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Caso práctico

Contribution to the management of the sensitive spaces by the geographical information systems and remote sensing: the case of the basin of the Gharb (Morocco)

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Resumen

Contribución de los sistemas de información geográfica y la teledetección a la gestión de espacios sensibles: el caso de la cuenta del Gharb (Marruecos)

El estudio de las limitaciones naturales en la depresión del Gharb y su costa, se basa en la integración y el análisis numérico de los datos procedentes de múltiples fuentes y métodos convencionales clásicos de síntesis. El área de interés es una depresión asimétrica limitada por dos dominios estructurales importantes, en el sur de la Meseta y el Rif en el norte. El resultado de esta configuración es un área plana con cauces de ríos poco profundos. El clima es mediterráneo. Desde el punto de vista sismo-tectónico, el área de estudio es inactivo. Su parte central corresponde a zonas de sismicidad baja o antisísmico. La morfología, la contaminación del agua y el suelo, cubierta vegetal y la explotación de canteras son las limitaciones que modelan la depresión Ghrab. La integración de todos los datos en un SIG desde múltiples fuentes de datos, se muestra como la herramienta más eficaz.

Palabras clave: Teledetección, SIG, Estudio geomorfológico, Gharb.

Abstract

The study of the natural constraints in the basin of the Gharb with his littoral is based on the integration and the numeric analysis of the multisource data and a classical synthetically approach. The zone is a dissymmetric basin, limited by two great structural domains: Mesetan domain to the South and Rifian domain to the North. It results from this configuration a flat zone with not very deep stream beds. The climate is of Mediterranean type. From a seismic-tectonic, the study zone is nether quiet central part corresponds to low seismic domains. The morphology, the pollution of water and soils, the vegetation and the exploitation of the quarries are the main constraints questioning the management of the basin of the Ghrab. The integration of the whole multisource data in a GIS and remote sensing, seems the more efficient method in term of the time and for the management of the spatially referenced data.

Key words: Remote sensing, GIS, geomorphologic study, Gharb.

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Introduction

Any project of regional planning and urbanization, such as the installation of the great infrastructures and projects structural aims the preparation a logic diagram making it possible to act in various ways. The objective is to show the environmental values of the zone in question. In the case of the socio-economically active depression of Gharb and in order to understand its specificities, we propose in this work to define the current physical state characterizing its natural environment. Within this framework will be to support the potentialities and the environmental constraints relating to the climate, ground, under-ground, geomorphology, water resources and biodiversity. Their definitions will be based on the combination of a digital surface updated analysis (thematic cards), so, will be drawn their interactions towards the geomorphological, ecological and geological environment, the purpose of which is to define the natural risks and their impact on the process of land settlement and the management of the sensitive spaces.

In this study, we shall become attached to the development of the quantitative and qualitative modelling of the potentialities and the physical constraints relating to any types of process of land settlement of the Gharb plain. In this frame the subject of the environment will have for objective to answer the question: Why the study of the natural risks in a territory so vulnerable in mid-term and long-term as the Gharb plain?

The Gharb plain aroused numerous geological, geomorphological studies (Michard, 1976; Thauvin 1996; Zouhri *et al.* 2001, 2002; Kacimi, 2004) and pedological studies (Ormvag, 1994 and Resing, 1994). Because of its extent and its agricultural profitability, the study of the constraints of development of the sensitive spaces, make that it is essential to resort to integration, in a SIG, of multi-source data. The cartography of the physical elements such, the catchment area, water resources, vegetable cover, the seismic-tectonic and grounds. This technique will make it possible to specialize the zones easily flooded, vulnerable, no suitable, etc.

So we will be interested in the relations between the natural constraints and their impacts on management of the territory of the plain. This one is given an important ecological inheritance diversified (littoral zone; plains; sites of biological and ecological interest (SIBE), forests, lakes, fertile grounds. This environment remains, in certain places, which we will delimit, fragile with very vulnerable. Their protection and safeguarding should be the subject of the governmental and non-governmental, national and international interventions.

Considering its environmental characteristic, the Gharb plain arouses a great interest of the various operators. The zone of Gharb is richest (fertile grounds, water available, easy accessibility, geographical proximity, beaches) in against part these assets are the subject of a bad management by ignorance (dewatering, water pollution, ground and ecology) these impacts constitute a permanent natural risk (risk of flood, impoverishment of the littoral zone). The protection and the safeguarding of the natural resources are real concerns. The analysis and the discussions below will be a prelude to the principal recommendations to follow for a good control of our territory.

These will allow us to begin a thematic discussion explaining the main questions, the objective of which is to facilitate, to the socio-economic operators, the understanding of the physical characteristics, their potentialities and their constraints, so recommendation and the measures to be taken.

Area of study

The Gharb plain is a Flat zone and directly open on the Atlantic Ocean. It is limited to the North by the first deformations of the chain, to the East by the basin of Saïs and the first mountainous reliefs of the Middle Atlas, to the South by central Morocco and to the West by the Atlantic Ocean. The perimeter of the studied area occupies the Northwestern center of Morocco and the Western part of basin of Sebou. The average altitude varies between 0 m and 200 m. These features are summarized in the figure 1.

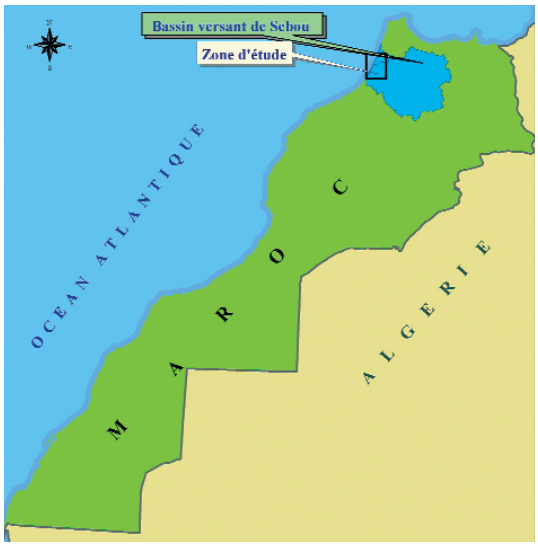

Figure 1. Geographical situation map of the Gharb basin.

Figure 1'. Image google-maps (2012) Gharb Basin (visible channel).

Materials and methods

The use of satellite remote sensing as a tool for control, management and development of the natural environment, has become increasingly necessary for preventive risk studies and studies of spatial planning. As such, satellite imagery could provide relevant information on the direct and indirect land in question. Indeed, these images, provided by onboard sensors by satellites, constantly becoming more efficient, in terms spectral resolution, spatial, radiometric and temporal.

In the present work, we will use only the generation of images TM and ETM + (Enhanced Thematic Mapper plus), whose acquisition of Landsat data globally, medium resolution (30 m resolution). This mission has gained a wealth of data on the terrestrial and monitoring of natural phenomenal changes and/or man. Given their spatial and temporal resolution, the sensor TM and ETM + images to provide a medium scale.

This study is largely based on photo interpretation, computer, digital spatial data in 2D (spatial and temporal analysis of satellite images Landsat TM and ETM +, topographic maps at 1/100 000 and others) and a classical synthetic approach (literature and controls the land). The data set is integrated into a Geographic Information System (GIS).

The purpose of this work will be to define the environmental potentialities and constraints, having direct and indirect impacts on the integrated installation in the sensitive areas. The definition of the potentialities and the constraints will be based on a space analysis of the geoinformation. In front of the multitude and the diversity of information, a data base to space reference (BDRS) will be developed, and will allow the integration of the whole of information in a SIG, whose paramount objective is to delimit the sensitive surfaces, according to degrees' of vulnerabilities.

This study is based on photo interpretation, computer-aided data numerical spatial two-dimensional 2D (topographical maps, satellite images Landsat TM and ETM + (spatial resolution 30 m), drainage, Google Earth images and a classical synthetic approach (field observation and review of the literature). the data set is integrated into a Geographic Information System (GIS). structures of spatial information, the study area, are treated according to the nature of objects (point, line, polygon, raster). storage and management of all has been made by well-defined topologies. modelling mainly concerns computer data structures, geo-referenced.

The adopted SIG results from the data base management system to space reference (SGBDRS). It will make it possible to manage the data base geo-referred (BDGR). This purely data-processing application enabled us to integrate, in the SIG, the various geographical structures. these structures of space information are introduced into an Euclidean space, by respecting the type of object (specific, linear,

polygonal, matrix). The storage and the management of the unit will be done according to well defined topologies' of the data-processing layers (integration, superposition, inclusion, crossing). It is about a simple operation, managed by the SIG and will allow extracting thematic cards while synthesizing the different information (potentialities and constraints)

The elaborated cards represent the physical elements of the depression. The superposition of the whole of space data in a SIG is an operation of integration and treatment of the geoinformation. In this work, we will approach the SIG to specify its interest on the data base management to space references like tool carrying the information, which will facilitate the good control of the factors such, the slopes, morphology, the seismic-tectonics, lithology, the hydrographical network, cover vegetable and the grounds, of which the goal is the definition of their impacts on the process of adjustment of vulnerable spaces.

Results

A monotonous morphology

The Gharb plain, located at the Northern center of the country, is a flat area with excess winter rainfall it is confronted with the risks of flood and tsunamis the plain is particularized by its proximity at the Atlantic coasts and by its flat topography. This morphological configuration constitutes a constraint for the Gharb plain management. Its morphometric structure results from the tertiary tectonic phase which is characterized by the genesis of a Riffian mountainous complex in the North and the basin of Gharb in the South (El Gharbaoui, 1987). the analysis of the morphometric data enabled us to formulate the following reports:

— The slopes are, as a whole central and littoral, weak and remain ranging between 0 to 4%. The weak slopes, lower than 2% are located primarily near the mouth of the Sebou Wadi, where the exaggerated shapes of meanders are configured (very weak slopes developing exaggerated sinusoidal forms, in the East of Kenitra). These localities constitute a zone of permanent risks of flood. Their managements remain expensive.

— The beds of the Sebou wadi and its effluents lose their widths of the downstream upstream. The direction general of the surface flows of water respects the direction general of slope, is (upstream) towards the West (downstream). In order to ensure perenniality, especially qualitative of the surface water resources of the littoral zone (downstream), the protection of the upstream remains strongly recommended. This one could be done via the installation of several hydraulic points ensuring the regularization of level of water at the time of risings.

— The visual quality of the environment landscape is quite ventilated. The projects of installations taking into account the environmental concern could only improve the tourist potentialities of the littoral zone, especially the beach of Sidi Boughaba and Moulay Bouselham. The adjustment of these places of interest, according to standards' in force, will have socio-economic and environmental repercussions of a great scale as well on a regional scale.

Rich and quite ventilated landscape

The analysis of the landscape is particularly important, when a process of construction of an urban infrastructure projects the realization of multiple potentially aggressive actions towards the environment. For this reason, it is necessary to divide, the zone in under zones or remarkable landscape sites, more or less homogeneous, allowing the study of degree of vulnerability, land uses, morphoterritorial characteristic, geological, etc.

If one puts at with dimensions some elements constituting the landscape such, the rivers, the agglomerations and the dispersed dwellings, one can then subdivide the zone of study into three sub-units:

— Northern landscaped unit: characterized by a flat morphology lined with fossil dunes and drained by large wadis of the catchment area of Sebou. it concerns the central and centro-western part of the plain. The landscape of this zone has an important value, not only by its own intrinsic value, but also, by the fact

that it constitutes a zone of strong agricultural potential on a very fertile territory but also sensitive.

— Southernmost landscape Unit: It is a flat areas mainly Covered by the forest of Maâmora. The two units are separated by the Sebou wadi;

— Western littoral Unit: this zone is characterized by a series of consolidated dune cords, forming sub parallel bands with the current coastal shore. This littoral area knows currently over-exploitation of the careers. This anarchistic exploitation, Hinder any action of littoral area planning. It became vulnerable area. Anticipation in term of planning of these vulnerable area, along the coast, will create a very important economic activity, while benefitting from visual quality from the coastal environment and its natural attractively.

There are other components which appear in the plain such, the rivers and the plantations, as well as specific elements like the careers and irrigated agricultural areas. These elements will be the subject of a study in the next paragraphs.

A regional geology of alpine type

A lithostratigraphy characterizing a basin of subsidence

The filling of the Gharb plain was completed by the formation of a vast alluvial plain corresponding to two banks of the Sebou wadi. Its evolution during Cenozoic involved the genesis of a vast flat plain with reliefs very little developed. In North, are located the first deformations of the Riffian chain, it is about pre-Riffian formation raised brutally in overthrust nappes directed NE-SW (Monitin, 1963). The whole of the basin knew a subsidence since average Vindobonien. Its collapse persisted since the Quaternary until today (Comb, 1975; Cirac, 1985).

Active tectonics

As for the sector of study, the Palaeozoic base is plunged South towards North, under the Neocene cover and Pleistocene of Gharb by a series of steps constituted by faulted and tipped panels towards the NNW (Cirac, 1985 and Flinch, 1993). The genesis and the structural framework of the basin of Gharb are mainly conditioned by the evolution of the Riffain chain (alpine orogenesis). Studies of seismic (Flinch, 1993; Flinch and Vail, 1998 and Litto and Al, 2001) showed that the material of the supra-tablecloth is affected by faults of various orders.

During the Quaternary one, the Gharb basin has sudden vertical movements in response to the neotectonic phase of alpine orogenesis (Michard, 1976; Aberkan, 1986; Piqué and Michard, 1987 and Zouhri *et al*., 2002). These neotectonic movements are induced by normal faults. The structure of the basin is controlled by Hercynian faults materialized by two great directions NE-SW and NW-SE. They controlled the paleogeographic evolution of the basin (Zouhri *et al.,* 2002).

A plain with strong pedological potential

In spite of its agricultural potentialities, the pedological studies are rather numerous (Aubert, 1950; Ormvag 1994; Resing, 1994). These studies enabled us to understand the pedological characteristics, to set up pedological map and to know their morphological and analytical characteristics. The studies of Ormvag (1994) showed the existence of 6 great groups of grounds described below (figure 2, chart of the pedological units).

— Soils of the type B or browned soils: These are soil that one finds in the perimeter of Maâmora and the northern zone of the forest. it is about sandy and washed soils, developed on the argillaceous areas. The thickness of the sandy surface layer exceeds 2m and presents a brownish coloring;

— Soils of the type C or Calcimagnésic soils: it is about the soils characterizing the north-eastern zone. They present a carbonated composition (calcium and magnesium) and are regarded as carbonated soils;

— Soils of the type H or hydromorphic sols: They concentrate in the depressions and the edges of the merges. Those present the

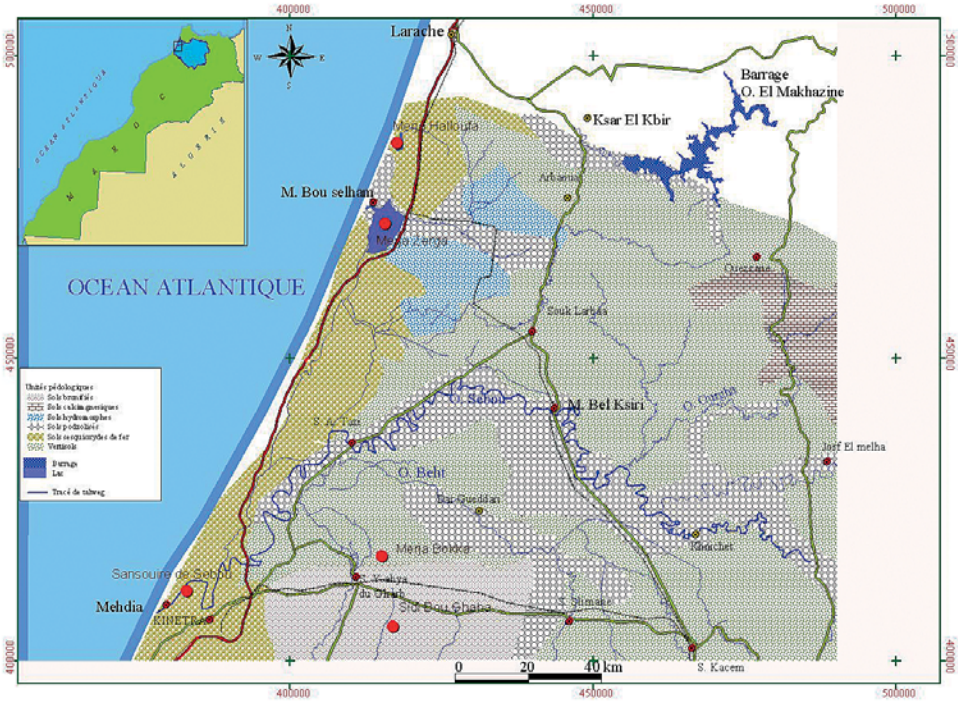

Figure 2. Schematical map of the pedological units recognized in the studied zone (from the "Atlas of the Gharb", modified).

character of old hydromorphie. They are fairly organic sols.

— Soils of the types P or podzolic sols: They are along Sebou wadi and its affluents, in the low zone. They are characterized by an incompletely broken up humus and of granulous structure. They have a rusts color caused by iron oxides, with tendency of concretion formation.

— Soils of the type X or sols with sesquioxides: These soils present a black color. They cover the relatively low zones and are developed on argillaceous alluvia of depressions. They have texture of an argillaceous type of low permeability.

— Soils of the type V or vertisols: It is about very fertile soils located on both sides valley of Sebou. They are soils with rounded and angular structure

The various identified and described soils are essential for maximum agricultural production: cereal, fruit groves, leguminous, industrial crops, market gardenings and fodder crops. These soils support an agricultural production, dominated by cereal. It covers the main regional and national needs. Other agricultural activities constitute also an important source of incomes. In spite of, the climatic variations which occur, since about twenty years, by a greater irregularity of rains, the problem of drought does not arise since the zone has an important underground source (tablecloth of Gharb).

Available water resources

Under ground waters: An important table water threatened by pollution

The zone of study has a large Water-table surmounted locally by several semipermeable lenses. The geological and hydrogeologic studies qualified these lenses as perched water table (Thauvin, 1996 and Resing, 1994). Their extensions can reach tens of square kilometers, their powers could exceed a few meters (figure 3 water map). They are related to the topography of red clays and to the thickness of the sand which surmount them (Kacimi, 2004). Their hydrodynamism is essentially

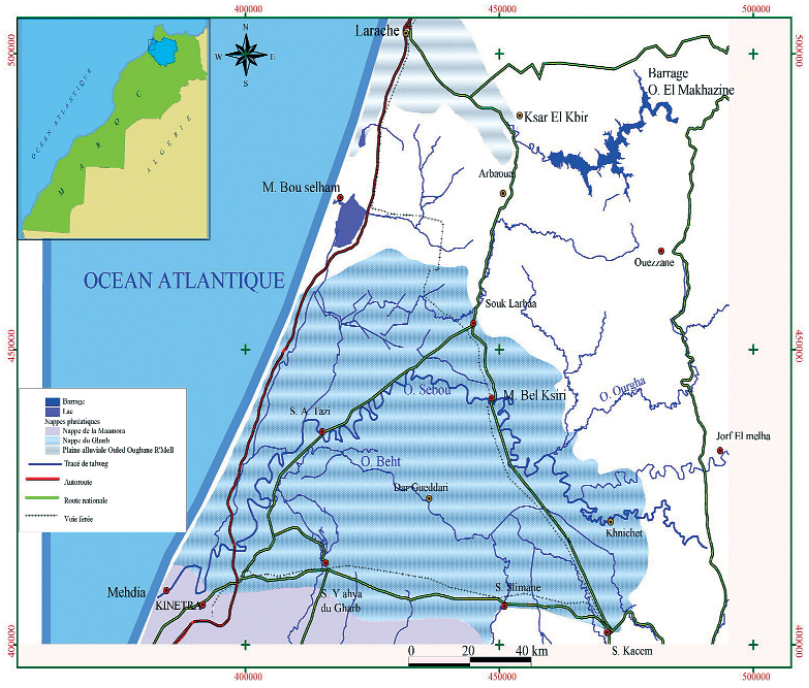

Figure 3. Map of the superficial and underground water resources, extracted from the topographical maps, hydrogeological maps of the Gharb basin and from (manually the Atlas of the Gharb).

laminar, with a karstic circulation in the coastal zone.

From the environmental point of view, the Gharb Water-table is directly threatened by the liquid infiltrations (pesticides, fertilizers, industrial waste…). The Permeability of the Surface and The vertical faults affecting the cover accelerate the risks of pollution of the table water.

Abundant and polluted surface waters

In this part, we shall develop the hydrological study to release the qualitative and quantitative aspects of surface waters (O. Sebou, dayas, lakes), while giving a detailed attention to the hydrographical network However, the principal objective of this study is to evaluate and develop the surface water resources (figure 3, map of water resources).

The analysis of the water resources map of the zone of study shows, the presence of a hydrographical network little developed, characterized by its exaggerated forms of meanders and its general orientation towards the west and the WSW. The principal wadi is Oued Sebou, it constitutes one of the principal sources of surface water. The river of Sebou and its secondary affluents such, Ourgha Wadi and Beht follow directions imposed by the flat morphology of the crossed zone, with a permanent flow.

A morphologically easily flooded depression

The morphometric analysis of the catchment area of Sebou shows, that the Sebou wadi flows in a relatively boxed bed wich is not very deep at its upstream part. It widens and is raised in its downstream part wich is relatively flat. Moreover, the catchment area of Sebou is subjected to a pluvial regime and the highest debits result from the Ouergha wadi. In 1963, occurred the strongest floods known in the basin of Sebou . In 1996, the zone knew other series of floods which involved important damage in the town of Kénitra (national Report on the prevention of the disasters, floods of the Gharb plain 1996). Figure 4 shows the easily flooded and vulnerable zones.

According to the analysis of this map, the delimitation of the zones of risks of floods shows that the town of Kenitra and its periphery are permanently exposed with the phenomena

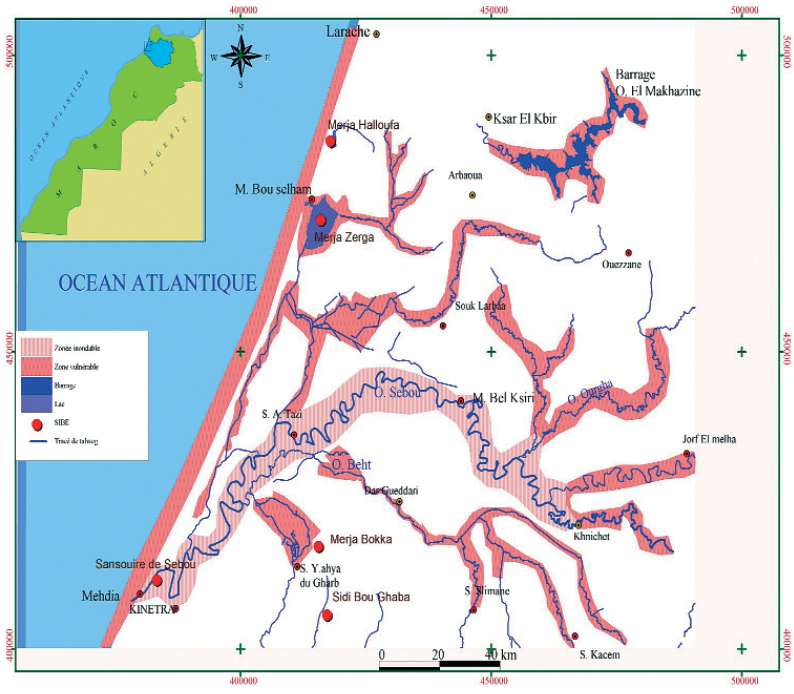

Figure 4. Vulnerability map and zoning of flooding risk.

of the floods. The installation of important infrastructure, (industrial park, residential zone, airport…), far from Sebou wadi, principal source of floods, will ensure an effective planning of this area. Within this framework and in order to minimize the risks of floods, the three large wadis: Sebou, Beht and Ouergha, principal sources of floods, are regularized by important hydraulic installations or dams, which were realized for the protection of the plain against the risks.

Quarries exploitation: an excessively exploited richness

Along the littoral zone, between (Kenitra and Moulay Bouselham), the majority of quarries are abandoned, without any remediation of the exploited sites (figure 5). The majority of the owners do not respect their CPS, especially, during the extraction (use of the high quantities of the mines, over-exploitation).

Conscious of the negative impact of the quarries badly managed on the environment, the persons in charge became exigent in term of opening of new quarries. Everybody is conscious of the importance of the natural area (landscape, agricultural zone, green space). But, in the practice hundreds of hectares disappear for the benefit of the urbanization and the installation of infrastructures: residential zones, industrial parks, freeway.

To limit these threats, the littoral of Gharb should be the subject of the urgent interventions of a preventive nature. Its levelling and its valorisation require the integration of leisure spaces such, the beach of Moulay Bouslham and Sidi Boughaba in the good governorship of the regional planning. Other virgin spaces locating enter the two great above-mentioned sites should be the subject of anticipatory installation against any kind of pollution. This could improve the attractivity and territorial competitiveness in term of urbanization, investment and tourism

A rich but vulnerable ecological environment

The zone of study includes the potential area which can undergo the impact of the activities

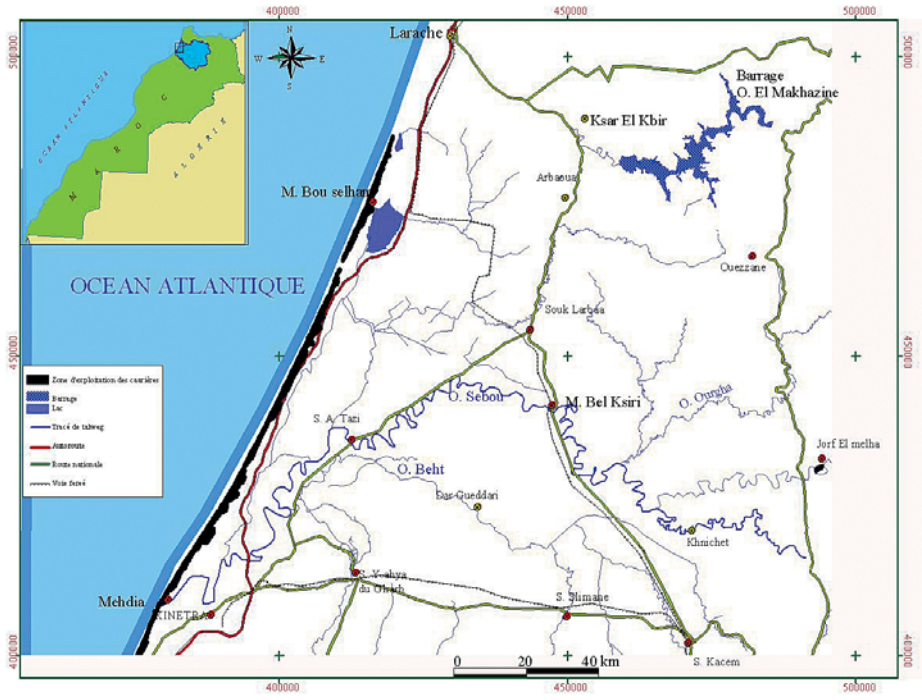

Figure 5. Situation map of the extraction sites of the building materials.

of the industrial facilities. It has potential sites constituting a natural environment of great ecological and biological interest, as well at the regional level as national, such, Merja zerga, merja Halloufa, merja Bokka, Fourat and Sidi Boughaba (figure 8). These ecological sites (SIBE) are considered, on the biological level, as one of the crossroads of fauna, ensuring a considerable natural balance. Its potential biodiversity is exceptionally high compared to the other natural sites of Morocco. Indeed, one can only insist on the floristic, faunistic and landscape richness during programming of any type of project having environmental impacts. The center of the area of study is practically empty or contains isolated green points. The Main species recognized in Gharb forest are: cork oak, holm oak, Thuya, Eucalyptus, conifer, mixed forests and matorrals.

The choice of color composites in the visible and infrared is well justified and wanted to surface mapping of the study area. The selected bands have several technical advantages (spectral resolution suitable for mapping of soil and vegetation). As such:

The blue band is only sensitive to wavelengths between 0.45 and 0.52 microns, defined in the visible. It also allows the differentiation soil-plant (Scanvic, 1993). Solar reflectance is maximum because of its short wavelength (λ);

Also according Scanvic (1993), the green band is an indicator of vegetation chlorophyll primary and secondary elements of heavy metal content. The correlation between the blue and green allows discrimination of dissolved organic matter. This band is sensitive to the spectrum ranging from 0.52 to 0.60 microns;

The red band is very useful in the visible spectrum for determining the limits of soil and land geological (lithological differentiation). The spectral signature of this wavelength (0.63-0.69 microns) provides a very high contrast lithological, with lower atmospheric disturbances from other visible wavelengths. It also serves as the structural analysis and plant classification;

The band near infrared (NIR) is useful for mapping vegetation stress resulting from geological and iron oxides (Scanvic, 1993). Its combination with band 3 allows the delineation of water bodies. The ratio of bands 3 and 4 allows to differentiate biomass and vegetation moisture. But, in situations where the vegetation is in early growth and in an arid or

semiarid, this differentiation becomes quite tricky and the spectral signature is much influenced by the signal from the ground, this could be possible disruption corrected (Escadafal and Huete, 1991).

Mapping the land of the study area is developed at a medium scale 1/200 000. The images TM and Landsat ETM + is a basic background including the optimal combination of colour in the visible red and near infrared FCC 321 and FCC 432 (false colour composite) for the analysis of land use and spatial distribution canopy.

The Satellite imagery and TM Landsat ETM + used are supplied with a level of radiometric and geometric correction detailed by the supplier. The choice of these scenes TM and ETM + (taken as a multiple dates, 15/04/1985, 12/09/1987 on the 20/08/1999, 23/08/2009 and 16/10/2010), but we will use the two scenes (15.04.1985 and 20.04.2010 of the colored composition FCC 432). This variety made based on multiple calendars climate zone (spring, summer and winter) to view the land and their business in different states (soil covered by vegetation, bare soil, no clouds, moist soil, etc.).

Combining FCC 432 is used for land cover mapping of the study area, knowing that it is an agricultural area with high potential. In the western part of the study area, the ground is covered, almost entirely, a canopy largely agricultural character (concentration of agricultural activities along the coast of linen depression Gharb to a depth of over 500 m of shoreline). This false-color composition allows the detection and differentiation of the vegetative study area.

432 tri-color image on the FCC vegetation is easily recognized by its own spectral signature in red with a maximum reflectance in the red and near infrared.432 FCC on this image, vegetation is easily recognized by its own spectral signature. For example, the red colour indicates the presence of vegetation (maximum reflectance in the red and near infrared (Scanvic, 1993).

The analysis shows that the two images in the red and near-infrared (NIR) ranges are red canopy dominant, especially in the western part of the study area. This can be explained by the sustainability of water resources of the Gharb basin (see paragraph 5: Water resources available) and soil fertility. In the study area, is one of the largest groundwater reservoirs (groundwater Gharb). The difference between the two images, may be felt towards the East Mediterranean, whose terrain and the remoteness of the water are their effects.

Still, the analysis of satellite imagery and TM Landsat ETM + (432 BCF and 321 BCF, Figure 6 and 7), the study area especially this coastal landscape units, characterized by a relatively flat morphology surrounded by dunes and fossil drained by the major wadis watershed Sebu. The landscape of this area has significant value in that it is an area with high

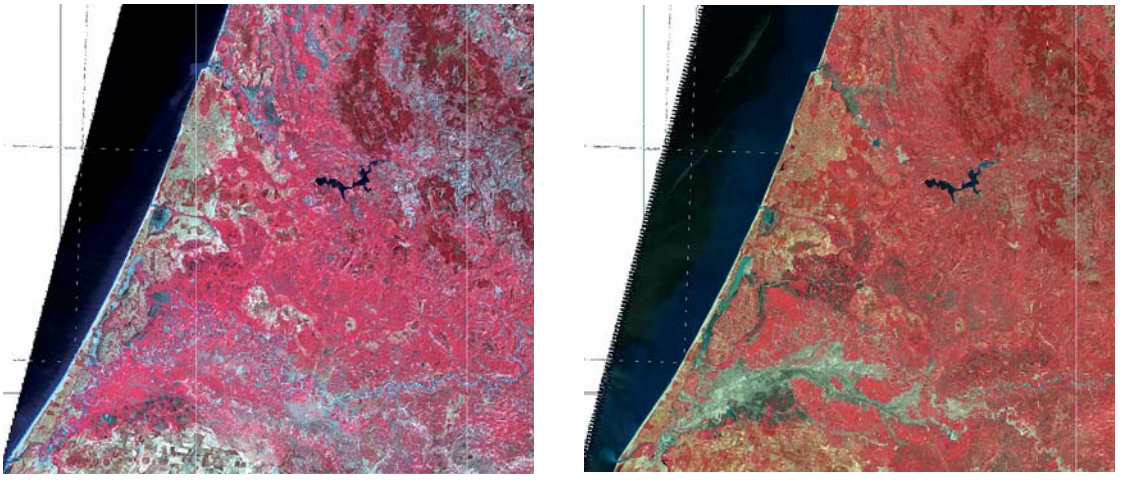

Figure 6. Comparative Images of reflection and absorption of EM radiation uneven depending on the wavelength of the tri-color picture composed of channel 4, 3 and 2 false-color, left the scene of 20/04/2010 and right stage of 15/04/1985.

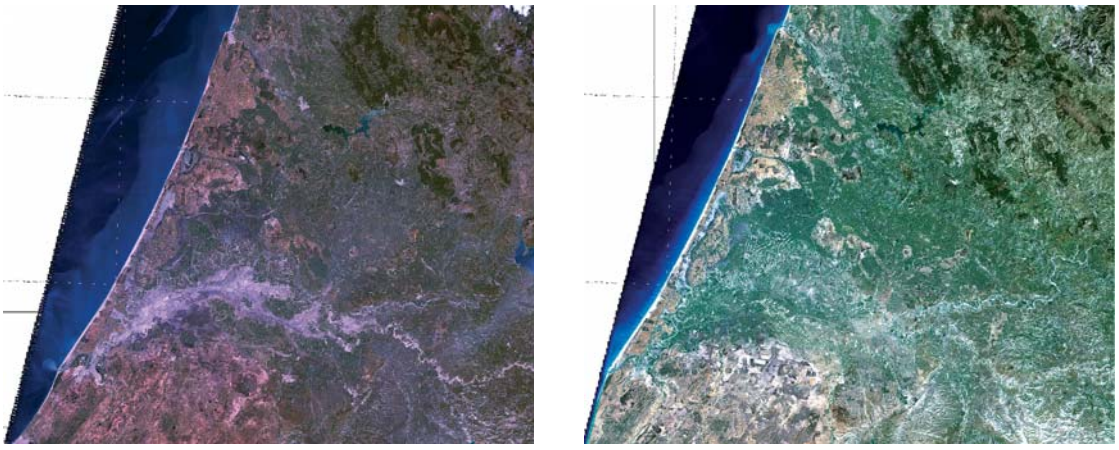

Figure 7. Comparative Images of reflection and absorption of EM radiation uneven depending on thewavelength of the tri-color picture composed of channel 3, 2 and 1 in the visible, left the scene of 20/04/2010 and right stage of 15/04/1985.

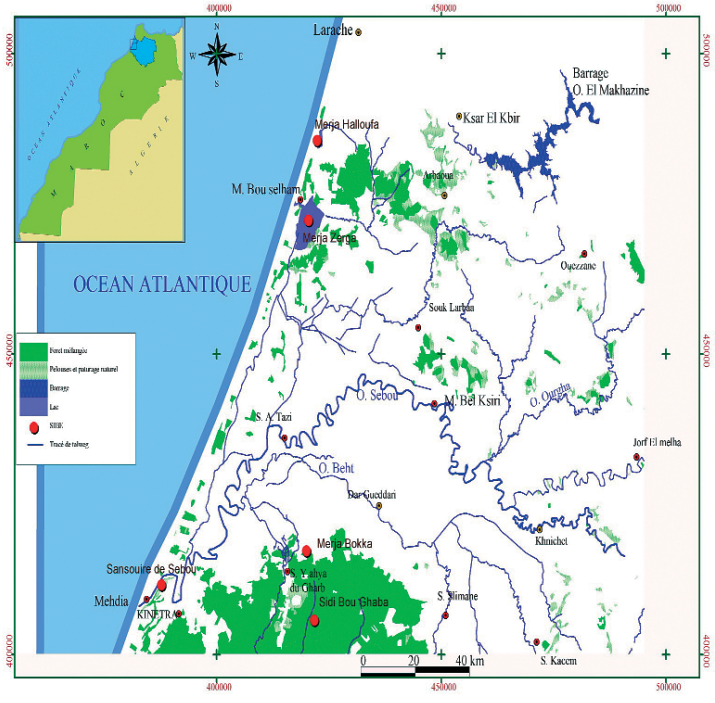

Figure 8. Map of the distribution of the vegetation (from the Atlas of the Gharb, modified).

agricultural potential (fertile land), but also sensitive. As we saw earlier, the evolution of the basin during the Cenozoic has driven the genesis of a vast flat plain resulting from the accumulation of a large sedimentary mass (which in some places exceeds 2000 m). Morphologically, said depression (Gharb basin) is in the form of a basin that receives the bulk sedimentary all comers. It's a wide open middle of the Atlantic Ocean, its intrinsic characteristics reinforce and promote the agricultural potential of the Gharb plain by climatic conditions.

Synthesis and recommendations

The analysis of the environmental elements (potentialities and constraints), it proves to be clear that the stakes of adjustment of the

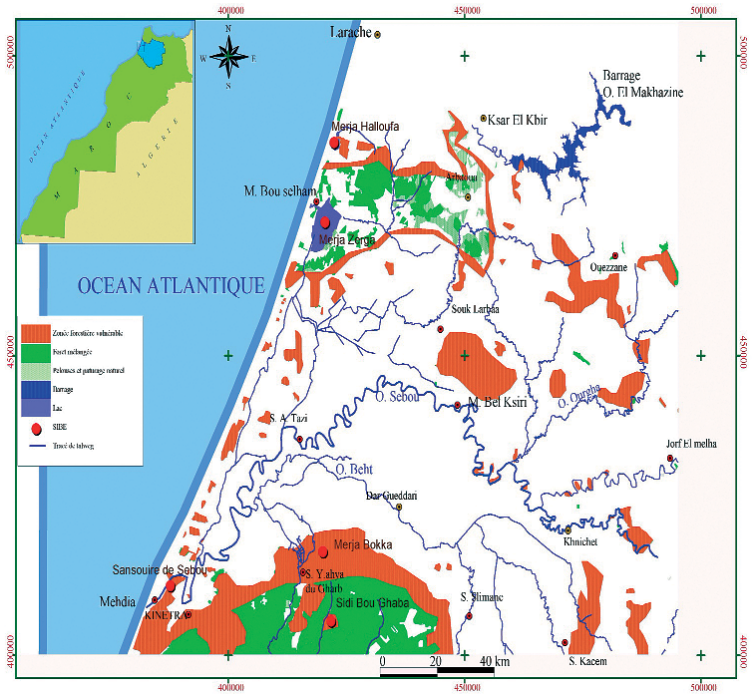

Figure 9. Map of the deforestation zones and weak zones.

depression of Gharb are important. The surface of study and rich in natural resources, they even constitute a constraint in a natural way or by a bad governorship. So all the actors, on a regional and national scale, must become aware of this reality. It is necessary that the policy of the regional planning integrates the environmental constraints in all its strategy of management of the territory. This could be done only by official will for the respect and the application of Laws and Regulations. Elements below recapitulate the main recommendations to be considered in:

Regional seismic-tectonic risks

The establishment of the map of the intensities observed, since 1901 until 2001, was facilitated thanks to the available data of the department of Physique of the Earth of the Scientific Institute (figure 9). The analysis of these seismic-tectonic data, shows that the zone of study is rather calm. It is in prolongation SW of the Rif chain. In addition, the zone in question is exposed to a certain tectonic activity qualified as neotectonic, recent tectonic activity of quaternary age, caused by shocks affecting the basin of Gharb. For this purpose, the last earthquake, which has occurred on June 28, 2001 of magnitude 5 on the Richter scale, reflects an important regional sismotectonic dynamism. The definition of the paraseismic standards is strongly recommended and this, according to the standards of paraseismic code RPS2000.

Strongly exploited water resources

The water resources remain quite sufficient compared to the soil potentialities which is pedologically ready to receive the irrigation. In addition to this strong potential of perennial irrigation, there are also important potentialities in seasonal irrigation. Indeed, since about twenty years, climatic variations occur by a greater irregularity of the rains and an extent, more and more, important of the area of study. This deterioration is amplified by the bad management of the water resources this induces degradations on the level of the physical environment, natural vegetation and quality of water. The good management of

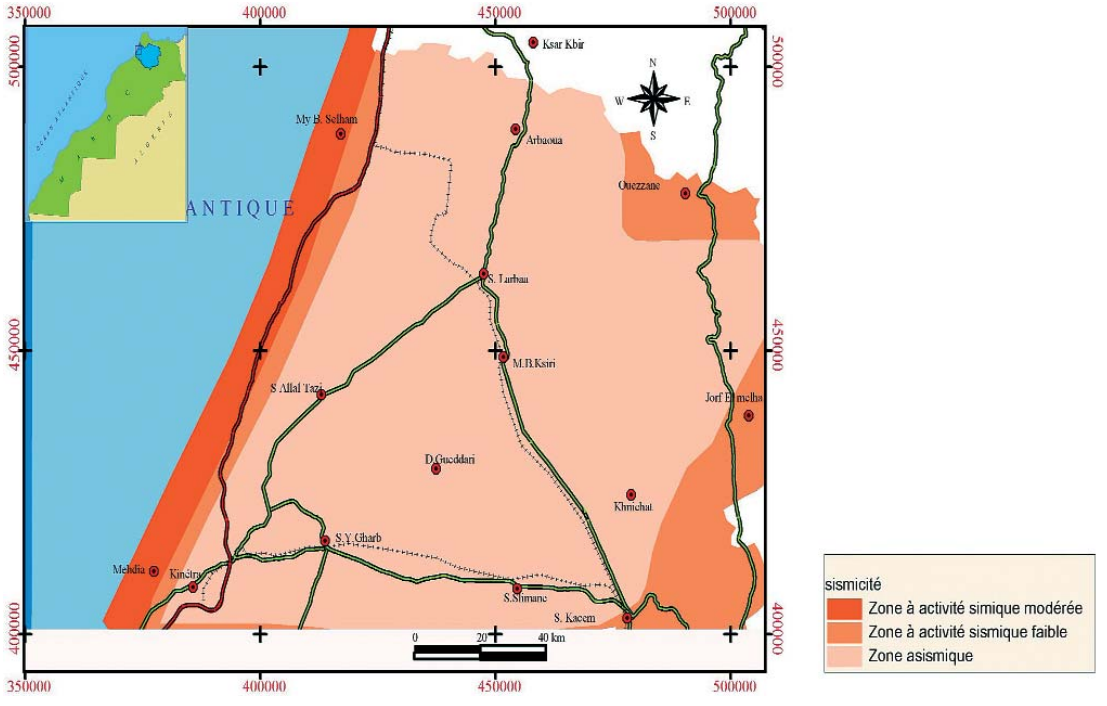

Figure 10. The sismotectonical activity map of the coastal zone of the Gharb, (Ait Brahim, 2003, modified).

these not renewable resources requires a crucial reflection during the realization of any project. While benefitting from the great wotk concerning the depollution of the Sebou Wadi and from the strategic and convenient programming.

Permanent risks of floods and the tsunamis

The flat morphological configuration of the Gharb plain has at the same time an asset and a constraint as regards management of the downstream areas. With this flat configuration and the hydrographical network, the risk of floods and tsunamis is real. Because of the significant absence of reliefs protecting the hinterland, the littoral zone is directly threatened by the risks of tsunamis. Moreover, the Sebou wadi threatens the whole western territory such Sidi Allal Tazi's urban area and Kenitra. In spite of, the establishment of several upstream hydraulic constructions. The flood risk of downstream area persists after each important downpour. So the department of the environment of the Ministry of Land planning, Water and Environment classified the urban centre of Kenitra as area of average risk. Its protection could be done only via dams of stabilization.

Safeguarding of the ecological environment

The negative impacts of engineering constructions, on the natural and landscape environment are taken into account, on the level of the impact study on the environment of the various projects. Located in a subhumide bioclimatic stage, the Gharb plain is particularly sensitive to deforestation especially in the forest of Maâmora (figure 10). The studies of vulnerabilities carried out within this framework, highlighted the multiplicity and the extent of the factors which go against the perenniality and against the variety of this not easily renewable capital. Among these factors, one quotes: the overgrazing, cutting of wood, absence of regeneration of the forest. The analysis of these factors of degradation, show clearly that the social pressure constitutes a factor determining of the deforestation of the forest of Maâmora. The consequences that will result from it are:

natural environmental pollution, Sanding up, economic cost, rural migration.

Littoral: potential area to protect

In spite of, its great landscape and of course tourist interest, the littoral zone, which extends between Kénitra and Larache, is strongly exploited and weakened by the extraction of building materials (figure 10). This over-exploitation caused real attacks with this fragile littoral environment (salinisation, pollution of the ground water of Gharb, disfiguration of the landscape).

In order to find the effective means for the safeguard of this non renewable natural resource, the state must directly intervene, in an urgent way, supported by the civil company, to oblige the owners to respect the terms of the impact study on the environment. For the political durability of the land planning, this article should constitute the object of the deepened researches undertaken by the departments, the concerned institutes and the researchers, whose objective is to more understand the characteristics of this naturally rich area, but vulnerable and very sensitive, and to induce the positive impacts, by limiting and treating those negative, if the control strategy of the programmed actions are taken into account in a suitable way.

Conclusions

The study suggested here, makes it possible to understand the importance of the use of the SIG in the studies of the Gharb plain planning. In addition, the discussions started in this study made it possible to contribute to the comprehension and the assimilation of characteristics of these potentialities and natural and/or anthropic constraints. For this purpose, certain conclusions were drawn:

— Morphology, water, vegetable cover and the exploitation of the quarries along the littoral zone are the principal constraints leading to an instability of the natural environment.

— From point of view seismic-tectonic, the zone of Gharb is relatively stable. It supports the construction of any kind of infrastructure, while respecting the standards paraseismic code RS2000.

— Except some isolated areas, the, not protected and badly managed, littoral like the industrial zone, is an unfavorable zone for the installation of an important infrastructure. The installation of such industrial constructions, will require a preventive strategy against the possible risks of the tsunamis and the re-mediation of the exploited sites

— The choice of the adequate sites for the installation of the great projects, should be the subject of a multidisciplinary decision.

— The integration of the whole of the multi-source data in a SIG, seems more effective in term of the management of the time and the data base.

Generally, this study enabled us to reveal the problems of the Gharb plain planning and the importance of the method applied in the zone of Gharb. In addition, this work made it possible to establish a synthetic data base. This one intervenes at the same time upstream in the characterization of risks and constraints (object of the research topic) and downstream like Decision Support for the planning of the area of study (objective of the research topic)

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