



Flood management: Case of the city of M'diq and Fnideq

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Abstract

In the Mediterranean region, the importance of floods and their intensity, involve decision-makers to consider this phenomenon in their strategy. In this context, the determination of areas expected to be affected by floods is necessary for better management of this risk. The evaluation of the floods of M'diq and Fnideq in this article, allows to determine the different protective structures such as gallery, storm depot, that have been realized during these last years. These structures were carried out by the company of Amendis, in partnership with ALOMRAN and the municipal council, in order to minimize the majority of the flooding impacts on these tourist cities. The protective structures that were put in place from 2007 play a key role in the reduction and management of these floods in the study. However, the realization of a 1 km of interception channel along the bypass road of the center and allowing the evacuation of rainwater from the basins bordering the sea or the Smir Merja.

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1. Introduction

Floods are natural hazards that can lead to loss of life, property damage, social and economic disruption and environmental degradation. Morocco is no exception to this rule. The most frequent and deadly disasters for this country are the terrible recurrence of floods. The floods of Oued Ourika of 1995, those of Oued Maleh of 2002, the floods of October 2008 (Tangier, Nador, Fnidek, Boulmane ...), and the floods of Wadi Baht (January- February 2009) remain etched in the memories of Moroccans [1].

The town of M'diq and Fnideq have been exposed to repetitive floods; such as floods in the Oued Fnideq in December 1990 and floods in M'diq in 1991 and 2008. The severe weather, the predominance of relief mountainous and the nature terrain,

which are generally impervious, are the main causes of flooding in these two cities [2,3].

The watersheds in the study area are at high risk of flooding. In fact, the bad weather recorded in this region shows how much the protection against floods has become a major issue. It is, therefore, a major challenge in the management of water resources. Indeed, the high degree of irregularity of the hydrological regimes, the nature of the often impervious soils and the disparity between an upstream mountainous terrain and a vast alluvial plain downstream explain the generation of significant runoff, torrential and violent floods. These factors can lead to floods that have resulted in loss of life and significant material and environmental damage [4]. In addition, climate change is increasing the susceptibility of the watershed to flood damage threatening the economic development, infrastructure and natural ecosystems of the region. Indeed, these changes

affect the increase in the frequency of floods in Mediterranean coastal areas, the rise in sea level and the prolongation of the drought period. The development of agriculture is most often in the plain, because of the presence of water, better grounds, as well as topography favorable to constructions and cultures. This risk of flooding is also linked to anthropogenic factors, notably the increasing urbanization experienced in the province of M'diq-Fnideq.

The main objective of this work is to analyze and evaluate the flood zones, as well as the different solutions and structures proposed.

2. Presentation of the study area

2.1. Geological presentation

The study area is located in the northern Rif. Following a very complex alpine tectonic structuring, this part of the Rif has acquired a submeridian disposition and shows the following major domains: the ghomarid and sebtian layers, with Paleozoic and metamorphic material respectively, in the East; the calcareous dorsal material mainly calcareo-dolomitic Mesozoic, in axial zone; mesotertiary flysch sheets and the Tangier unit with Cretaceous schisto-marly material in the west [5.6].

Transverse tectonic accidents have created a particularism of the sections of the Rif chain. This recent structuring of the Rif chain, not yet blurred, as indicated by the seismicity of the region, bequeathed a contrasting morphology of the land and its periurban: a line of ridges (Dorsal limestone) and hills (ghomarids) bordering the west side of the alluvial plains and a narrow coastal strip.

The alluvial plains subject to urban extension serve as overflow and lateral wanderer lands of oued Martil, Allila, Smir, Negro and Fnidaq.

2.2. Climate presentation

The climate of the region is of Mediterranean type with oceanic influence. It is characterized by winter and summer temperatures softened by the proximity of the sea (23°C as average of maximum and 14°C as average of minimum); and average rainfall of the order of 650 mm. Although these average values do not reflect the torrential nature of the rains. East (Charki) winds prevail from May to October, and West (Gharbi) winds from October to February [4.5]. While a balanced wind pattern from ENE to WSW occurs from March to April.

2.3. Geographic location

The prefecture of M'diq-Fnideq, was limited by the Mediterranean on the north and the east, by the prefecture of Fahs Anjra in the west and by the province of Tetouan in the South side (Fig 1). It was created in 2005, as a part of the province of Tetouan. It has been divided into three urban communes: M'diq, Fnideq, Martil and tow rural communes: Alliyenne and Belyounech [4]. In the context of the upgrading of Moroccan cities, the cities of M'diq and Fnideq have benefited from a redevelopment of their urban centers and the improvement of the quality of circulation, notably by creating pleasant maritime walks and installing a series of urban

infrastructures. The city of Martil is also part of a process of urban upgrading [4].

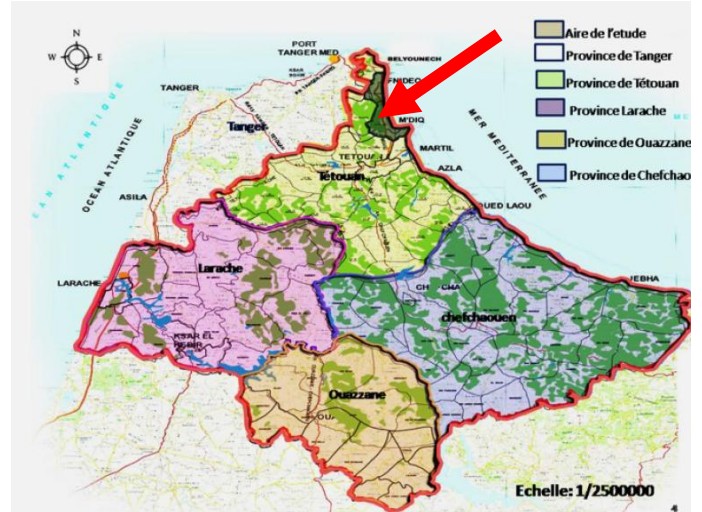


Fig.1. The location of the prefecture of M'diq et Fnideq [5]

2.4. Population

The commune of M'diq currently has a population of about 56227 inhabitants, according to the last census (2014). The urban perimeter of the city extends on an area of 480 ha of which 153 ha are urbanized. The urban commune of Fnideq, extends along the edge of the Mediterranean on an area of 28.5 km², which cause an extension of urbanization in the region that has already a strong stand density. The City currently accounts 77436 inhabitants. Le tableau 1 shows the results obtained from to the last general census (2014) [6]. The tourism, fishing and commercials are the main activities of these cities.

Tab.1: General Population and Housing Census, 2014

Population of the Prefecture	household	Population	Foreigners	Moroccans
M'diq-Fnideq	51 139	209897	579	209 318

3. Problematic of the study area

Streams with a small watershed in the study area have been altered by mostly informal urban development, which give rise to new areas of storm water stagnation and drainage black spots. For example, the Khandaq near to the Auxiliary Forces subdivision, Foom El Oulik, Nile Avenue, Lala Nouzha Avenue, Rabat district, M'diq El Jadid, El Bahr district, Kabul street in M'diq and Oued Fnideq, Khandaq Echbar ravines, Sidi Boughaba, town center, Moulay Rachid subdivision and Merja in Fnideq [7.8].

3.1. The area of M'diq

3.1.1. Characteristics of the Smir Watershed

The watershed of the Oued Smir extends over an area of 90 km². This basin is subdivided into two sub-watersheds, one located upstream of the Smir dam, which is regulated, and which supplies drinking water to the cities of Tetouan, Fnideq, M'diq

and the coastal zone with an area about 75 km² [1]. Figure 2 shows the delimitation of the the Smir Watershed realized by the Arc GIS program.



Fig.2: Delimitation of the Smir Watershed

3.1.2: Town center of M'diq

The center of M'diq is located between reliefs, where several chaâbas originate in the upstream of the Mediterranean coast and the Merja Smir. These chaâbas were subdivided as follows:

- Chaâba Southeast and the neighboring chaâbas that flow towards the southern part of the city center
- The chaâbas Northeast which flows towards the Marja Smir.
- The chaâbas coming from the Al Jabl housing estate and the Moriskiène district, cross the city center via an underground canal that no longer works properly because of the blockage of the heads of engulment by the solid bedload. At the time of the floods, the waters follow Imam El Boukhari Avenue (Hay Salam), and then pass through the Ibn Battouta College to arrive at the Rabat district, characterized by its flat terrain, which is an ideal area for stagnant water. These three chaâbas have an area about 0.5-1.6 and 10.5 km² respectively [9.10].

In the case of heavy rainfall, the watersheds that drain the waters of these chaâbas are responsible for the floods that know the city. The impacts of these floods have been increased by the anarchic urbanization that has been developed on all the basins, and by the almost nonexistence of the network of drainage of the sanitation waters and the waters of the floods. The frequent damage recorded during floods is summarized as follows:

- The flooding of the center with rising water (from 0.2 to 0.6 m per location).
- Stopping traffic at RN 13, due to damage on the roadway and nearby businesses.

The problem of the floods in the Sekka district was mainly due to the encroachment and strangulation of the chaâbas, which cross it through the constructions. Moreover, the chaâbas pipes

are insufficient to evacuate flood flows, causing sudden overflows, threatening the neighboring dwellings. Figure 3 shows the different photos of the flood of the city of Mdiq



Fig.3: Flood of M'diq city (2014)

3.2: The area of Fnideq

The main watercourses of Fnideq are Oued Fnideq, and the chaâbas located on the north of the city such as, Chaâba Condessa, chaâba Aghattas, chaâba Sidi Boughaba, Chbar district, chaâba Merja and Oued Condessa, which favored flooding problems at the time of floods.

3.2.1. Characteristics of the watershed: Oued Fnideq

With an area of 35 km², Oued Fnideq is the largest river that crosses the urban perimeter of the city of Fnideq [1]. The very strong urban expansion spread to the bed of the Oued, which leads to the construction of new constructions in the thalwegs of Oued Fnideq. New neighborhoods are emerging at this zonet

and are highly exposed to floods. Moreover, the bed of the Oued and the talwegs have numerous deposits of building materials, such as rubble, rubbish and domestic waste hampering the flow and blocking the crossing structures. Figure 4 exhibit the delimitation of the Fnideq Watershed realized by the Arc GIS program.



Fig.4: Delimitation of the Fnideq Watershed

3.2.2. Town center of Fnideq

The so-called Chaâbas converge on the northern part of the city, were channeled by scuppers whose slabs were locally removed because of the ease of maintenance. The canalization of the scuppers converges on a single structure (Ovoid) which passes under the houses and crosses the center of the city then the RN 13 before coming out at sea. Due of their urban location, these scuppers receive a lot of waste of any type. In addition, the slopes upstream of the chaâbas lead to the transport of very important solids (silt, gravel, stones, branches, etc.). The configuration of the pipeline can be presented as follows:

- Two separate scuppers collect the waters of two chaâbas, each draining 53.3 Ha and 129 Ha. About a hundred meters from their entrance, these scuppers are divided into a single culvert for a length of about 180 m.
- A chaâba draining the rainwater of a bare ground, join the ditch in the city center. In this zone the abundant vegetation confirms that it is a sector of convergence and stagnation of water. Moreover, according to the testimonies gathered, the floods of the city center begin in this zone before touching the districts located downstream.
- All the works join a channel at the end, crossing the entire center for a length of about 700 m. before reaching the sea, this canal has rather modest dimensional characteristics (ovoidal section of T 180 mm). Moreover, during the floods of December 1990, this collector was quickly saturated, the water overflowed by the looks and the degraded parts of the underground channel put under pressure [7.11]. Figure 5 shows some images of the floods of the Fnideq city.



Fig.5: Floods of the Fnideq city(2014)

4. Analysis of the study area

The flood situation in the two cities was analyzed as follows:

4.1. M'diq city

- Creation of a 1 km long interception channel along the bypass road of the center and allowing the evacuation of rainwater from the basins bordering the sea or the Smir Merja
- Limiting the drainage capacity by constructing non-homogeneous scuppers into sizes and shapes resulting in repetitive flooding at each downpour.
- The installation of the gullies and grids, which were unable to drain all the volumes of the heavy precipitations, which causes the appearance of the new black spots.
- The very large construction of the Sekka district namely, Ain Choufou, Kalaa, Chrifa, Fom al Oulik[8], produced a large quantities of cuttings. Which were subsequently poured upstream of the talwegs and then drained by the rainwater to the collectors, this leads to a reduction in the drainage capacity of the effluents, especially when arriving at the low zone characterized by its low slope. This trend lead to a decrease in the flow rate of the decantation of carts and the deposits carried and, sealing of pipes.
- The Sekka quaira was equipped with a unitary sewage system with a single pipeline to the Bahr pumping station. However, the station was designed for sewage only, which affects other parts of the city connected to the station. In addition, the capacity of the station cannotstand the overflow of rainwater and roof water during showers.

4.2. Fnideq city

- Rainwater sewer lines were blocked by garbage deposits and bedding. This caused flooding problems due to insufficient evacuation capacity.
- Buildings were built on the Merja Collector. The collector diameter was reduced at several points that disrupted the drainage capacity. The collector suffered damage mainly during the repetitive floods of 1999 and 2008, given the lack of access under the constructions.
- Oued Condessa was encumbered by all kinds of garbage and deposits, which limited its drainage capacity.
- The chaâba of the Oued Fnideq district, presents the same problem and has been used as a clandestine dump.

5. Results and discussion

In the face of this situation of repeated flooding several services such as, the province of M'diq-Fnideq, the urban commune of M'diq and Fnideq, the hydraulic basin agency of Loukkos and the electricity and sanitation water agency (Amendis), had spent time, effort and cost of solutions each on its own in order to limit the severity of these floods.

5.1. M'diq city

Several solutions have been realized for the protection of this area against flooding.

- Prohibition of new constructions along the chaâbas beds of Aquaparc and Saniat Torres downstream of the embankment of the RN13.
- Prohibition of garbage and rubble deposits in beds of châabas.
- Resizing of the sewerage network in the city center, notably at the Rabat district level and the South-East neighborhoods located at the old railway line: (Sekka).
- Clearing large parts of watersheds directly on the sea without going through existing collectors.
- Realization of a T220 gallery in the al Jabal housing towards the sea [10].
- Realization of an ovoid collector Φ 1600 from Avenue Nasr towards the Smir lagoon [10].
- Realization of two collectors Φ 1000 in district Rabat towards the lagoon Smir [10].
- Installation of storm overflows on the unit network to limit the incoming overflow to the al Bahr station.
- Multi-point overflow system to alleviate al Bahr station.
- Renewal of collector Oued el Makhazine in diameter about Φ 1400 [10].
- Creation of special structures in direct intersections to avoid perpendicularity of the force of outcrops.
- Installation of pumps with a flow rate of 300 L / s to evacuate rainwater.
- Renewal of the collector Abdelkarim el Khatabi Φ 1400 on 250 meters and the installation of an intersection structure between the collector of Oued el Makhazine and Abdelkarim el Khatabi.
- Offloading of the watershed al Jabal directly to the al Bahr pumping station, instead of Oued al Makhazine, by a T 220 gallerie on 600 meters towards the sea.

5.2. Fnideq city

The solutions used for the protection of the flooded areas were presented as follows:

- Protection of the left bank of the Oued Fnideq and extension of the protections upstream of the road bridge.
- Periodic cleansing of the Oued at the center
- Substitution of the passage projected by a battery of 9 scuppers of 3mx3m under the Massira project by the CGI in collaboration with Amendis and the ABHL
- Prohibition of any deposit at the Wadi Fnideq level and buildings in the neighboring areas that are not yet urbanized, which could be converted into a green space.
- Departure by Amendis the Merja canal via two scuppers of (2x3) towards the sea.
- Loosening of the Merja and Oued Fnideq catchment basins towards the sea by two galleries avoiding the transport of waters from the two watersheds to the city center,
- Construction of a Sidi Boughaba Φ 1600 collector over a length 360 m to the sea,

- Realization of a Dalot Ras Louta on a length 400 m 2x2 towards the sea,
- Construction of a collector Aghattas dalot 2x2 length 500 m towards the sea
- Construction of a Condessa Φ 1800 collector in the Sidi Boughaba district to protect the Moulay Rachid subdivision in addition to the installation of various batteries of grids on the heads at the head of the works,
- Realization of the Gallery

6. Conclusion

The situation as it currently stands has seen remarkable improvements following the implementation of several development projects for the protection of the city centers of M'diq and Fnideq and the installation of new storm water drainage systems and Are of paramount importance in the flooding process before, during and after floods.

However, the projection of new structures to future horizons must be put in place in order to mitigate the disastrous impacts of such situations, particularly in the governance of environmental issues at the local and regional level when developing adaptation strategies and Updating of the development plan of the study area.

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