



ELSEVIER



CrossMark

Available online at [www.sciencedirect.com](http://www.sciencedirect.com)**ScienceDirect**

Procedia Economics and Finance 18 (2014) 544 – 551

**Procedia**

Economics and Finance

[www.elsevier.com/locate/procedia](http://www.elsevier.com/locate/procedia)

4th International Conference on Building Resilience, Building Resilience 2014, 8-10 September  
2014, Salford Quays, United kingdom

## Seismic risk and urbanization: the notion of prevention. Case of the city of Algiers

Khaididja Boughazi<sup>1</sup>, Samia Rebouh<sup>2</sup>, Messaoud Aiche<sup>3</sup>, Naim Harkat<sup>4</sup>

<sup>1</sup>Assistant - professor, University of Hadj lakhder, Batna, Algeria. Research Unit: Emerging territory and society, university of Constantine 03 ,  
Algeria. [boughazikhaididja@yahoo.fr](mailto:boughazikhaididja@yahoo.fr)

<sup>2</sup>Assistant - Professor, University of Larbi Ben M'Hidi - Oum El Bouaghi, Algeria. Research Unit: Emerging territory and society, university of  
Constantine 03 , Algeria. [andi.samia@hotmail.fr](mailto:andi.samia@hotmail.fr)

<sup>3</sup>Professor, University of Constantine 03, Algeria. Research Unit: Emerging territory and society, university of Constantine 03 , Algeria.  
[aichmessaoud@yahoo.fr](mailto:aichmessaoud@yahoo.fr)

<sup>4</sup>Doctorant, University of Constantine 03, Algeria. [harkatnaim@gmail.com](mailto:harkatnaim@gmail.com)

---

### Abstract

Seismic risk is among the major risks that threaten our country. Algiers is considered the most vulnerable city of the country. Not only, it bears witness to terrible seismic disasters but it is based on six seismic faults that can move at any time. Added to this phenomenon, Algiers is facing extreme urban mutation and the urbanization process since independence has not taken seriously into account the seismic risk factor. The present communication has not the pretention to explore the whole question of the seismic risk of the city of Algiers, but debates the question of the risk under the angle of prevention.

© 2014 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/3.0/>).

Selection and/or peer-reviewed under responsibility of the Centre for Disaster Resilience, School of the Built Environment, University of Salford.

*Keywords:* Seismic risk, disaster, urbanization, Algiers, prevention.

---

### Introduction

Today, prevent the major risks constitute one of the main challenges for any urban development which aims to be sustainable. Given their devastating effects, seismic risks continue to cause real disaster since it is virtually impossible to predict or prevent them from occurring, even if the progress that knew the Earth sciences allows, today, to limit the effects as well for human as for the buildings and the infrastructures.

Compared to other countries, Algeria is considered a country with proven but relatively moderate seismicity. However, because of the localization of the seismicity in the highly urbanized area, the effects of earthquakes were often catastrophic.

These risks are localized on the northern fringe of the country, where exactly concentrates the major part of the population and the socioeconomic installations. The various geological and seismological studies show that 70 % of the northern fringe is subjected to a seismic activity Ministry of Regional Planning and the Environment MRP.E (2005). In which the city of Algiers (first city in Algeria by the fact that it is the political and economic capital of the country) is unfortunately located in full center of this area because it is situated in the contact point between the African plate and the Eurasian plate Centre for Research in Earthquake Engineering CEE (1992).

These risks are now more important and more threatening because of the rapid urbanization that knows the Algerian city, of the polarization of the activities and the increasing development, which goes against the dangers, imposed partially the rarity of the urbanizable land. Indeed, the growth of the urbanization to greater vulnerability of societies that they are increasingly dependent on urban networks.

The links between the urbanization and the risk of disaster are extremely complex and clearly dependent on the context. Urbanization does not necessarily lead to increased disaster risk and can, if properly managed, contribute to its reduction. However, there are a number of key features of the urbanization process that can directly contribute to the configuration of risk.

*“The city and its risks are a couple more today than ever inseparable “.* Hartmut (2004).

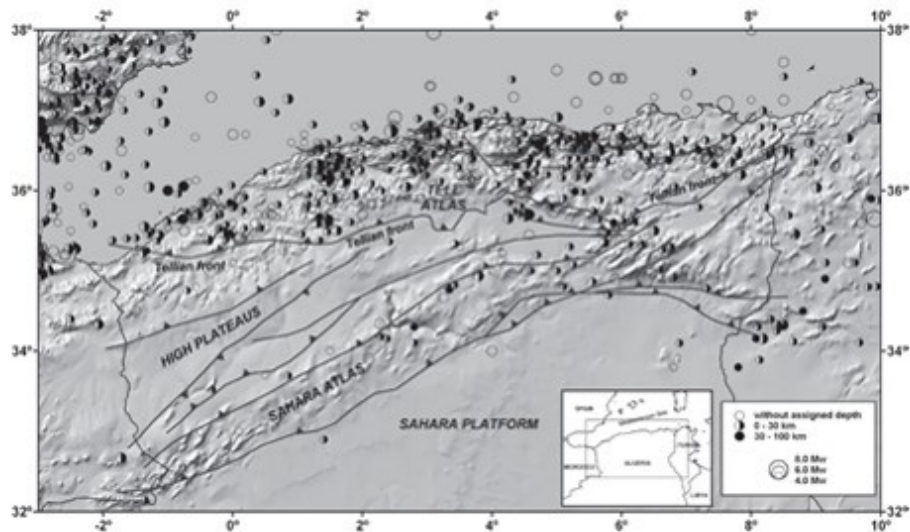


Fig. 1. The tectonics of the Algerian North simplified by Bracenne and al .2003 including the catalog séismique.

Source: M. Hamdache, José A. Pelaez, A. Talbi, I et C. Lopez Casado :  
A Unified Catalog of Main Earthquakes for Northern Algeria from A.D. 856 to 2008

If the urban growth in a place subjected to the seismic risks is accompanied with standards of adequate constructions and if the urban planning takes into account the risk, then we can avoid the disaster and better manage the situation and even reduce the damages Chaline and Dubois-Maury (1994). However, it is not always the case, Algiers, following the example of the Algerian cities, knew a great movement of urbanization. From the medina to the metropolis, from the collected fortress, it is transformed into a fragmented and split up city subjected to high degrees of vulnerability.

However, after the independence we attend a vast urban spreading neglecting the precautions, which would have been necessary towards the seismic risks, the consequence of the urgency to find grounds to build equipments, and housing for a surplus of population always more important.

The geology of Algiers makes from seismic risks an objective reality but rare are the constructions that ensure the application of the earthquake-resistant standards. The non- regulated area, the shanty towns, the illicit housing environment and the archaic buildings are, in this respect the most vulnerable Boughazi (2012).

These, many facts that make the seismic risk in the region of Algiers is permanent and threatening. The preservation of the current trends in the occupation of the territory is going to be translated by the strengthening of the demographic weight of the zone and the heavy incidences of consequences with regard to the seismic risk.

Faced with these difficulties of the urbanization from Algiers, the instruments of town planning as well as the strategies of actions try with difficulty to take care of a complex situation.

## 1. The seismic risk in Algiers:

### 1.1. History of the seismicity in Algiers:

The first sources describing earthquakes having affected Algiers are situated in XIV th century, in 1365 date in which was mentioned a rather strongly felt earthquake. The earthquake of January 4th, 1365 completely destroyed the city of Algiers and was followed by an important tidal that flooded the city where several people were drowned.

During Ottoman period, Algiers was destroyed during both earthquakes of March 10th, 1673 and February 03rd, 1716. Ambraseys and Vogt 1988 place the epicenter of these two destructive earthquakes at the bay of Algiers but without specifying the seismogenic source CRAAG (2007). According to the Centre for Research in Astronomy Astrophysics and Geophysics (CRAAG) the magnitude of the earthquake of 1716 was estimated at  $M_s=7.5$  on the Richter scale with an equal intensity  $I_0 = X$ . This earthquake caused irreversible damages, more than 20000 victims and almost all the kasbah was ruined.

After the independence, several other earthquakes shook the region between Algiers and Chenoua. The first one struck the city of Tipaza 9/2/1990 with  $M_s$ : 4.9, and the second, located near Ain Benian took place the 04/09/1996 ( $M_s=5.7$ ). These two earthquakes were attributed at first to the blind fault of the anticlinal of Sahel, but the direction of the swarm of the retorts is not in agreement with the direction of this structure Harbi (2000). Further to the disaster engendered by the earthquake of Boumerdès - Algiers in 2003 and for cause Algiers is, since this earthquake of May 21st, 2003, classified zone III and passes from area medium to high seismicity.

### 1.2. Seismic context of Algiers:

The sismotectoniques studies in the north of Algeria began seriously only further to the earthquake of El-Asnam in 1980 (Ambraseys, on 1982; Meghraoui, on 1988; Ambraseys and Vogt, on 1988). Today the main faultsactive intra-plates of Algerian North are identified on the ground but the danger also comes from active faults at sea. Indeed, several historic and recent earthquakes took place in the wide. Among the active faults identified in the Inhabitant of Algiers:

- The fault of Sahel dresses a great importance since it is below the country's capital where more than three million inhabitants live.
- The fault Thénia constituting the NE edge of the basin ranges from Mitija Issers southeast until a few kilometers offshore in the North Massif Bouzaréah in the northwest direction.
- Mitidja lets believe that a fault in the South of the pond, the mirror of the fault of Sahel, would continue until Boudouaou in the SW of Boumerdes.
- The fault Chenoua, shape "L", a land and a part submeridian at sea
- The fault of Zemmouri, according to the first seismological modellings and the observations of ground, the active fault that caused the earthquake of 21 May 2003 is located at sea
- In addition to the supposed flaw at sea: a number of indicators argue for the existence of potentially active faults in the sea, including earthquakes Chenoua (89) Ain Benian (96), Boumerdes (2003) and especially that of Algiers in 1365 that spawned a tidal wave.

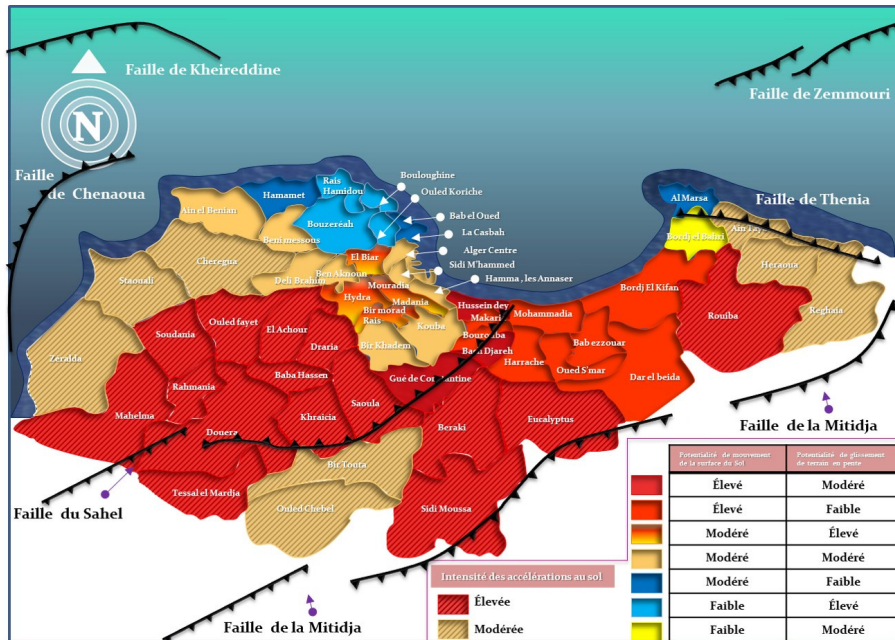


Fig. 2. Map of the seismicity of Algiers.

Source: Author

## 2. The Algiers urbanization faces earthquake risk:

### 2.1. Consciously secular urban seismic risk:

During a whole long period which spreads out over centuries, the majority of the urban interventions were made at the level of the site of the kasbah of Algiers, in particular thanks to the potentialities which it offers, but it turns out that all the constructions of the low kasbah were often destroyed after earthquakes and floods caused by the arrival of the tsunami tide. During Arab-Berber period, Djazaïr Beni Māzghennan was the theater of four major earthquakes, two destroyers (1359-1365) Abdessemed-Foufa (2007). However, during the Ottoman period, Al Djazaïr's medina was rocked by 20 earthquakes. All the Kasbah was seriously destroyed and damaged by the great earthquake of 1716 Abdessemed-Foufa (2007). Further to the latter, the organization of the kasbah as well as all the constructions compose with this parameter- the seismic risk-. It presents a constructive system having a preventive technology adapted to the architectural typology developed during XVIII th century.

The construction of the Kasbah were performed in a tradition of the art of building, as well as the materials used for the structural system or construction technique. Masonry with stones and various mortar mixtures was basic materials for their realization. Walls, the most dominant elements in the construction, were in masonry of freestones or rubble stones. Adobe walls or various concretes are also used in these constructions. Wood logs are also introduced into walls, giving them greater flexibility and deformability especially in flexion Boumansour-Djaafri (2005).

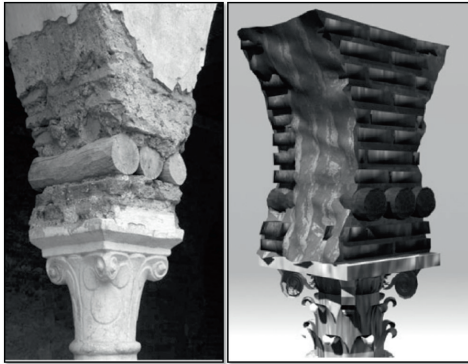


Fig 3: Arch-Column departure details one layer of three logs of thuya inserted between the brick masonry.  
Source : A. Abdessemed-Foufa;D. Benouar; Investigation of the 1716 Algiers (Algeria) Earthquake



Fig 4: The q'bù

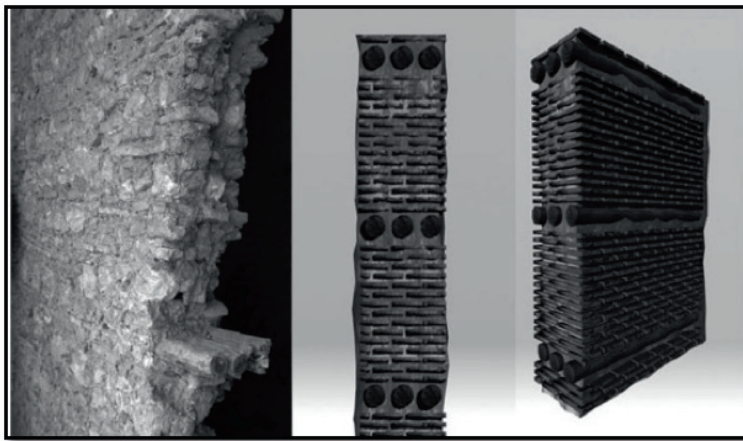


Fig 5: Reinforced bricks masonry walls by logs of wood and three-dimensional reconstruction of the walls  
Source : A. Abdessemed-Foufa;D. Benouar; Investigation of the 1716 Algiers (Algeria) Earthquake

Indeed, all these structural and architectural elements on the previous photos, bearing walls and q'bù or cantilever, and their constructive typology proved seismo-resistant. It should be noted that after the catastrophe of 1716, the traditional society and with the limited resources she possessed was able to understand the seismic event and invent techniques quite clever and effective at the moment.

## 2.2. Recent urbanization amplifying seismic risk:

The city of Algiers knew, since the independence of the country in 1962, a problematic urbanization. The various processes of urbanization, by their means of elaborations and actions, were not able to act on an urban arrangement to protect and develop coherent urban forms. In the urban growth and in the spatial transformations of the urban conglomeration from Algiers are added socioeconomic tensions, which translate particularly the problems of housing environment, employment, functioning and urban management. In front of these difficulties of the urbanization of Algiers, the instruments of town planning as well as the strategies of actions try with difficulty to take a complex situation Boumansour-Djaafri (2005) .

### 2.3. The urbanization of the Mitidja and the Sahel of Algiers “area subject to seismic activity”:

It is important to remind that the mobility of the Algerian population, after the independence is engendered by the occupation of the villages of colonization of Mitidja and Sahel of Algiers. The deficit in housing led in the sale of grounds where from the proliferation of shantytowns around the periphery of Algiers and on the lands of Mitidja without respecting the legislation Belhai-Benazzouz and Djelal (2010) .

As confirmed By Marc Côte : “Algiers is no longer growing , but the growth has been focused on the large crown. Mitidja is now the place of the massive and complex pendular movement because the centers such as Sidi Moussa or Rouïba attract each morning tens of thousands of workers coming from Algiers. The metropolitan area of Algiers covers now the two-thirds of the Mitidja “ Cote (1996) .

The saturation of the current urban conglomerations of the zone of Algiers engendered the extension of the urbanization, on one side, towards Mitidja and, the other side, eastward in the Wilaya de Boumerdès. This trend goes towards the occupation of the regions which turn out unfavorable on the seismic plan, especially that the seismic activity in this region (the east of Algiers) is growing more and more.



Fig 6: nibbling of agricultural land in the peripheral municipalities of Algiers

Source : Belhai-Benazzouz Atika et Djelal Nadia (2004) : le foncier Vecteur de l'étalement urbain algérois

It is admitted by the scientific community, that the sedimentary ponds amplify the seismic signal because of the character furnish sediments which perform them. The zone of Algiers is characterized by the presence of the quaternary pond of Mitidja, which extends since El Afroun until Boumerdès. The seismological recordings made during the earthquake of 2003 confirmed the possibility of increase of the seismic signal in the pond of Mitidja Laouami and al. (2003) . The fig 7 shows so clearly that the intensity during the main shock marries the shape of the pond of Mitidja. In addition, the basin is bordered by major active faults Ministry of Regional Planning and the Environment MRPE (2004) .

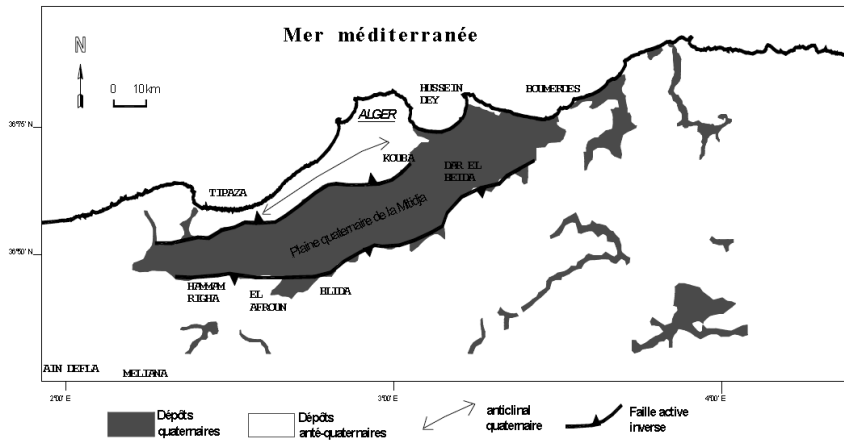


Fig 7: Map showing the zone of Algiers, in particular the quaternary pond of Mitidja

Source : M.A.T.E (2004), Coastal Area Management Programme

It is to notice that the city can only sink into irreparable situations. Its urban spreading and its irreversible character are a real threat on the land tax which is a not renewable commodity. The push of the city of Algiers and its spreading on its metropolitan space entailed the increase of the demographic and economic weight of the city, public authorities estimate much more important needs for the city, in front of the shortage of the land tax reserved for the urbanization. So the lands which have to receive the demographic surplus can be only the farmlands of Mitidja, Sahel and coast with all the major seismic risks and the ecological, economic dangers and the infringement on the food safety policy.

It is thus necessary more than time to rethink the city and the land management, by coherent actions of arrangement in a vision integrated by new tools developed within the framework of a medium and long-term strategy and especially to ensure the strict respect and the application of the laws and regulations of town planning.

And as well, to think about the reduction of the demographic weight, economic and functional of the capital through a large-scale action to redefine the redeployment, and gather the necessary conditions for the development inside the country by creating small and average cities within the framework of a coherent and well-balanced spatial urbanization and planning.

### 3. Prevent the seismic risk for Algiers:

The choice of a good site on a good ground with adapted foundations, while respecting the compulsory prevention measures and those recommended, will allow to limit the damage in case of shock. Given that there is until now no means of forecast of the earthquakes, which can be reliable. The establishment of the 'Seismic Plans of Risk prevention', the discount for level of the instruments of town planning in the plan of the effective coverage of the seismic risk, the application of the 'earthquake-resistant Rules' as well as the use of the 'Guide of Earthquake-resistant conception of buildings' should begin to solve partially this question.

As regards the management of the seismic disasters, it is essential to have a good plan of evacuation and help appropriate to the seismic risks and the good coordination between the various concerned services. However, the real key of the puzzle is that there is a good communication and collaboration between the scientists and the political powers.

All these measures will be however, insufficient in the particular situation of our country, because of the superimposing on the same zone of Algiers of the strongest probability of occurrence and intensity of earthquakes, on one hand and on the other hand, the strongest concentrations of population and the economic potential of the country.

These measures must be necessarily accompanied, by measures and actions of anticipation, aiming within the framework of the national politics of arrangement and the sustainable development of the territory in:

- Direct the redeployment of the demographic and economic surcharges of the capital and all the vulnerable urban areas of the tellienne zone towards High lands and the South, territories much less threatened by the seismic risk.

### Conclusion:

Within the framework of a good prevention, it is a question of taking place, not only before the seismic disasters occur, but also after they are produced to imagine what to do in this eventuality. It is a question in fact of asserting a more responsible awareness, in front of these potential dangers, by stopping a process of anarchy urbanization, in the periphery of the right, to print in a constant way and continue a development and a harmonious arrangement. It is a question of considering the necessity of a coherent politics of management of the seismic disasters, as a supplement to the one who has for first mission to avoid them.

The recommendations made in this respect, besides those who are classic and who concern the restructuring of the urban fabric as the strengthening of the strategic buildings, the creation of free areas etc..., the strengthening of the legislative framework, the raising awareness and the education of the public and also the establishment of a national Delegation to the major risks. Architects, engineers, contractors, craftsmen, builders, scientists, government officials, but also individuals; the mitigation of the seismic risk is the adage of all. It is only while uniting our efforts, that we can obtain a real improvement of the situation. An earthquake is not an isolated event, and we shall always be subjected to this kind of drama. It is then necessary to accept this fate and to work that these hazards cause, in the future the minimum of dangers to our societies.

### References:

Abdessemed-Foufa , A., 2007. Contribution pour la redécouverte des techniques constructives traditionnelles sismo-résistantes adoptées dans les grandes villes du Maghreb (Alger, Fès et Tunis) durant le XVIIIème siècle. *PhD in Architecture, option : architecture and environment. E.P.A.U of Algiers.*

Belhai-Benazzouz ,A & Djelal ,N. , 2010 . Le foncier vecteur de l'étalement urbain algérois. *Symposium: Identity and territorial competitiveness, from 20 to 22 September 2010 ASRDLF-AISRE.*

Boughazi, K., 2012. Risque sismique et urbanisation, regard croisé sur la ville d'Alger. *Magister Thesis option: cities and urban risk , University Mentouri of Constantine.*

Boumansour Djaafri ,R ., 2005 . L'impact des plans d'urbanismes élaborés pour l'extension de la ville d'Alger et la plaine de la Mitidja sur l'étalement urbain. *Symposium cities the challenge of sustainable development, which control urban sprawl and associated segregation? , from 24 to 27 November 2005 Sfax , Tunisia*

Centre for Research in Earthquake Engineering., 1992. *le risque sismique en Algérie*, CEE , Algeria ,15 p.

Chaline, C. & Dubois-Maury, J., 1994. *La ville et ses dangers : prévention et gestion des risques naturels, sociaux et technologiques*. Ed. Masson, Paris, 247 p.

Cote , M. , 1996. *l'Algérie espace et société*. Ed. Masson/ Colin, Paris, 253 p.

Centre for Research in Astronomy Astrophysics and Geophysics., 2007. *Séismes en Algérie entre 2002 à 2006*. CRAAG, Algiers .

Harbi, A., 2000. Analyse de la séismicité et mise en évidence d'accidents actifs dans le Nord-Est Algérien, *magister thesis (IST-USTHB, Alger, Algérie)*

Hartmut, H., 2004. Apprivoiser les catastrophes, *les annales de la recherche urbaine n° 95, 0180-930-vI-04/95 /*, pp.125 METATT.

Laouami ,N., Slimani, A. Bouhadad, Y. and Nour A. , The 05/21/2003 Boumerdes Earthquake. *Preliminary analysis. Intern Report of the center for research in earthquake engineering.*

Ministry of Regional Planning and the Environment., 2005. *Report on the status and future of the environment*, MRPE, Algiers , P 243.

Ministry of Regional Planning and the Environment., Coastal Area Management Programme (PAC) Algiers coastal zone, 2004. Maîtrise de l'urbanisation et de l'artificialisation des sols. *Report : Prospective study of urbanization*. MRPE, Algiers .