this square was intended only for an illogical grouping of some cafeterias and their terrace, another part of this square was intended for use of parking (parking).
- Another large square located on the northern side of the old centre, more exactly at the main entrance of the port of Skikda, unfortunately, it is having no clear function, only for the regrouping of the townspeople and some seasonal activities

Figure 6. Map of the downtown of Skikda city(CTC 2012a)

The efficiency of the road network is essential, it is the main means of inter-connectivity of the whole urban space, it is essential to be able to better manage all types of flows, especially if this space is permanently exposed to possible industrial risk, a reduced resilience in the face of a hazard can lead to an internal rupture of the different flows which can cause a paralysis during and after a crisis.

Normally the space follows the function by its scale, dimension and morphology, unfortunately in the case of the city centre of Skikda and with time; the society has mutated, and its needs have changed and increased, but the urban structure has remained fixed and afflicted with decrease and flagrant urban degradation due to time and over the occupation of the space. Human density is high and exceeds recommended standards, mechanical and pedestrian traffic flow is moderately difficult and worsens during peak hours, and it gets worse during summer.

Therefore, the current state of the road network cannot overcome a possible disaster, the possibility of total paralysis of the urban space is very likely due to its limited resilience and its reduced possibility to ensure a minimum of fluidity and connectivity of the different components of the urban space.

B- The Building

We can notice two types of buildings; the first is characterised by interaction and superposition of functions (housing and commerce) and the second is materialised by punctual equipment (theatre, administrative headquarters, tourist accommodation facilities, cultural centre). The foundation of the colonial grid pattern is based on modern urban planning, which is characterised by the concentration of the different functions of the city (living, working, traffic and leisure). This theory did not take into account the growth of the population, which generated a great dysfunction in the city's structure.

The city centre of Skikda dates back to the colonial era; its general state is quite degraded and cannot withstand strong aggression, such as an industrial accident. Foreign technical expertise concerned 2000 buildings which were classified into three categories, namely "strongly degraded", "degraded" and "threatening ruin". (See Fig.7)

No deep intervention on the existing fabric was made except for some punctual repair operations, several buildings succumbed to the effect of time, and the remainder of these districts remains in abundance, all of whichhave generated a very vulnerable site and with high risk for its users.

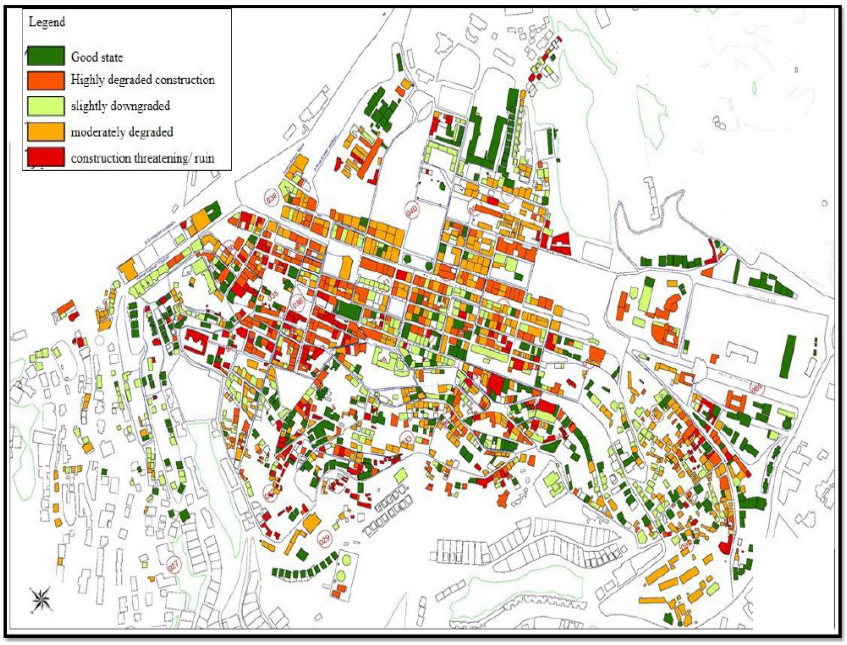

Figure 7. Classification of the level of degradation of buildings (CTC 2012a)

Figure 8. Stabilisation of the main boulevard arcades

The figures announced by the service of technical control in 2012 show that the state of the built-up area of the old city of Skikda is disastrous (See Table. 3), especially with the important number of residents and daily users (workers, visitors and others) of the urban space, the resilience of the built-up area with the current state has reduced not to say non-existent in front of an eventual industrial risk.

Table 3. Assessment and ranking of the level of degradation (CTC 2012b)

	Constructions		**Dwellings**	
	Number (U)	Surface (m2)	Number (U)	Surface (m2)
Good state	421	201145,83	499	146398,70
slightly downgraded	403	199376,16	1061	165758,60
moderately degraded	577	242153,69	1594	189246,26

Highly degraded construction	353	193964,57	1288	152439,48
construction threatening/ruin	292	84498,81	826	70233,44
Total	2047,00	921139,04	5268,00	724076,47

Indeed, these buildings, due to their degraded state, cannot overcome the mechanical effect which can be defined as an overpressure phenomenon resulting from a shock wave (deflagration or detonation); caused by an explosion.

Table 4. The urban structure

	Level 1	**Level 2**	**Level 3**
Urban Structure			Failed

Accessibility

The quality of accessibility of the areas was determined from an analysis of the main road network, taking into account the topographical and hydrological obstacles.

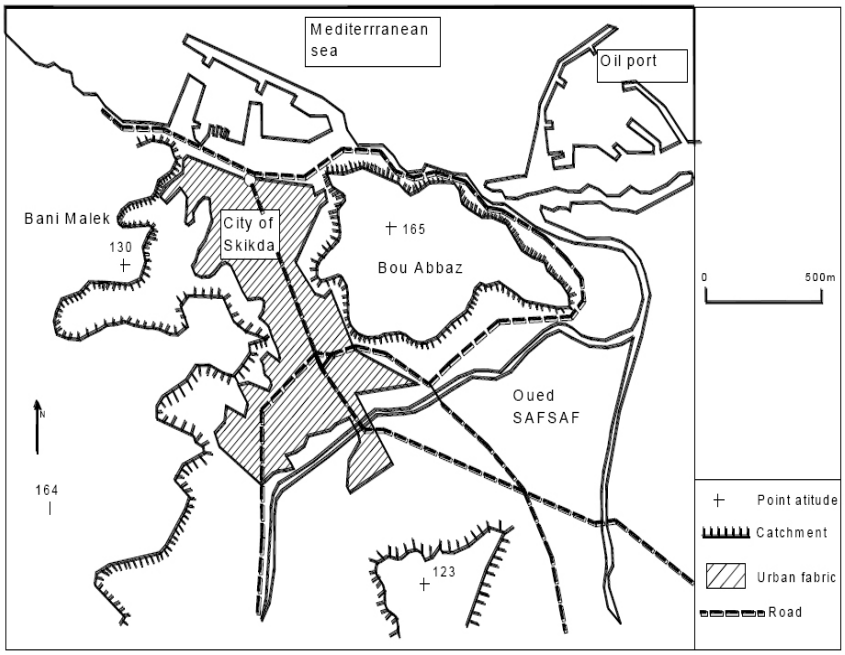

Figure 9. Topography and accessibility of Skikda (Aissa 2011)

From reading the previous map, the road networks that access the city are limited and insufficient, conditioned by the topographic and hydrological characteristics of the site (the heights of *BOUABBAZ, BENI MALEK* and *OUED SAFSAF*) whichlimit all types of intervention of evacuation and management of human and mechanical flows in case of an industrial accident.(See Fig. 9)

As a result, the accessibility indicator can be classified as level 3

Table 5. Accessibility

	Level 1	**Level 2**	**Level 3**
Accessibility			Failed

CONCLUSION

Through the superposition of the proposed indicators, it was detected that with an important human overconcentration in the core of the city of Skikda and a fragility of the urban structure; corned by poor urban accessibility to better manage and evacuate any human or mechanical flow in case of crisis.

Table 6. Overlay of results

	Level 1	Level 2	Level 3
Human concentration			Failed
Urban structure			Failed
Accessibility			Failed

The superposition of the different indicators allowed us to detect the fragility and great vulnerability of the old city centre of Skikda, which brings us directly to a limited and very reduced rate of resilience in front of a permanent risk juxtaposed to the city.Therefore, the behaviour of the old centre in case of an industrial accident will be disastrous and will directly increase the rates of risk as a consequence of the human and material damage will be more important.

This verification of the behaviour of this urban space in the face of industrial risk and the dialogue between the different indicators which intervene in the foundation of the logic of resilience of the urban space, allowed us to understand on the one hand the different urban failures and the different indicators which directly influence the rate of the resilience of urban space, and on the other hand the complexity of this approach and the difficulty of concretizing it on the ground.

The verification of the behaviour of the urban space in front of the industrial risk is primordial to well manage and controlling the vulnerability of the space and trying to decrease to the maximum the damages in case of an industrial accident; in our case study; the urban space requires an urban restructuring; it is a radical and deep action which will aim to address all urban failures to better manage industrial risks and is part of the foundation of sustainable urban spaces.

Another recommendation is the introduction of new environmental approaches,(D'Amico et al. 2007)defend this concept and consider it as a solution for a sustainable urban environment, not only through the insertion of a policy of safe and non-harmful industrial activities but also through the recycling of industrial waste and using it as a raw material instead of non-renewable natural materials.

Rethinking the city: safer reconstruction, improved neighbourhood design, easier access, internal fluidity to living areas and services. Can be a solution to increase resilience and urban efficiency. This approach remains to be verified with the different urban dimensions of other cities exposed to high industrial risks.

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