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The cliffs between imbalances and protection strategies

« Situation of Amouni cliff in Safi city »

Les falaises entre les déséquilibres et les stratégies de protection

« situation de la falaise Amouni à la ville de Safi »

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Abstract:

The seashore of Safi is part of the Atlantic coast of Morocco, It extends over a distance of about 120 km, characterized by cliffs that have unique characteristics along the Moroccan Atlantic coast, it is one of the longest high cliffs succeeding continuously on the Atlantic coast, it is a considerable geomorphological inheritance, unfortunately they are the subject of an intensive erosion by morphogenic processes which make this heritage more and more crisp.

In order to cope with the deterioration of Amouni cliff in Safi, and to limit the damage that can severely the adjoining structures we will present the problems and solutions to protect Amouni cliff.

Keywords:

Coast, cliff, imbalances, strategies, protection

Résumé :

Le littoral de Safi fait partie de la façade atlantique du Maroc. Il s'étend sur une distance d'environ de 120 km, caractérisé par des falaises qui ont des spécificités uniques au long de la façade atlantique marocaine, il s'agit de l'une des plus longues falaises hautes se succédant de manière continue sur la côte atlantique, c'est un héritage géomorphologique considérable, malheureusement elles sont le sujet d'une érosion intensive via des processus morphogéniques qui rendent ce patrimoine de plus en plus fragile.

Dans le but de faire face aux dégradations que connaît la falaise de Jorf Amouni de Safi, et de limiter les dégâts que peuvent subir les ouvrages mitoyens nous allons présenter les problèmes avec des solutions de renforcement pour protéger la falaise du jorf Amouni.

Mot clé :

Littoral, falaise, déséquilibres, stratégies, protection

General Introduction:

The coasts are complex ecosystems, very diversified and particularly rich since they are located in contact with the lithosphere, the hydrosphere, and the atmosphere. This wealth explains why these spaces are coveted by human societies, they are the most populated in the world, where many economic activities are mainly concentrated (industry, tourism, trade, fishing, agriculture ...), which leads to many conflicts of use (Desmazes F, 2005).

The littoral is multiple, It's a boundary, a strategic territory, It is above all linear entity "between nature and society" mixing superimposed heritages (Husson J, 1998). It is composed of ecological details specific to an interface medium modified according to anthropization, What has imposed safeguarding strategies around the world, by adopting the tools put in place to establish, harmonize, make coherent and protect, sustain or even restore natural coastal ecosystems, depend on their functioning and their application of the ante state (Quilès P, 1991).

Multiple interventions are observed in all countries of the world, in Morocco which has a coastline stretching over more than 3500 km generating an extreme ecological and socio-economic interest. Nevertheless, these crisp areas are subject to countless pressures, demographic (more than 67% of the national urban population), urban (domestic waste), industrial (more than 85% of industrial activity), tourist (more than 63 % of tourism), and the development of modern agriculture (intensive use of pesticides and fertilizers).

These pressure sectors have a negative impact and produce huge quantities of effluents that are directly dumped, and without any prior treatment on the entire national coastline, affecting both the physical environment and the living environment and this contributes to the degradation of a territory that designs and generates huge wealth that is part of the national Gross Domestic Product (GDP).

The coast of Safi extends over a distance of about 120 km, it is characterized by cliffs that have unique characteristics along the Moroccan Atlantic coast, it is the longest high cliffs succeeding one another continuously on the coast Atlantic (Weisrock A, 1980), it is a considerable geomorphological inheritance, unfortunately they are the subject of an intensive erosion via morphogenic processes which make this inheritance more and more fragile, also the mode of current development contributes to the accentuation of these processes which contributes to the degradation of this environment, in this context, this article can help to answer the problems related to tenure, development and management, since they are urbanized cliffs that do not evolve in a natural way, but under ever increasing anthropogenic pressure, which not only contributes to the rapid decline of the cliffs but threatens lives, personal property and public infrastructure, this reciprocal interaction is the pivot of the problem. Indeed, the management of this littoral suffers from an insufficient knowledge of the processes governing its natural evolution, it will then be necessary to answer several questions such as the identification of the processes of evolution of its morphological entities, the forms and the levels of degradation, and the most fragile areas, with a view to exhorting strategies for safeguarding and sustainable development through management that integrates all the sensitivities and actors interact closely in Safi.

1- General natural framework of the study area:

The natural frame of the city of Safi characterized by diversity will be discussed in detail as follows:

Map 1: location of the study area:



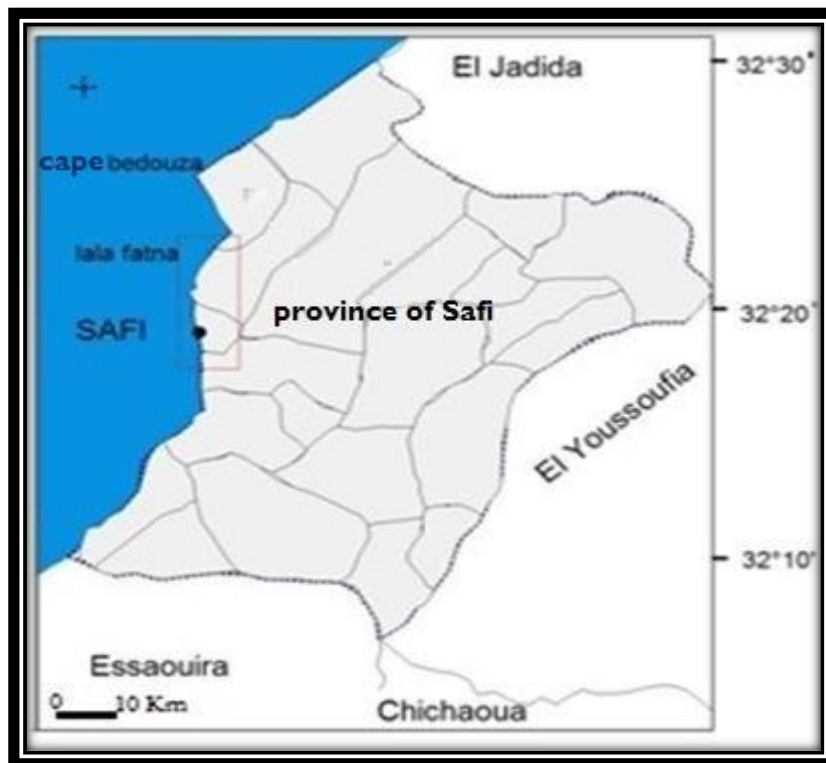
Source: urban agency.

1.1 General Geographical Framework of the Study Area:

The study area is between Lalla Fatna beach in the north and Jorf Lihoudi (Lihoudi cliff) in the south.

It belongs, therefore, to the great Moroccan morphological unit called Western Meseta, between latitudes $32^{\circ} 24' N$ and $32^{\circ} 10' N$ and longitudes $9^{\circ} 15' W$ and $9^{\circ} 16' W$.

Map 2: location of the study zone:



Source: urban agency.

the littoral object of the study is composed successively, from South to North, of Jorf Lihoudi (Lihoudi cliff), of the bay of Safi and its beach, the segment Borj Nador, El Boudali, and the beach of Lalla Fatna, it displays an original character. It is mostly rocky although there are sandy beaches interspersed between high and medium cliffs. This site represents nearly 30 km of irregular coastline.

1.2 a wavy topography:

The study area is the western end of the Abda region, which lies to the south west of the "Moroccan Coastal Meseta" domain, which shows a tabular alpine cover placed on a penetrated primary base (Weisrock A, 1980). it consists of low coastal plains, ancient eroded massifs and low and high plateaus, known by the Abda Doukkala plains and plateaus. The plateaus of this coastal sedimentary basin dominate to the north and north west and are almost absent to the south and south east. It is a set of uplands with altitudes above 100 meters, which means that the river system is hosted and these areas look like uplands (Weisrock A., 1980).

Safi tray:

It is an intermittent tray with an average altitude of 110 meter to "dar si Massoud" (9 ° 06'W; 32 ° 12'N) from an EW (east west) direction, there is an average altitude of 20 meter and a tilt of 2.66%.

The previously described units are in contact with the sea by an extensive, undulating and irregular coastal band; by cliffs that have different altitudes that can reach 153 meter to "Borj Nador" (9 ° 10'W; 32 ° 12'N).

Indeed, the northern part of the study area, from Sidi Bouzid to Lalla Fatna, 60 to 150 meter long continues on the Moroccan Atlantic coast. Elsewhere, they are very localized, from the beginning to the end, through the study area and the Atlantic atlas (Cape Tafelny, Timezguida Oufas, Imousouane), where they are not higher. Many other areas are also very difficult, but low (less than 50 meter).

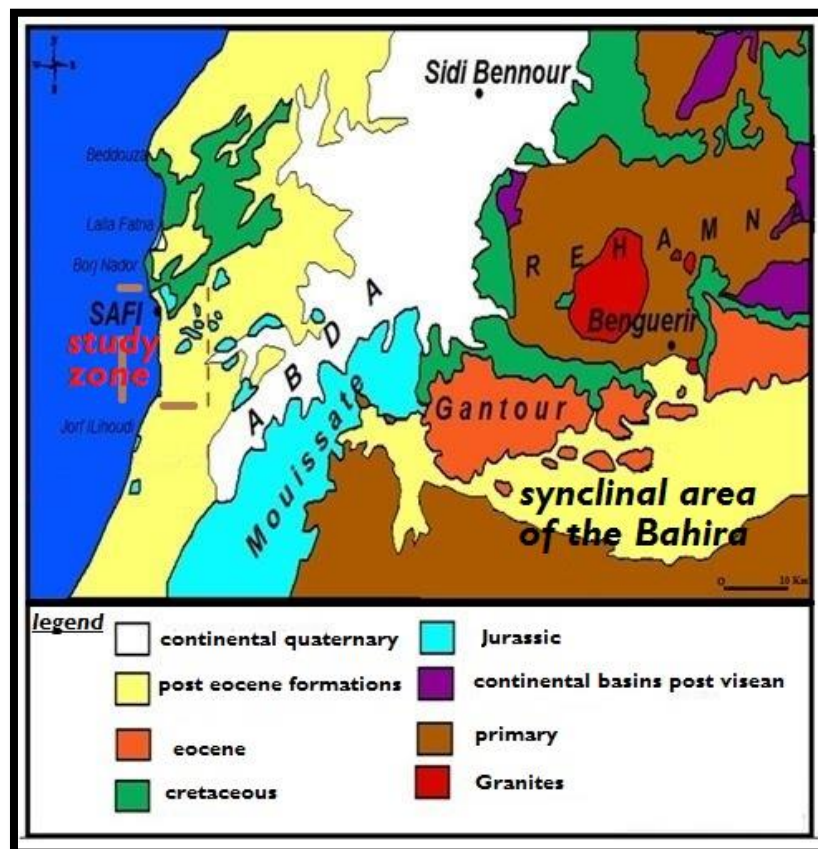
This classification obviously excludes dead cliffs, which can be much higher (more than 300 meter at Cape Rhir), as well as fake cliffs (a "false cliff" is only a relief modeled continental diving into the sea, without the latter having really shaped and slashed it other than at its base (Guilcher A, 1966).

The cliffs of the Safi region are real cliffs that owe their existence to the action of the ocean (Weisrock A, 1980).

1.3 Geological and Hydrogeological Framework:

Our study area, belongs to a morpho structural unit known as the "Moroccan coastal Meseta", and more specifically to Abda Doukkala plains, and plains characterized by a tabular regime of secondary and tertiary deposits, deposited on primary sites strongly folded by the Hyrcanian orogeny and then penetrated (Michard A, 1976).

Map 3: Simplified geological map of the Safi region:



Source: Geological Service of Morocco, 1954.

2- The climatic characteristics of the region:

The presence and the latitudinal displacements of the Azores anticyclone make the climate of Morocco in variation from one season to another. It is affected at the level of its littoral fringe by cold fronts during the winter, carrying wind, rains as well as a cool temperature. On the other hand, in the north of the country the displacement of this anticyclone allows the rise of tropical atmospheric cells and the prevailing winds coming from North East sector during spring and summer.

Due to its geographical position (32 ° 30 'North 9 ° 24' West), Safi has a climate semi arid, strongly influenced by the ocean, which has strong repercussions on the morphodynamics of its coastline.

Indeed, the study area is located under a Mediterranean climate in temperate and humid winter, and in summer hot and dry, the proximity of the ocean, orientation, zonation and exposure of the littoral are all factors that determine the penetration and degree of oceanic influences.

2.1 Flagrant intra annual and interannual variations in rainfall:

The rainfall received by the Safi region seems to have a remarkable intra annual and interannual irregularity, it depends on several factors which are the latitude, the continentality and the exposure of the slopes in the vicinity of the Rehamna massive.

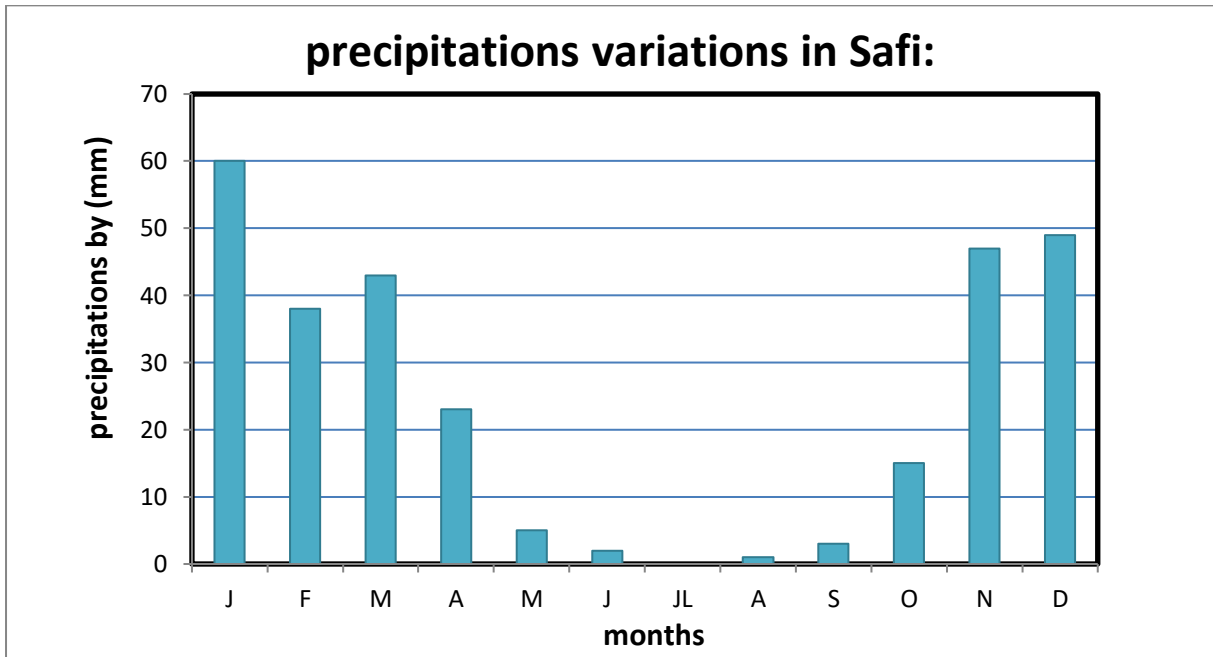
Also the proximity of the ocean has a pluviogenic role, It is a large surface of evaporation. The air soaks moisture and when it reaches saturation it causes precipitation at sea or on the coast.

The rainy season covers, on average the period from October to March, on average.

According to observations and calculations made over several years the average rainfall in the region is of the order of 308 millimeters.

Precipitation plays an important role in the morphodynamics of the study area, in particular by their influence on the slopes of the cliffs, since the flow of precipitation waters favor the formation and developments of ravines and groundwater recharge, eventually reach the sea in the form of springs.

Diagram 1: Average Monthly Precipitation (monthly average) in Safi between 2000 and 2018:

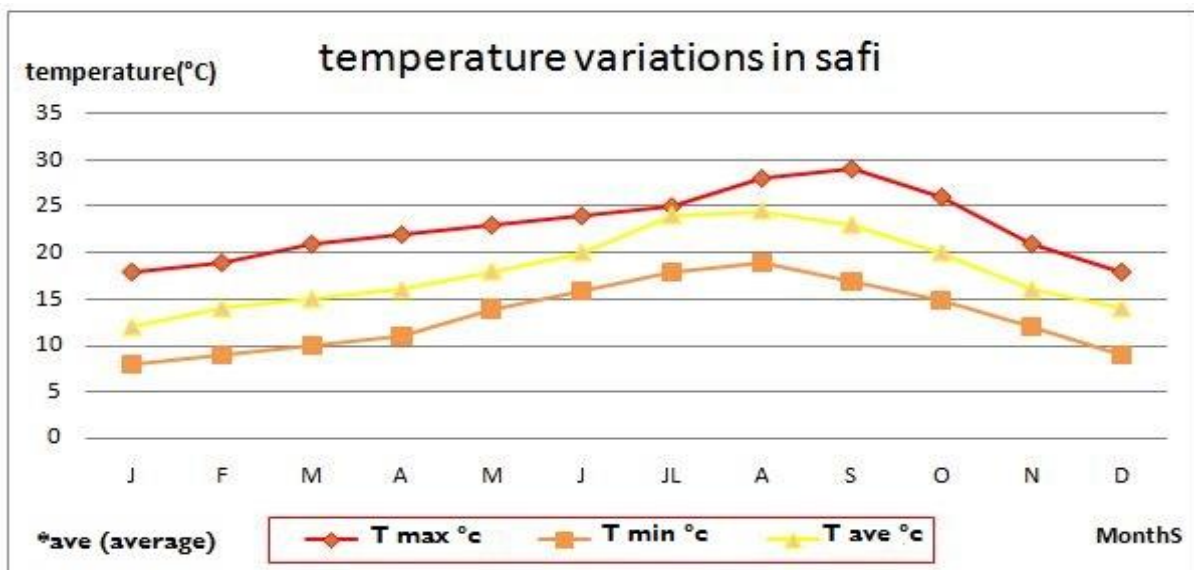


Source: Provincial Directorate of Agriculture in Safi 2018.

2. 2 The ocean has a very important thermal role:

The thermal role of the ocean is to be a regulator, The thermal inertia of the ocean makes it possible to cool or heat the sea facades due to the sea currents. These are powerful water mass transfer agents.

Diagram 2: Average monthly maximum, minimum and average temperatures in safi between 2000 and 2018:



Source: Provincial Directorate of Agriculture in Safi 2018.

In the region of Safi temperatures are moderate in the areas near the ocean, more contrasted inside. The temperature parameter has inter-annual variability, but it varies a little from one year to the next. Over the course of a year, there are two periods. One is a warm-weather period from May, June to September, October. the other is mild-cold weather from November to March April.

2.3 Hydrodynamic agents:

A. The winds in the Safi region:

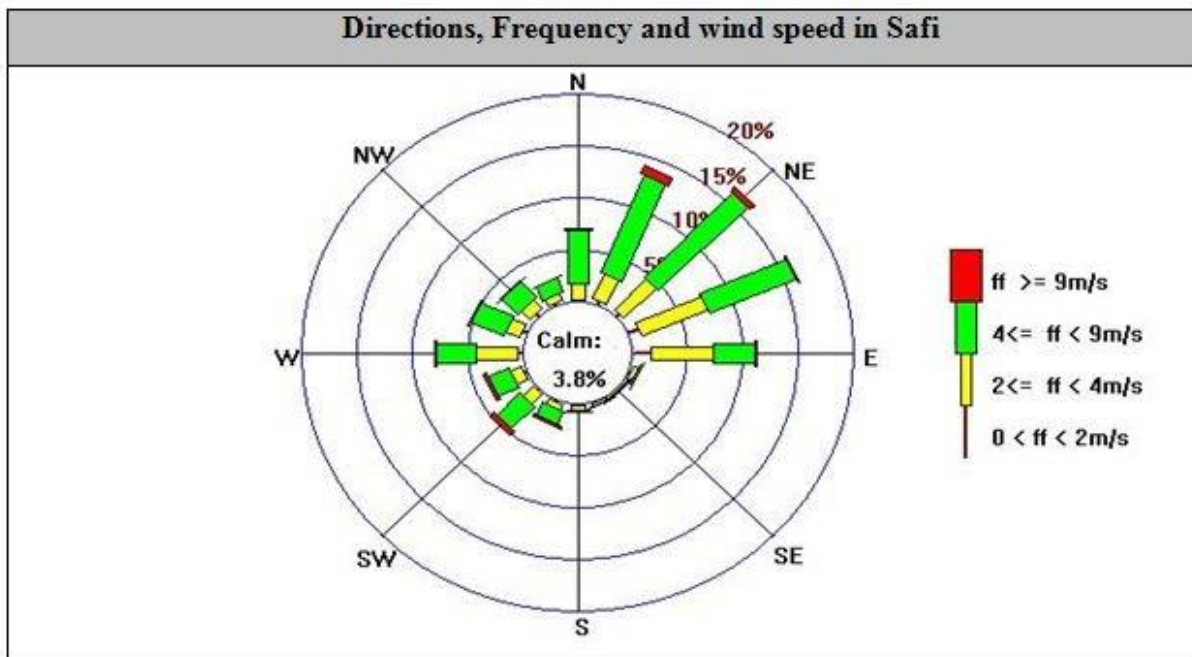
The most frequent winds are light to moderate winds (speeds between 2 and 10 m / s), mainly from the interior (East and North East sectors). They change direction during the day, blow from the East in the morning, while in the evening they arrive from the West North West sometimes turning to the North North East, According to the mission (Zakarya M, 1994).

The strong wind direction is North East and West, accounting for only 1.9% of observations, While the strong wind comes from the West and South West sector, sea wind. These winds, strong to very strong have a speed of 17 to 24 m / s.

Stormy winds disrupt the bustle of the waters, causing a very shallow chop and great violence near the coast, They also act on the regime of the currents and increase the curve of the swell when they coincide with their direction of propagation.

Tidal currents are influenced by local winds that are generally very weak, especially when ebbing, They modify the superficial water movements that result from affecting them with an average western component (Zakarya E, 1994).

Diagram 3: Directions, Frequency and wind speed in Safi:



Source: OCP environmental impact study, 2018.

B- The tide and currents in the Safi coast:

Schedule 1: The tides in Safi:

Tide	Full sea in m	Low sea in m	Amplitude in m
Long live water	+3,6	+0,8	+2,8
Dead water	+2,7	+1,4	+1,3

The hydrological zero is located 2.14 meters below zero
(Moroccan general leveling)

Source: Direction of Safi Port, 2018.

Like all the Atlantic coast of Morocco, the tide on the coast of Safi is of semi diurnal type in high water, a tidal range of 2.8 meter, and in dead water 1.3 meter.

Schedule 2: The tides in Safi:

Tide	Zero hydrological
Full High Water of Long live exceptional water in meter	+4,50
Full low sea of Long live exceptional water in meter	+0,00

Source: Direction of Safi Port, 2018.

C-Generally weak currents:

Currents in the study area come essentially in four forms:

- General currents.
- Currents due to wind action.
- Currents due to the action of the tide.
- Drift currents due to the action of the oblique swell in the breaking zone.

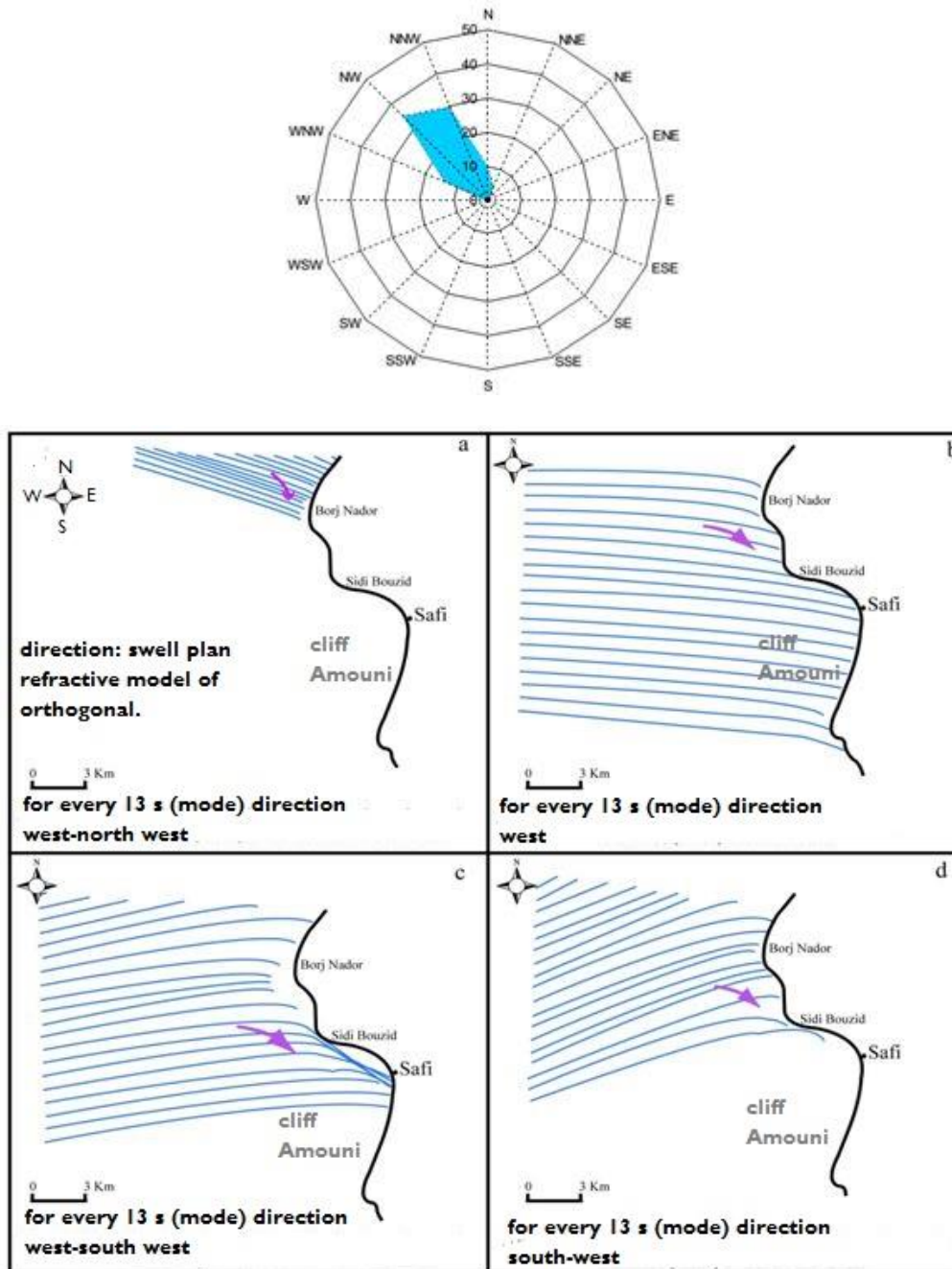
The tidal currents are alternative toward West North West, while the other three forms have a homogeneous direction towards the South South West.

In general, it should be noted that the currents in the study area have an amplitude generally less than 0.5 m / s, the tidal currents modify the surface of the body of water causing the waves to blossom, the flow is almost always accompanied by a recrudescence of the agitation, giving rise to coastal currents whose velocities are low, while The velocities are very low (Zakarya M, 1994). This shows that the tidal currents have a very weak influence on the transport of materials, their action fairly limits the spread of sediments.

2.4 Swell on the coastline of Safi:

In Safi the dominance of a swell West North West at North North West.

Schema 1: frequency of wave directions of Safi:



Source: Minoubi, 2006.

The shoreline of Safi is characterized by three types of swells, which according to their sources.

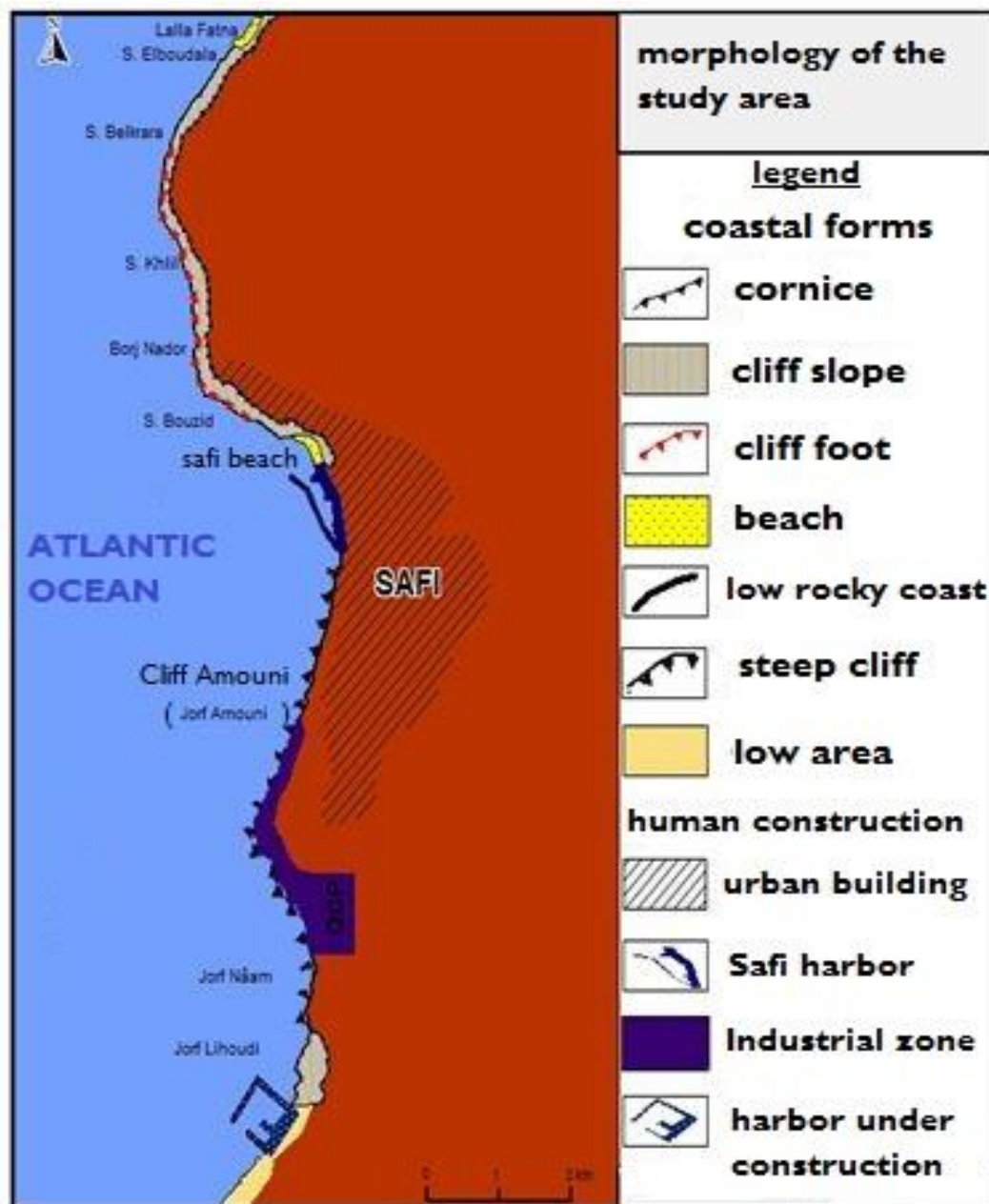
- a swell W at WNW (50%) of a period of 10 to 18 seconds, it is active for three seasons, spring, summer and autumn.

- a swell WNW to NW (23.5%) which is characterized by great strength, its duration exceeds 18 seconds resulting in disturbances and storms in the Atlantic Ocean.
- SW swell at WSW (18.5%) dominant during the winter season, it is characterized by a short duration and weak force.

3- the characters of Amouni cliff and the state of place:

Rocky Area from the southern point of the beach to the northern point of Safi beach, characterized by small and medium cliffs of steep shape from 5 to 25 meter high (low cliffs), and they are limited to the south by the high Lihoudi cliff (about 90 meter high).

Map 4: Morphology of the studied area:



Source: map 1/50000 of Safi and Souira Lakdima, and Magueri 2013.

3.1 The structure of the rocks:

The shoreline of Safi consists of exclusively sedimentary rocks, The nature of the rocks varies according to the natural conditions of the deposit environment. The geological properties of the rocks have already been described. It's limestone, clay and sandstone rocks, The resistance of these rocks is therefore variable.

It should be noted that the limestone layers have a good resistance, The layer of sandstone is very resistant, it is consolidated, These are hard rocks, Limestone and sandstone are not very sensitive to chemical weathering processes. Moreover, mechanical erosion is effective, Clay layers are soft layers that have low resistance to wave action, they are soft rocks. It should be added that the presence of sandstone and calcareous shoals, interposed within these formations of clays and marls, shows the differential erosion between these rocks.

Also, it is essential to remember the hydro geological properties of these rocks, Lime stones are porous rocks, they are permeable, while clays are impervious. Dridrat limestone contains the main aquifer.

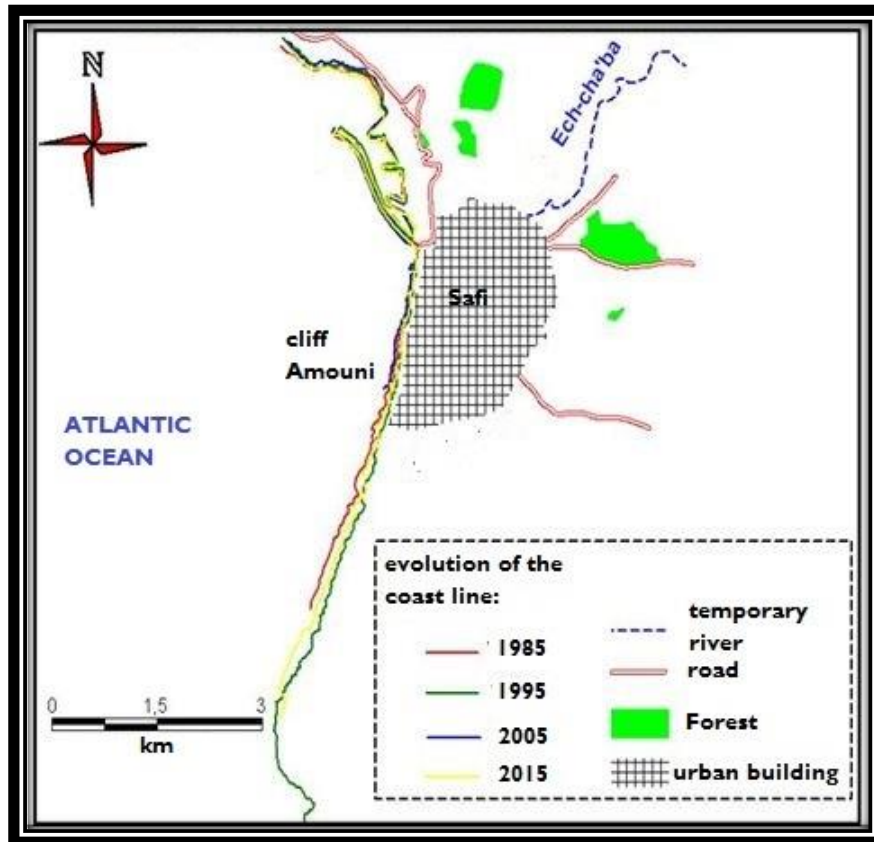
In fact, the underlying clay layer blocks the infiltration of water. This has the effect of concentrating the groundwater in this shallow reservoir layer. The flow of groundwater is between these two layers in the form of a blade, and it generates landslides at the exits of the cliffs especially north.

Thus, clays have been the subject of many studies for several years and are still of great interest, not only because of their mineralogical nature, but also because of their very particular physicochemical and geotechnical properties (Locat J, 2002).

The southern set of the study area is characterized by essentially low cliffs, 5 to 25 meters, carved in homogeneous formations of quaternary sandstone and limestone, and limited to the south by the high cliff (Jorf Lihoudi) about 90 meter high.

3.2 coast line evolution:

Map 5: Safi coast line evolution between 1985 and 2015:



Source: personal realization

Despite the great challenges facing the coastline in Safi city, which consists of waves and sea currents, especially the southern region, which includes the Amouni cliff, but the decline of the coastline was simple where it is not more than a few meters (probably 6 meters), and can be explained that the cliff includes a layer of calcareous resistance represents a resistance front of the Marine influences.

3.3 The urbanized cliff of Safi a declining heritage:

The sub aerial processes already mentioned above do not play the same role, here the marine processes that persist, the role of the action of the swell and the effects of port and industrial developments are not foreign to the evolution of this cliff.

The presence of Jurassic material, largely made of marl and gypsum, explains the attack of the cliff at its base. On its materials rest sandstone and limestone, sensitive to the effects of breaking waves and infiltrations of natural and wastewater.

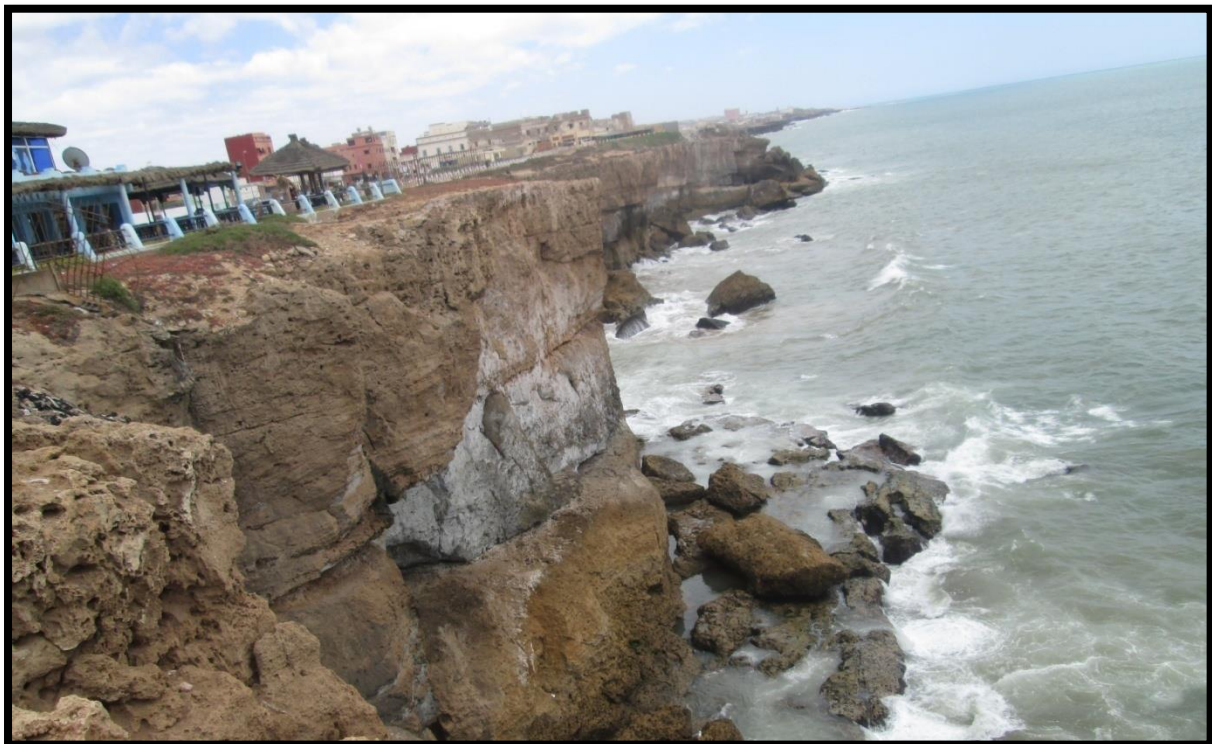
The materials, losing their limestone cement, eventually crumble. The cornice is therefore gradually cantilevered and falls by gravity, and this causes the cliff to retreat.

The urbanized cliff of Safi city (Amouni-Trab Sini) is a big part of the Trab Sini zone and the railway that takes a tunnel of 200 meters which are here threatened. The road linking the

center of the city to the canneries and the Portuguese fort are also affected by the decline of the cliff. Part of this neighborhood of 11,000 inhabitants had to be razed, after relocation of residents in other areas, but the problem remains for all those who still occupy the site.

This does not only concern the habitat, the railway, the castle of the sea some of which collapsed, and the rest is very threatened by the many cracks and galleries developed in this cliff. These caves are located in the areas of attack in the tidal flapping zone in less cemented rocks, Similarly we can have a vertical development of the cave if we are in a place of weak resistance (Mouabid J, 2002).

Photo 1: The Amouni cliff made of dune sandstone linked by a limestone cement:



Source: urban agency 25/1/2018.

The Public Laboratory for Studies of Trials and Studies (LPEE) has noted the presence of eight cavities of varying size in section and length. The most dangerous is the one that has already caused a superficial collapse of the railway. This cave of 8 meter wide and 1.2 meter high was certainly clogged with concrete as a local and temporary act, but the problem of erosion continues around this filling, and new caves are being formed.

3.4 Several factors contribute to the decline of the southern cliffs of Safi:

A- Swells wide cause erosion of poorly cemented passages:

The cliffs south of Safi that extend from the location of the sea castle in a southerly direction, about 7 km, consist mainly of dune sandstone, bound by a limestone cement with the presence of poorly cemented passages, and continually subjected to wide swell especially

from West to West North West and South West direction, thus causing a gradual erosion of the most sensitive strata.

Parts with weak cementation especially at the foot of the cliff facilitate the attack of the waves, where the mechanical action is important, the blades which break against the walls exert considerable pressures. The multiplication of echoes shakes the rocks which produces cracks. The breaks are enlarged and extended by the compressed air. At the moment of water withdrawal, an inverse phenomenon of inspiration occurs, blocks can then be displaced, and the fracturing favors this dislodgement.

When the waves have equipment at their disposal, their attack power is greatly increased. The bombardment with the pebbles of the foot of a cliff allows the digging of a notch which turns into caves, since the structural conditions allow it (soft bench, grinding zone), It thus creates an overhang which put the cliff cantilever. This one shaken by the impact of waves, cracks and soon collapses, in more or less large parts, under the effect of gravity.

B- The lengthening of the pier accentuates the swell downstream:

The port of Safi is located on $9^{\circ} 15'$ longitude West and $32^{\circ} 18'$ North latitude, it was established in the 12th century at the bottom of Safi Bay wide open, to provide a safe shelter against South West storms and so that its harbor offers a good anchorage sheltered from the high cliffs against the prevailing winds which blow during all the summer of North East, and all the winter of the South West.

The port of Safi was built in its current location in 1916, having then only 4 hectares of water, (current fishing port) the discovery of phosphates in (Youssoufia city) in 1923 began the construction of the current commercial port (Basin II), this required the lengthening of the pier, this planning ended in 1938.

The development of phosphate and ore traffic led to the development in 1952 of the current ore port (basin III) and the extension of the pier.

In 1965, the development of fishing on the one hand, and the creation of Morocco chemistry (super phosphate and ammonium phosphate) on the other, made necessary the extension of the port and the extension of the main pier of 200 meter and it is the longest extension (service infrastructure and development, direction of the port of Safi 2017).

The lengthening and extension of the main pier of the port of Safi several times did not take into account the specificities of the cliffs downstream south of the port, the swells are reflected and accentuated towards the southern cliff, also the harbor installations are also responsible for the disturbance of the sedimentary transit, which gives rise to the risk of erosion, also the discovery of the phosphates in El Youssoufia city, and the impact of the vibrations on the Railways National Office (ONCF), rails that use a 200 meter tunnel inside the cliff to transport phosphates and derivatives to the port and sulfur in the opposite direction to the phosphate complex (OCP), triggered a series of degradations at the level of the cliff and therefore habitats.

C-An acidity of seawater that exceeds the standards:

In the study area, and to characterize the acidity of the seawater, samples are taken in two sites, to measure the acidity of the seawater by an electronic pH meter in the laboratory of the National Drinking Water, its results are presented in the following table.

Schedule 3: Acidity of sea water at the southern coast of Safi:

site	Z 1	Z 2
Acidity by (PH)	7,4	6,5

Source: Levies made by public testing and study laboratory (LPEE) on 12/04/2018.

Zone 1 was taken just north of the sea castle.

Zone 2 was taken at the foot of the cliff (Trab Sini area).

The results of the analysis showed that at the northern point of the cliff Amouni Z1 the water is alkaline, in contrast to the other site Z2 where the seawater is acid and that by the combined effect of industrial discharges of acidic origin made by complex of phosphates (OCP) and the agri food and domestic factories of the sanitation canal. The decline here of the cliff is apparent, complex of phosphates had to put embankments and tetrapods to protect its facilities.

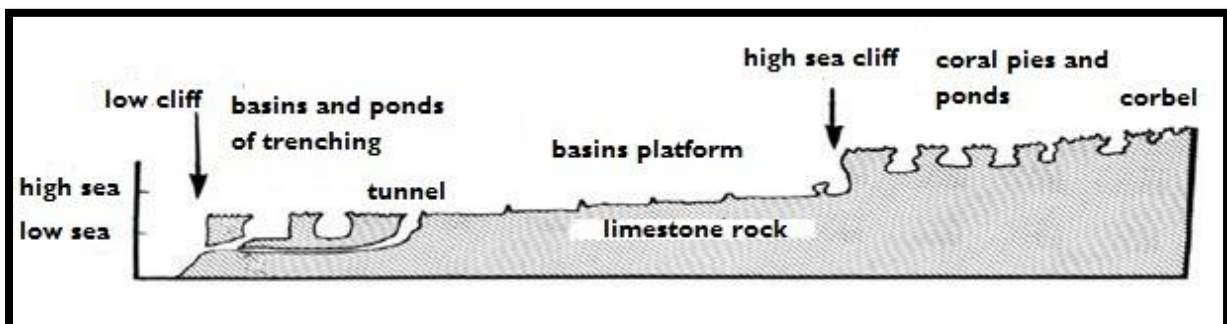
D- Corrosion contributes to the modeling of the morphological landscape:

On the southern coast of Safi, corrosion plays a major role in shaping the morphological landscape, there are several morphological forms namely ponds, basins and Karren. Corrosion by crystallizing salt in supra-littoral ponds appears very effective. Also, the biological perforations by the microscopic Cyanophyceae certainly play the capital role, but not only in the stage of sea spray and packets.

Also, the action of macroscopic organisms such as sea urchins, on the lower floor of the foreshore is also present (Mouafak F, 1990).

In total, biological processes are considered essential in shaping the southern coastline of Safi.

Schema 2: Staging of morphological forms:



Source : Mouafak F and al, 1990.

E- The existence of karstic caves:

Due to the karstification phenomena of existing calcareous rocks, it is worth mentioning that the existence of karstic caves that extend under the city of Safi jeopardize the stability of buildings and other constructions along the cliff.

Photo 2: cave in Amouni cliff:

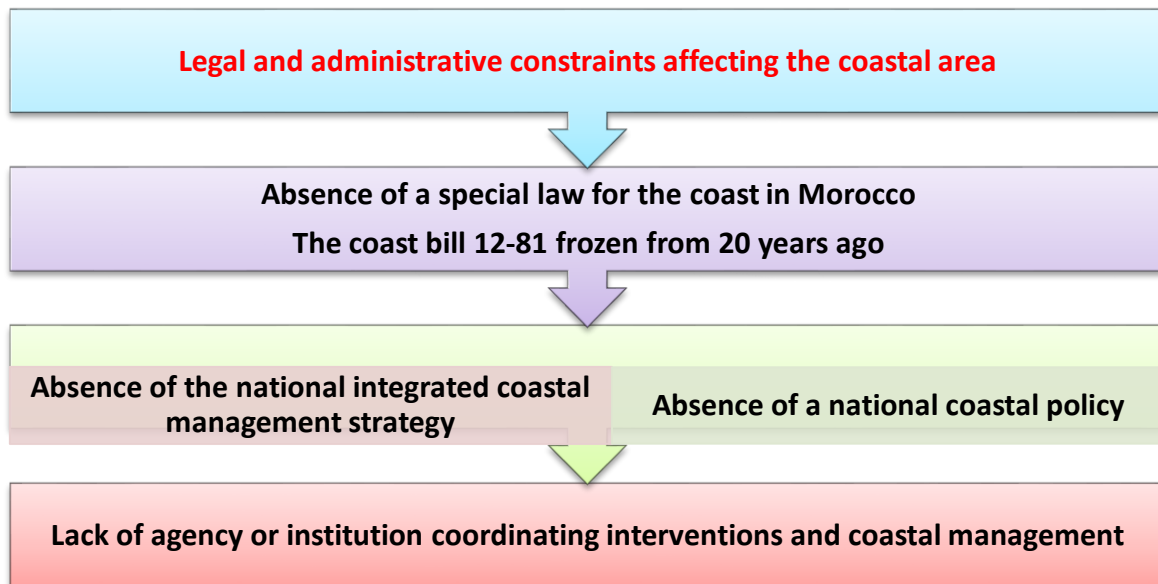


Source: field work in 15/12/2017.

3.5 Management Constraints:

The crisis of the coastal environment represented mainly in increasing pressure on natural resources, and poor public administration effectiveness, which will accelerate the degradation of coastal areas.

Chart 1: Legal and administrative constraints:



Source: Mansoum M, 2015.

Although the coast is the cornerstone of national territory and the pole of economic development, the public policy of water basin management lacks the integration of the marine and coastal dimension.

As well as the lack of collaboration and coordination between the administrative sectors can lead to a lack of harmonization between the objectives of the programs and the projects to be carried out in the city, which can be detrimental to the local services.

4- Strategy and protection tools:

To stop the decline of the cliff, it is necessary to protect against the causes of its degradation by effective solutions.

4.1 Reinforcement of the cliff:

This recommended solution to reduce the rate of degradation of the cliff consists of:

- + Fill some caves by concrete bags.
- + the filling of some cavities.
- + Sewage treatment.
- + block remediation
- + clogging cracks

4.2 types of Reinforcement:

A- Clogging of the caves:

Creation of an access chimney of 1.20 diameter from roof of the cliff to the roof of the cave. This gallery will allow the transportation of materials necessary for the comfort of the cave and access to it.

careful cleaning of the siding the roof and the raft to eliminate all the decompressed land and carry out the possible shoring and evacuation of cuttings and cleaning materials.

closing of the opening of the caves (sea side) by concrete bags.

filling in sections of 10 meters in length each, starting from the bottom of the caves using non porous dry stones and carefully stacked.

Disposition at the roof of the cave and on the periphery of the cave, by injection tubes and tubes vents that will serve to complete the filling of the caves, by injection grout.

Build the walls by resistant rocks, then pour the concrete for injection of the mortar and the grout.

mortar by injection of dry stone in the first phase, followed by a keying grout in second stage.

B- clogging cavities:

The filling of cavities will be done by concrete bags. Access to the cavities will be from the sea coast.

C- Sewage treatment:

Treatment of solid and liquid waste before dumping it into the sea.

D- block remediation:

This process consists of executing the controlled fall of blocks whose balance is unstable by mechanical means.

E- clogging cracks:

The filling of cracks likely to cause detachment between blocks will be by injection of cement grout after a possible clogging of the exhaust locations.

4.3 Consolidation of the cliff faces:

This type of treatment concerns the disorders that manifest as follows:

- Existence of cracking and cavities through the vertical facings of the cliff (especially under building areas bordering the cliff).
- Location of fissures in the terrain along the crest of the cliff at the upper plateau.
- Existence of dislocated blocks at the foot of the vertical wall of the cliff.

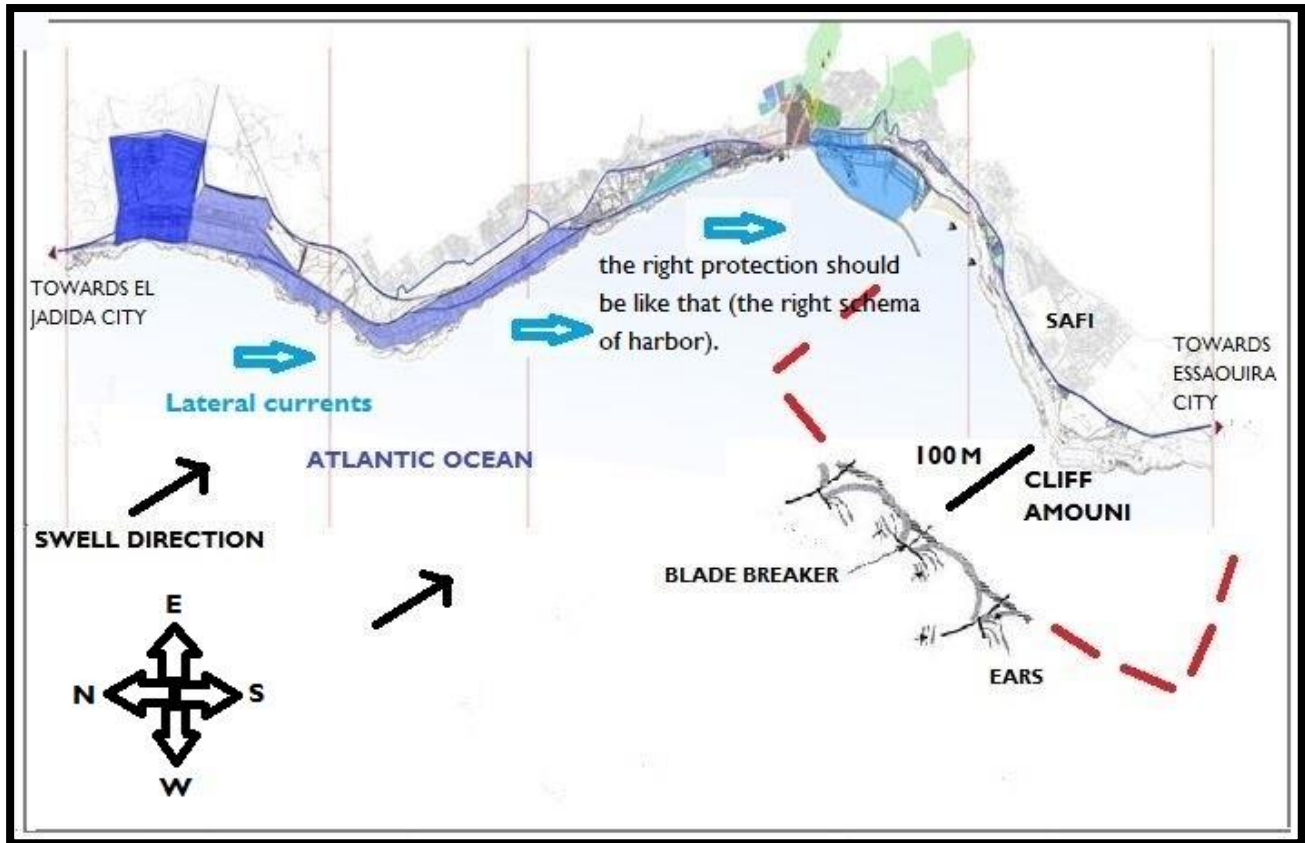
For this type of degradation, the type of treatment consists of:

- ✚ Remediation of dislocated blocks along the foot of the vertical cliff face.
- ✚ The construction of retaining walls of concrete, gabions or masonry and the execution of a shoulder of draining materials covered by an impervious layer (case where the crest of the cliff has steep slopes and may experience slips).
- ✚ The use of shotcrete with mesh and nailing for the crest with vertical cracked face, or through the bolting system.
- ✚ Waterproofing of the plateau terrain.

4.4 protect against the action of the swell:

To stop the regression of the cliff, it is necessary to protect against the causes of its degradation, mainly the action of the swell.

plan 1: blade breakers front off Amouni cliff:







Source: Personal work.

The regression of the cliff needs urgent solutions. These are some of them.

Schedule 4: types of feasible solutions at Amouni cliff:

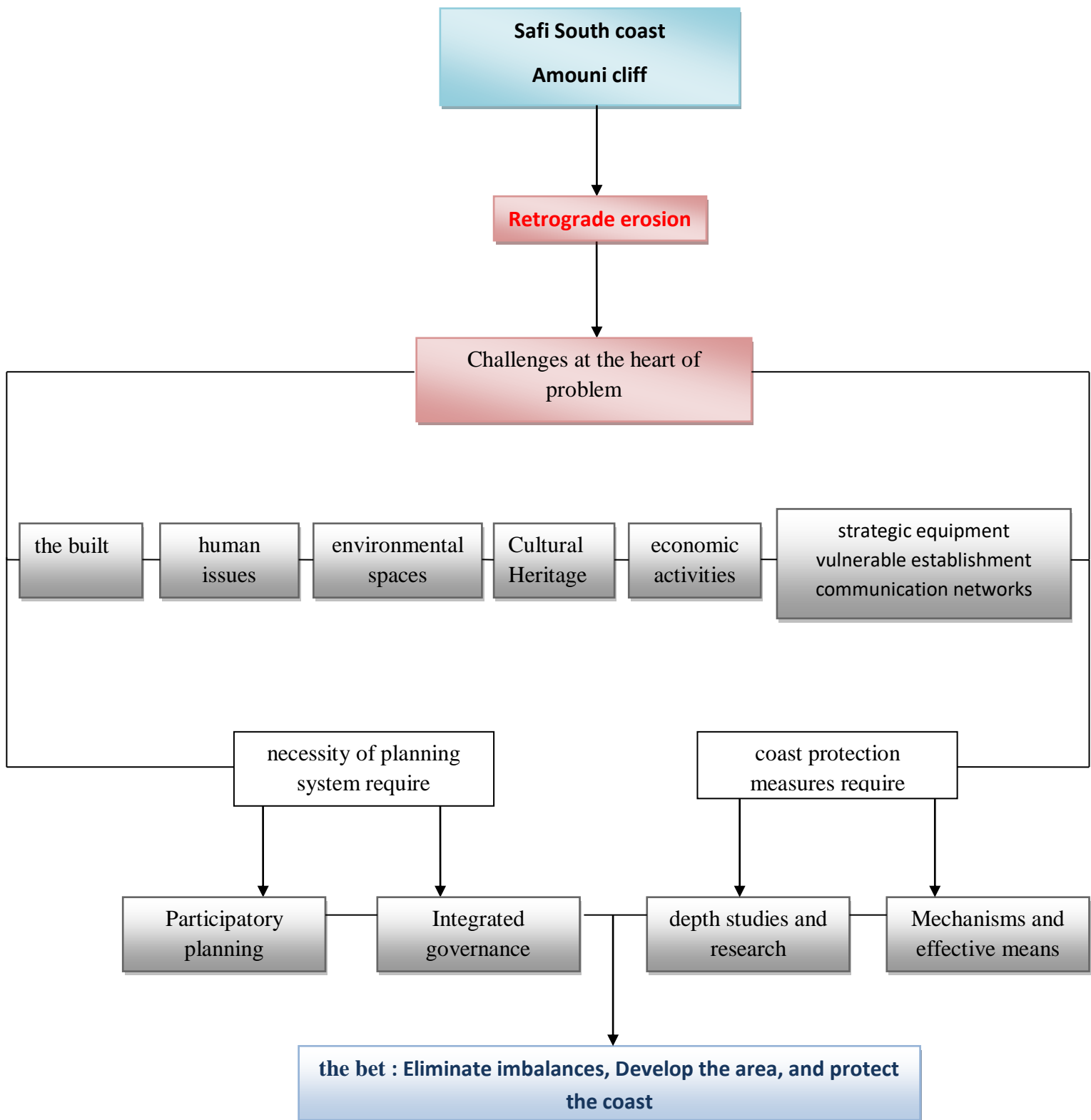
Type of solution	designation	Advantage
<p>blade breakers</p>	-Longitudinal protection adherent.	- Solution to solve the problem of regression.

<p><u>dikes</u></p> 		
<p><u>Embankments</u></p> 	<p>-Longitudinal protection adherent.</p>	<p>- Solution to solve the problem of regression.</p>
<p><u>Tetrapods</u></p> 		
<p><u>Rocky fronts (rock revetments)</u></p> 	<p>- Longitudinal protection adherent. - lower cost - more effective than concrete fronts</p>	<p>- Solution to solve the problem of regression. -positive impact on the socio-economic component. -Positive reflection on the environment</p>

Source : Personal work.

4.5 Governance and integrated management:

Schema 1: coast integrated management:



Source : Personal work.

General conclusion:

At the end of this study, it appears that the cliffs of Safi are under the combined effect of three dynamics that contribute to the degradation of this coastline in a different way.

The decline of the cliffs is today very high in the South zone, due to marine action more than the continental processes. That said, during the transgressive phases of the recent Quaternary, marine erosion was more important.

The profile of the cliff was different in past although his decline wasn't fast. The current morphological legacies of these transgressions are the slope and the cornice. Although very functional according to continental dynamics, these forms are essentially due to the action of marine processes.

Indeed, these are the waves; most powerful erosive agents; who dug the clays and attacked the ledge and low cliffs south of Safi. Today, marine processes act only at the southern cliff. Depending on the lithology, determining element of the facies of the cliffs, these processes shape either a sharp cliff or a low coast. Wave action is responsible for mechanical erosion. The breakup causes shock that can erode loose materials and move large masses.

All this requires the interaction of various actors, in order to develop effective programs and measures, based on accurate scientific and field research for the protection of the coast and its environmental sustainability.

Especially that the southern coast is characterized by transformations at all levels environmental, economic, cultural, and social, which requires great efforts and searching for the most effective means to keep pace with these current transformations in order to rehabilitate the southern coast and protect it as an important geomorphological heritage.

Indeed the field dynamics are now clear and the difficulties of control are doubling more and more, due to the interactions between humans and nature, resulting from human activities on the one hand and natural elements on the other, and in order to reduce the imbalances, it is necessary to intervene quickly through the various actors to develop efficient effective and decisive measures.

Through the adoption of accurate diagnosis and develop flexible designs and programs, and strategic plans taking into account the current constraints and future bets in these area.

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