

Implementation of A GIS (Geographic Information System) Dedicated to Agro-Ecological Diagnosis and Integrated Development of Mountain Land in the Wilaya of Tlemcen, Algeria

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ABSTRACT

To develop agriculture in mountainous areas, environmental analysis is a necessary step. However, the traditional methods of agro-ecological diagnosis, which are numerous and diversified, do not make it possible to study large areas in a reasonable period of time and often do not meet the expectations of the practitioner in the field.

The purpose of this project is to set up an approach consisting in carrying out the analysis of the environment by favoring the choice of a spatial dimension (level of perception) in accordance with the needs of the farmer (agricultural spatial unit). This analysis will be carried out on the most relevant physical, biotic and socio-economic indicators according to two distinct but complementary approaches:

- First, through the synthetic vision of the landscape offered by satellite imagery by limiting the number of ground surveys, a spatial remote sensing approach will be adopted;*
- Then, by the performance allowed by the Geographic Information System (GIS) tool, the spatially referenced data will be combined;*
- Finally, based on the results of the agro-ecological diagnosis using the geomatics tool (mapping, remote sensing and GIS), development guidelines will be outlined to enhance mountain land (soil, water) and preserve the weakened agro-ecosystems of three (03) selected test sites, along a north-south transect, in the wilaya of Tlemcen.*

Keywords: Geographical information system (GIS), agro-ecology, agro-ecosystems, planning, mountainous areas, Transect, Tlemcen (Algeria)

Mathematics Subject Classification Number: 62P20

1. INTRODUCTION

For several years, we have been witnessing a spectacular regression of agroecosystems due to socio-economic dynamics, characterized by strong demography and increasingly aggressive methods of exploiting the environment.

It has been recognized by all observers for several years that the regressive dynamic of agroecosystems is only the manifestation of a socio-economic dynamic, characterized by strong demography and increasingly aggressive methods of exploitation of the environment. .

Often more or less sectoral studies devoted to the planning and development of mountain land, establishing diagnoses and solutions more or less accepted by the populations concerned. Consequently, we are below expectations for three main reasons:

- The currently developed mountain lands represent only a tiny part of the overall potential of the territory of the wilaya of Tlemcen;
- The technical solutions adopted by the public authorities for the development of mountain lands are not always favorably received by the populations who may consider them unsuited to their interests; it follows that, sooner or later, the regressive dynamic of the rural world returns;
- Although having a wealth of knowledge on mountain lands, the solutions provided have not made it possible to create a balance better suited to the modes of use of the space.

Much of the work devoted to the development of models for the integrated development of mountain land, in order to react in time through regulatory actions, has also seen little application in the field. We always come up against the eternal problems of structural rigidities and shortage of means: going from understanding a phenomenon to taking action is not easy. As effective as the techniques are, in order to be applied they must encounter structures on the ground that are receptive and conducive to change, and this is precisely the main obstacle, because very often the effectiveness of rural development depends more on qualitative changes than on the amount of resources devoted to it.

Since the late 2000s, agricultural development programs have been widespread. We now recognize that we must think in terms of "participatory" and "sustainable development".

In terms of agricultural development, this approach essentially consists of stimulating and supporting the evolution of agricultural systems in mountain lands towards forms of exploitation that reconcile the interests of the populations and the agro-ecological balance.

The previous reminders show the interest of placing oneself in an action-research context and of observing the two rules below:

- Bring together in the same approach, the socio-economic dynamics and the biophysical dynamics, because it is only by correctly understanding the interactions between these two dynamics that we can envisage the structural changes which will have an impact on the exploitation middle;
- Use methods of analysis and scales of perception that are recognized and accepted by the researcher, the development worker and the farmer. It is, in fact, difficult to initiate a concerted development action if the participants do not speak the same language or use different scales of appreciation.

This research proposal, directed to mountain lands, attempts to bring these two conditions together by defining and testing a concept suitable for the simultaneous apprehension of the two dynamics, the

area of potentialities and exploitation practices in the context of choice. Methods and a partnership mechanism conducive to the transfer of subsequent learning and concerted action..

2. MATERIALS AND METHODS

2.1. Methodologies for the implementation of the project:

The methodological approach adopted must make it possible to target the following objectives:

A- Main objectives:

- Evaluate the agro-ecological resources and, consequently, quantify the potential of mountain lands of the wilaya of Tlemcen, using remote sensing data and exogenous data, in a GIS logic, by applying the techniques of the field reference already acquired;
- Understand the relationships between socio-economic dynamics and agro-ecological dynamics through the relationship between resources and production systems;
- Define spatialization criteria which make it possible to resituate production systems within zones in order to balance potentialities and exploitation practices;
- Create a cartographic database suitable for concerted development actions by integrating the visions of scientists, practitioners and farmers into the cartographic process.

B-Thematic objectives:

- Remote sensing of parameters associated with current land use and agricultural potential of mountain lands;
- Exploitation of the complementarity of remote sensing data and collateral data to assess land use and agricultural areas;
- Exploitation of the complementarity of static and diachronic approaches (seasonal dynamics) to assess the potential of mountain lands.

C-Methodological objectives:

- Develop simple remote sensing and mapping methods that are inexpensive and adapted to the needs of operational staff in the field to ensure maximum scientific and technical transfers, at the end of the project, and certain continuity; this implies:
- The use of simple and locally accessible technical means;
- The compensation for the modesty of the technical means by the work of interpretation on the ground. The interpretation of remote sensing data will be preferred to experimental methods requiring material and human resources, hence the interest of involving partners in the field who know the environment.
- Define and test socio-economic survey methods adapted to a spatial vision of the agricultural systems of mountain lands;

- Exploit the composite nature of the pixel by trying to detect synthetic descriptors directly, without having to go through the classic factorial maps, which take too long to obtain.

2-2- Concepts of geomatics, diagnosis and integrated development of mountain lands:

It should be noted that the place of geomatics in the diagnosis and integrated development of mountain land consists of the collection, processing, storage and dissemination of multi-thematic data. The diagnosis concerns a network of stations spread over three (03) priority sites, and selected for their eco-geographical and agro-ecological representativeness.

The methodology for diagnosis and integrated development of mountain land, reproducible for all sites, integrates geomatics for an approach combining georeferenced agro-ecological and socio-economic data. Each discipline thus contributes to the definition of an information layer representing a particular theme. All the layers thus generated on a given site, representing multi-thematic data, are integrated into a geographic information system (GIS).

Geomatics, defined as the set of computer processing techniques for geographic data, uses databases, GIS and remote sensing for the production, processing and management of geographic information. For our project, geomatics is integrated into the diagnostic methodology and the development of an integrated development model for mountain land.

To achieve this objective, it is necessary to fix the conceptual and methodological approach of the geomatics tool which will allow the diagnosis of agro-ecological resources. Indeed, in the sense of agro-ecological diagnosis, it is mainly a question of studying the agro-ecological environment of mountain lands; this study uses specific data collection (field) and then processing (statistical) methods. Therefore, the choice of field methods, applying the geomatics tool, must be consistent with the desired level of accuracy. The purpose is in fact the production of spatialized data on the biophysical environment and their compatibility with the methodology of agro-ecological diagnosis; The choice of an appropriate level of perception, both from an agroecological and spatial point of view, is therefore fundamental.

2-3- Hierarchisation of levels of analysis: the triptych field - remote sensing – GIS:

Geomatics offers technical possibilities for prioritizing data and results with a view to their spatialization. The combination of field observations and remote sensing allows obtaining a valid cartographic representation of the arrangement of the landscapes in a given space, control over field stations allowing the establishment of a reference for the interpretation and processing of satellite images.

An approach of this type, classic in remote sensing, can be used for the diagnosis of agroecological resources; the realization of cartography of the USA (Agricultural Spatial Units) will constitute the plan on which to apply a method of stratified sampling. The integration of data (attribute tables + maps) into the GIS will make it possible to carry out the spatial processing and operations necessary for

decision-making and the pursuit of research, the system remaining evolving over time. Hierarchical interlocking from specific survey stations to an area covering a larger spatial field (the site) can thus be operational thanks to a structured distribution of tasks. This remains dependent on the means available on the sites: GIS under ArcGis and MapInfo,

2-4- Strengthening the diagnostic methodology of the agro-ecological environment using Geomatics

To meet the project objectives, the chosen methodology will be implemented by applying the following technical operations:

a) Collection of technical documents (maps, satellite images, aerial photos) and preliminary data processing: (1) geographical location and delimitation of the test areas selected for the agro-ecological diagnosis; (2) acquisition of vectorized topographic maps (1/50,000) from the INCT; (3) acquisition of aerial photographs (1/20000) from the INCT; (4) acquisition of ALSAT high spatial resolution panchromatic satellite images (2.5m) from ASAL; (5) downloading multi-spectral satellite images from specialized sites; (6) collection of existing thematic maps (vegetation map, bioclimatic map, soil map, etc.); (7) Extraction of maps of priority sites selected for the experiment; (8) exploitation of vectorized topographic maps and the DTM (Digital Terrain Model) for the establishment of cartographic repository for the GIS; (9) agro-ecological zoning using aerial photos and satellite images; (10) production of the various factorial maps (GIS information layers)

b/ Typology of homogeneous agro-ecological units or USA (agricultural spatial units) This is a multi-variable approach: the agro-ecological descriptors and the components of the environment will make it possible to describe the stations. Indeed, on each of them, a systematic and stratified description of the components of the environment will be carried out. Each variable will be georeferenced and notified from a visual estimate. Thus, a typology of homogeneous agroecological units or USA (agricultural spatial units) can be produced.

c/ Proposal for an integrated development model for mountain land The various homogeneous agro-ecological units or USA (agricultural spatial units) will be the subject of concrete proposals for hydro-agricultural development actions.

3. RESULTS

3-1 Presentation of the study area:

The wilaya of Tlemcen is located in the far west of the country. It is limited to the north by the Mediterranean Sea, to the east by the wilaya of Sidi Bel Abbas, to the south by the wilaya of Naâma, to the northeast by the wilaya of Ain Temouchent and to the west by Morocco. . It covers an area of

9061 km². The territory of the wilaya of Tlemcen is made up of a set of natural environments which follow one another in a roughly parallel manner. We distinguish from North to South: the mountain range of Traras, the plains and plateaus limited to the South by the mountains of Tlemcen and finally the steppe zone which extends to the borders with the wilaya of Naâma. This territory is characterized by a complex and diversified geology. Thus, there is a succession of formations dated from the Primary to the Quaternary. (figure 1).

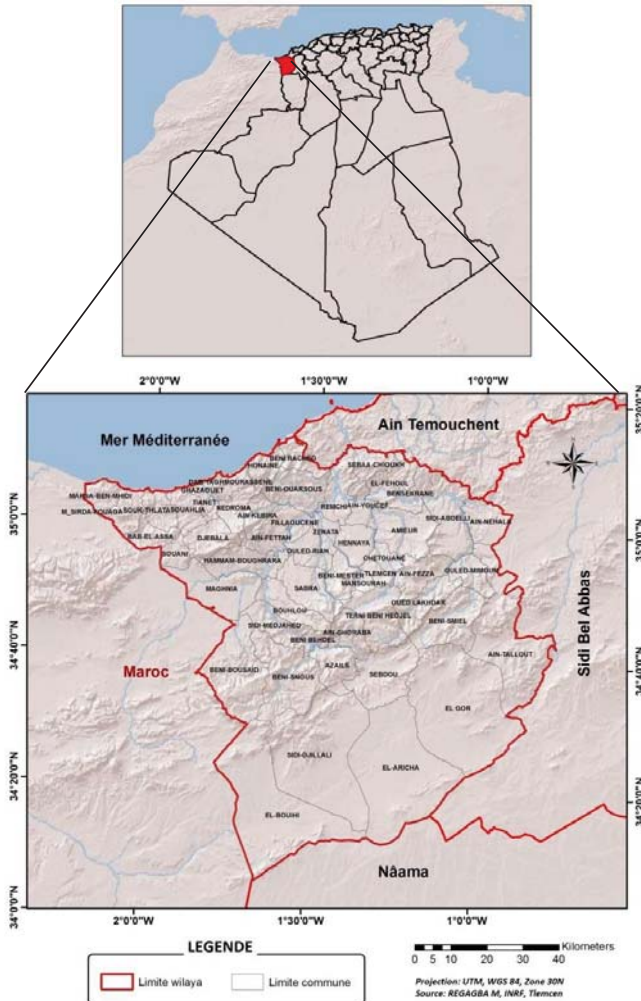


Figure 1. Presentation of the Tlemcen study area - Algeria

3-2- Development of the master plan

The Wilaya master plan was drawn up in the form of a prospective land allocation map which translates and brings into line the principles, options and development orientations defined in the previous phase of the study in terms of planning, land use and spatial organization in a long-term

perspective. It is based on a reallocation of land according to the potentialities, constraints and objectives of a rational and balanced use of space and resources. (Figure 2).

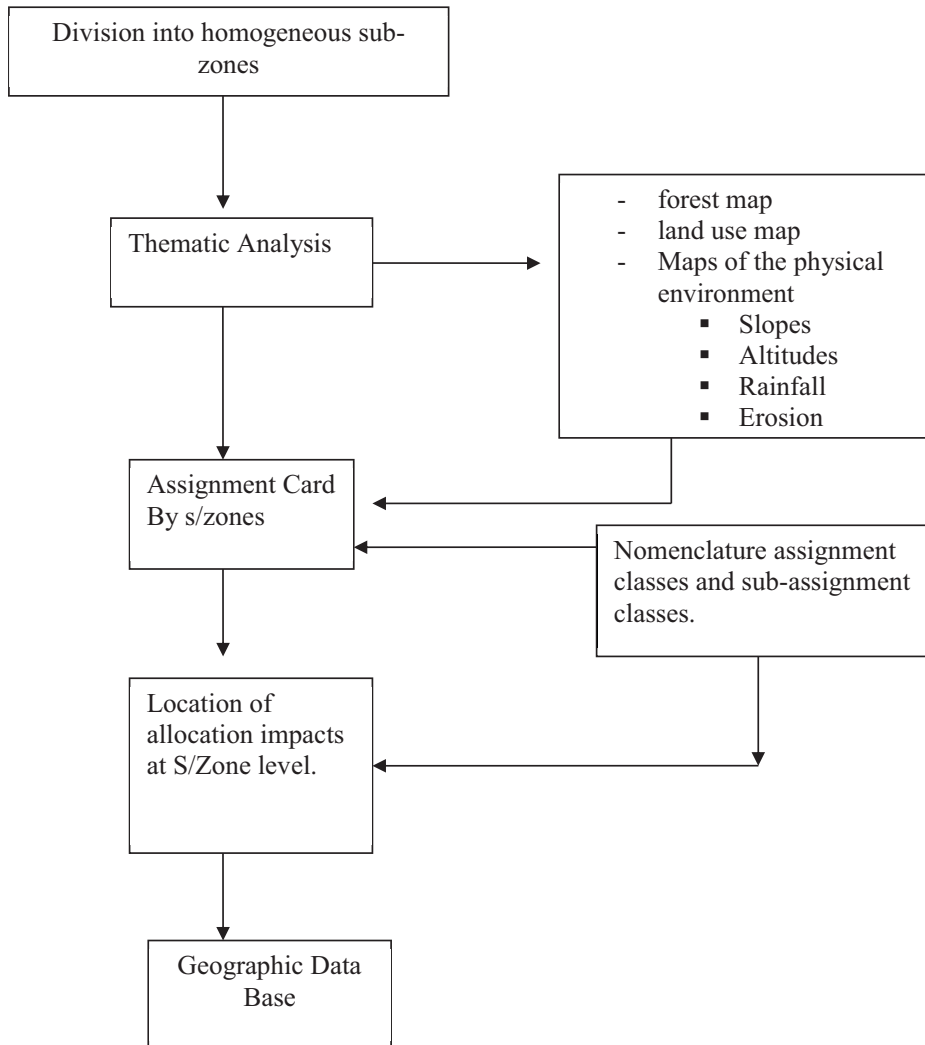


Figure 2: Diagram summarising the methodological approach

3-3- Land use:

The prospective land use map was drawn up in two stages:

- Division of each homogeneous zone into sub-zones.
- Assignment by sub-zones

a)-Division into sub-zones:

The homogeneous zones, as they were defined in the previous phases correspond for the greatest number of them, to large homogeneous territories. They are insufficiently suited to serve as a spatial framework for drawing up a land use map: areas that are too vast, homogeneity corresponding to a dominant typology which may include several entities with different potentialities and vocations.

It was therefore necessary to carry out a finer division of each constituent homogeneous zone, i.e. a division into sub-zones, entities as homogeneous as possible in terms of their characteristics and potential, their vocations and the major types of assignment and possible and desirable actions.

The division of the territory of the wilaya of Tlemcen highlights 04 homogeneous zones which are spread over an area of 904,626 Ha (table 1) (Figure3)

Table 1: List of homogeneous zones and sub-zones

Zone	Sub Zone	area	%	Typology
High Plains Steppiques-Sebdou-EI Aricha	High Plains Steppiques-Sebdou-EI Aricha	238120	26	agricultural and pastoral
Tlemcen Mountains	Tlemcen Mountains	327357	36	Forest
Traras Mountains	Traras Mountains	160410	18	Forest
Tellian Plains of Maghnia-Tlemcen Remchi	Tellian Plains of Maghnia-Tlemcen Remchi	180250	20	Agricole
Total		906137	100	

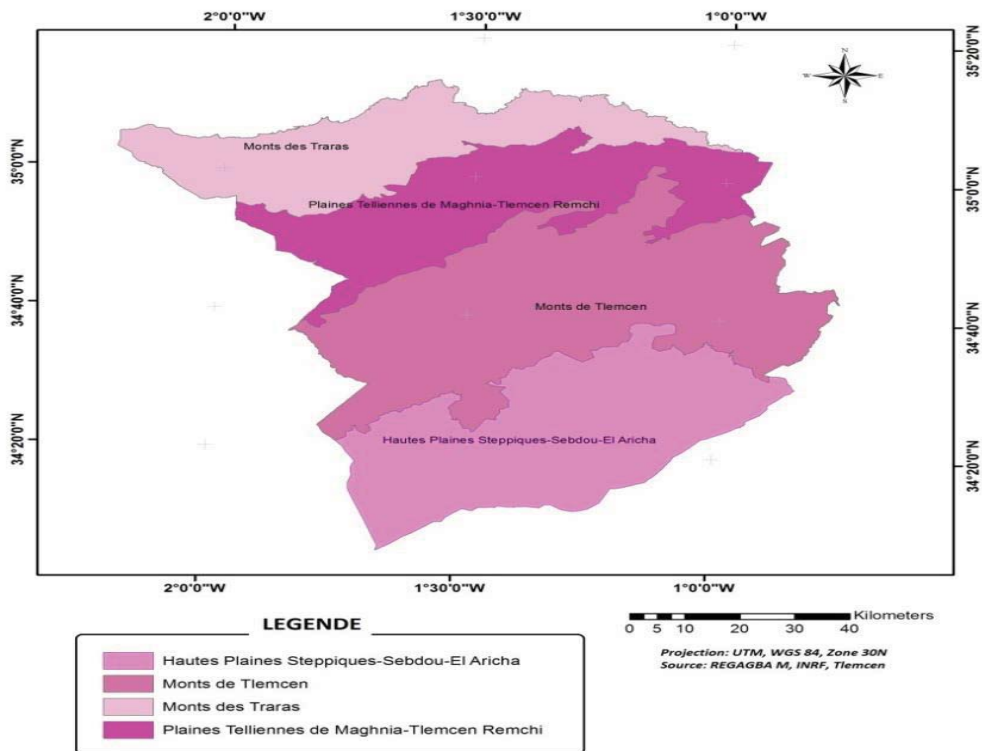


Figure 3: Map of Homogeneous Areas

b)-Assignment by sub-zone:

The allocation by sub-zone was established from the combined analysis of the various factors of the agro-ecological environment of the sub-zone by superimposing the thematic maps at 1/200,000 (in particular the map of slopes, the map of land use, the population map, the climate map and the erosion map). The assignment map thus established by sub-zone indicates the main possible and desirable assignments which have been determined according to the potentialities and constraints on the one hand and on the other hand in an objective to be achieved in the long term of an occupation of the soil according to the vocation of the land and with the double aim of improving the production potential of agricultural, forest and pastoral land and of preserving the natural environment against degradation. The ultimate goal of this division is to obtain operational sub-zones for the development of a precise and well-located plan of planning and development actions.

b-1- Forest allocation:

It concerns all wooded land, maquis, reforested land and land intended for reforestation for the purpose of protection or production, and this regardless of the conditions of the relief, soil and climate. Intended for roaming livestock, pastoral use concerns existing rangelands (foothills rangelands, steppe rangelands) that need to be preserved and improved, and land intended for fodder plantations, such as eroded land and land for marginal crops to be converted.

b-2- Agricultural assignment:

It concerns all current agricultural land and land to be used for agricultural development which corresponds to the potential and the natural vocation of the areas and/or agricultural intensification is possible, in particular through fruit growing.

- Land heavily affected by erosion and which is therefore considered unsuitable for an agricultural activity.

- Land of marginal crops on steep slopes, which are to be reconverted by forest or fodder plantations.

However, land that shows moderate erosion (sheet or surface erosion) is to be considered suitable for agriculture, provided that appropriate farming techniques and anti-erosion systems of the CES type are applied. (Figure 4).

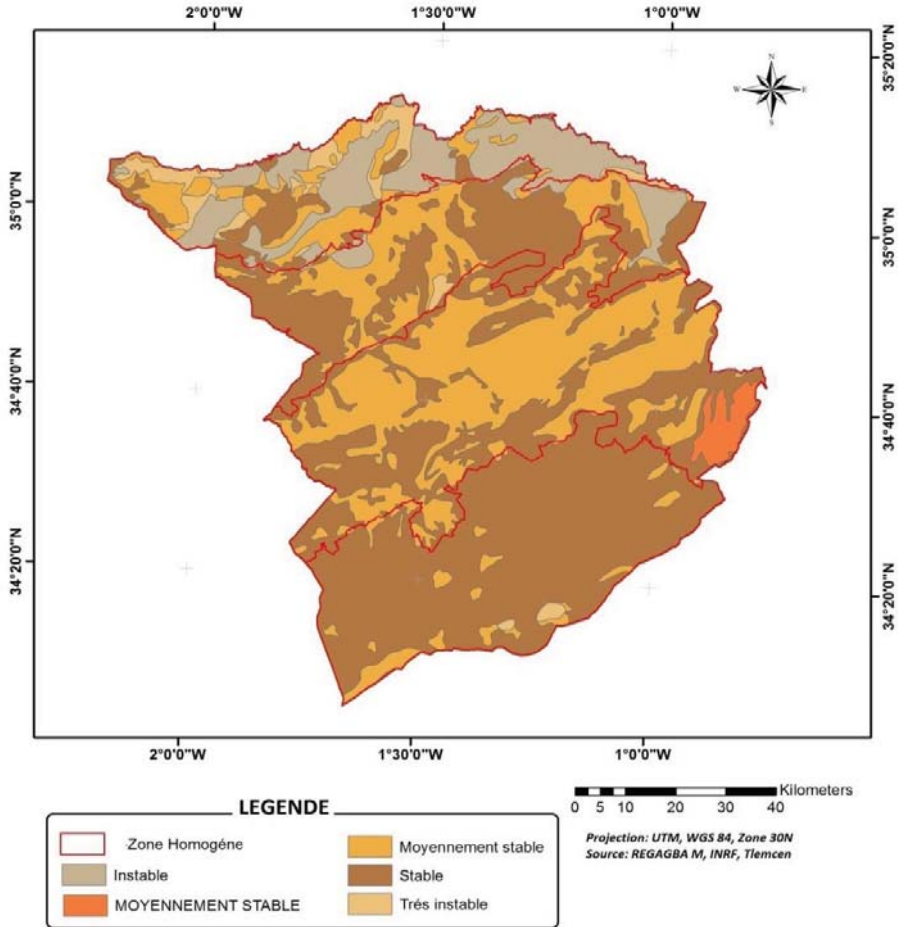


Figure 4: Tlemcen Wilaya Erosion Map

- **Land use:**

For each of the homogeneous zones, the land cover results from the planimetry of the land cover maps and those of the forest formations.

Land use is on the whole marked by the importance of forest land which covers an area of 238,820 Ha, ie a rate of afforestation of 26%, a value higher than the national average.

The fact remains that the wilaya has considerable agricultural potential, represented by crops and rangelands. The whole occupies 654,814 Ha, or 72% of the area of the wilaya, at the level of the foothills, valleys and plains.

- Agricultural land (Crops and crops associated with rangelands) occupy an area of 416,165 Ha or about 46% of the area of the wilaya. (figure 5).

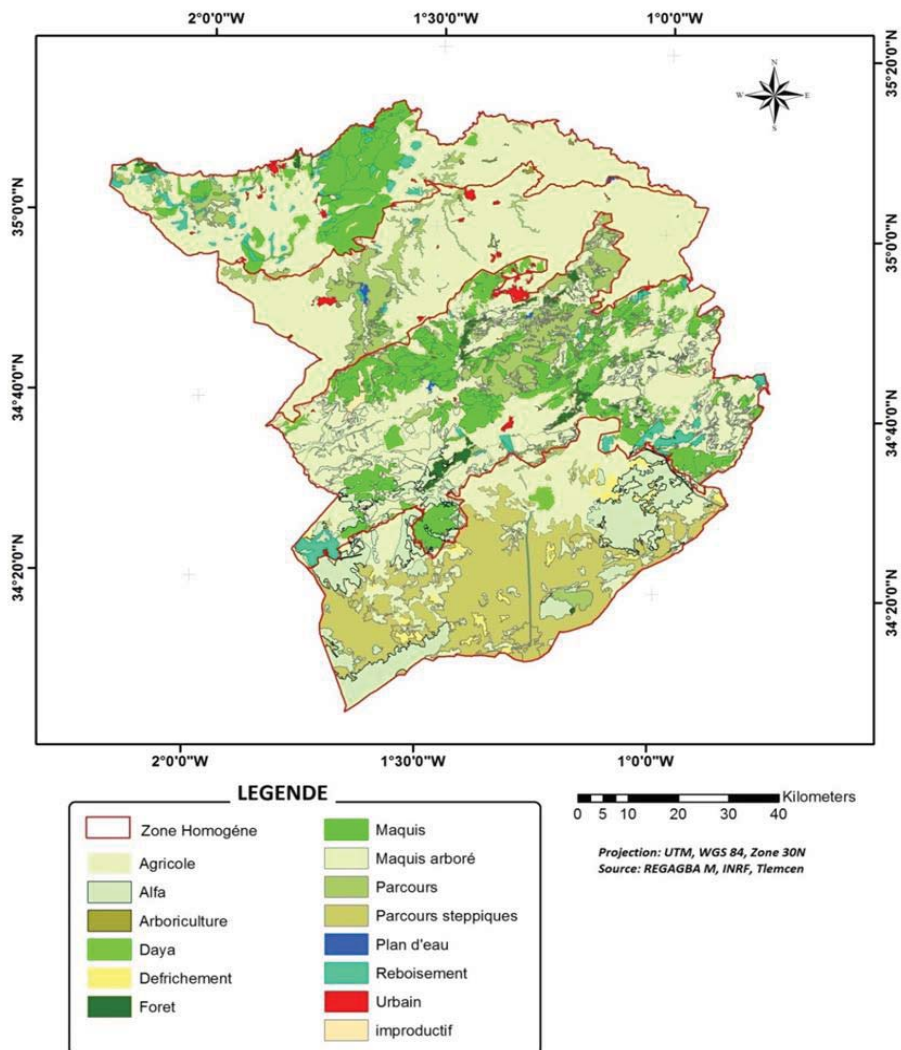


Figure 5: Carte d'occupation du sol de la wilaya de Tlemcen

Zone	Land use
Traras Mountains: 160 400 Ha	predominantly agricultural (72% of the area) despite the extent of land with steep slopes that are not suitable for farming, which has the effect of accelerating the processes of erosion and instability of the slopes : - The forest cover is insufficient quantitatively (48,532 Ha, i.e. an afforestation rate of 30%) and qualitatively (forests fragmented into several islands of residual forest formations in the state of clear maquis and with young reforestation scattered in rangelands). This scattered and low-density forest cover is insufficient to ensure the protection of land with steep slopes. The forests in the area are characterized as follows in terms of stand types.
Tellian Plains of Maghnia-Tlemcen Remchi: 180 200 Ha	Extensive, semi-extensive and intensive irrigated agricultural type (cereals, vines, and arboriculture). Forests represent only 1.7% of the total area of the area.

Tlemcen Mountains: 327 400 Ha

-The forest formations occupy 187,392 Ha or 57% of the area of the zone. This rate of afforestation is insufficient given the magnitude of the steep slopes and given the fact that the degraded forests (by overgrazing) have been reduced over 91% of their area to the state of generally clear maquis and wooded maquis which cannot properly fulfill their role of protecting the slopes.

- The Alfa occupies 11,007 Ha or 3% of the area.
- Crops occupy 89,000 Ha or 27% of the area.
- The routes = 36,700 Ha (11%).

High Plains Steppiques-Sebdou-El Aricha: 238 100 Ha.

- Essentially made up of steppe courses (47%) and cropland (30%).

- Forest occupation:
Alfa = 49,800 Ha or 21% of the area.
Forest = 1,180 Ha (i.e. 0.5% of the area),
Consisting mainly of young reforestation.
Wetland = 1,400 Ha..

• Relief:

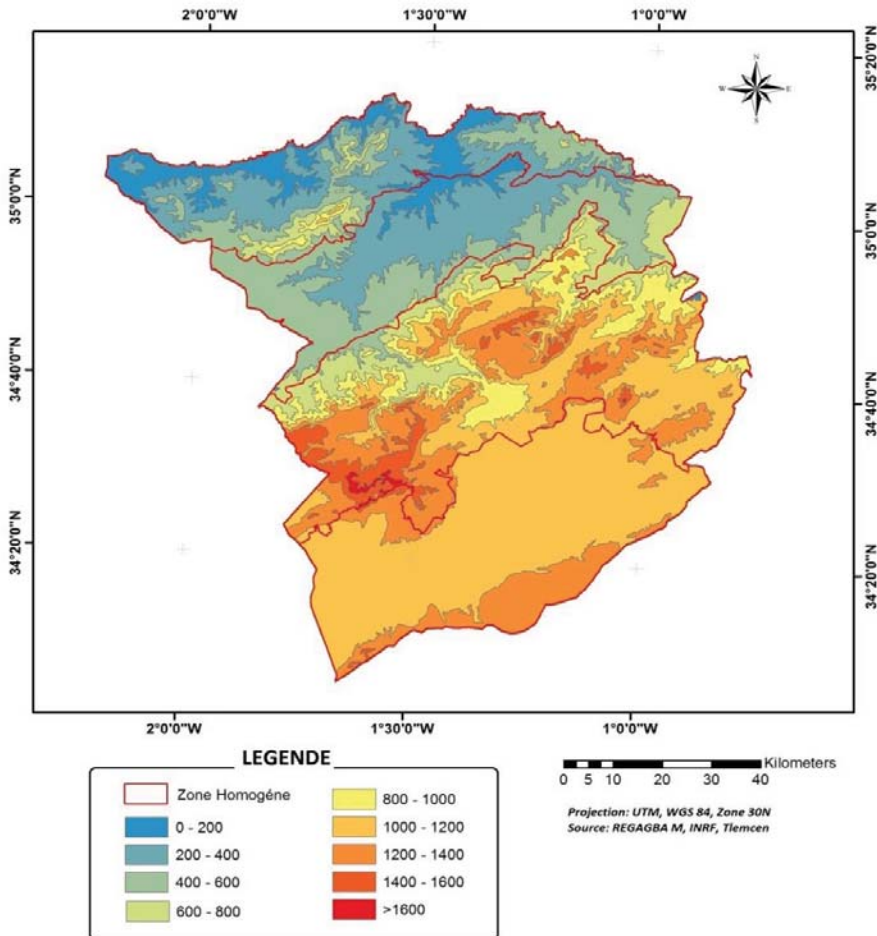
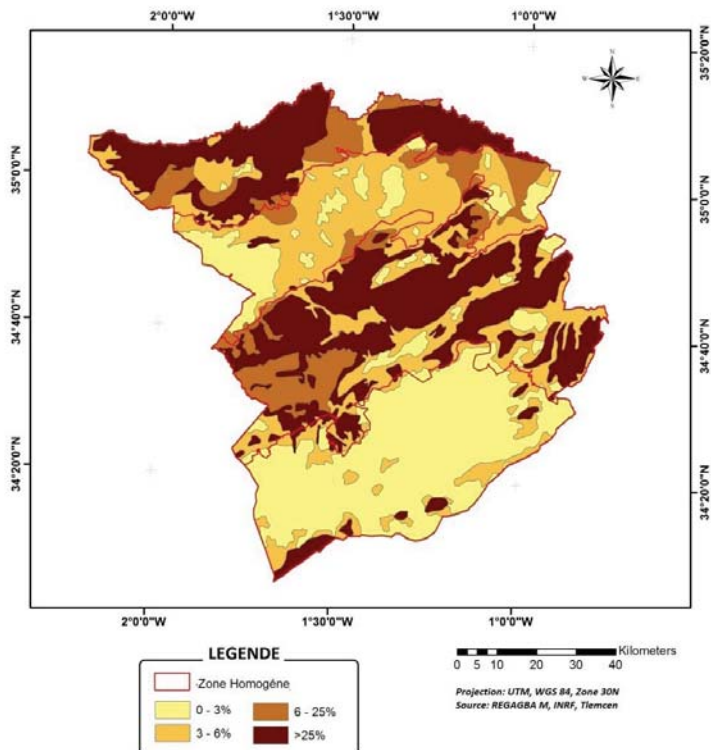


Figure 6: Tlemcen Wilaya Hypsometric Map

Zone	Relief
Traras Mountains: 160 400 Ha	Coastal range with cliffs, and crossed by a series of transverse wadis. This chain is made up of the Jebels Zenndal, Dahr Ed Dis and the foothills along Oued Tafna. 2/3 of the areas have an altitude of less than 400 m. Land with an altitude above 800 m (3%) is located in the inner part of the area (Djebel Fillaoussene). (Figure 6)
Tellian Plains of Maghnia-Tlemcen Remchi: 180 200 Ha	Interior plains with flat and hilly relief and at low altitudes (200 to 600 meters) (Figure 6)
Tlemcen Mountains: 327 400 Ha	The northern part of the Monts de Tlemcen presents a high mountain relief at high altitudes (400 to 1,600 m), with steep slopes greater than 25% and a harsh climate, hence the problems of isolation and isolation of some areas. - The southern part has over half of its surface a relief with low slopes of less than 12% (favorable to agriculture) and the rest constitutes high mountain relief (slopes greater than 25% and high altitudes 800 to 1,600 m) . (Figure 6)
High Plains Steppiques-Sebdou-El Aricha: 238 100 Ha.	Flat relief at high altitudes (1,000 – 1,200 meters above sea level), and with gentle slopes descending slowly towards Dayet El Ferd. To the south, the area is delimited by the Djebel Sidi El Abed, Djebel Mekaidou (Figure 6)

• Slopes:


Figure 7: Tlemcen wilaya slope map

Zone	Slope
Traras Mountains: 160 400 Ha	75% of the area of this area has a slope greater than 25%, the rest forms the foothills located along the main wadis and in the Nedroma region. (Figure 7)
Tellian Plains of Maghnia-Tlemcen Remchi: 180 200 Ha	
Tlemcen Mountains: 327 400 Ha	
High Plains Steppiques-Sebdou-EI Aricha: 238 100 Ha.	

• **Lithology:**

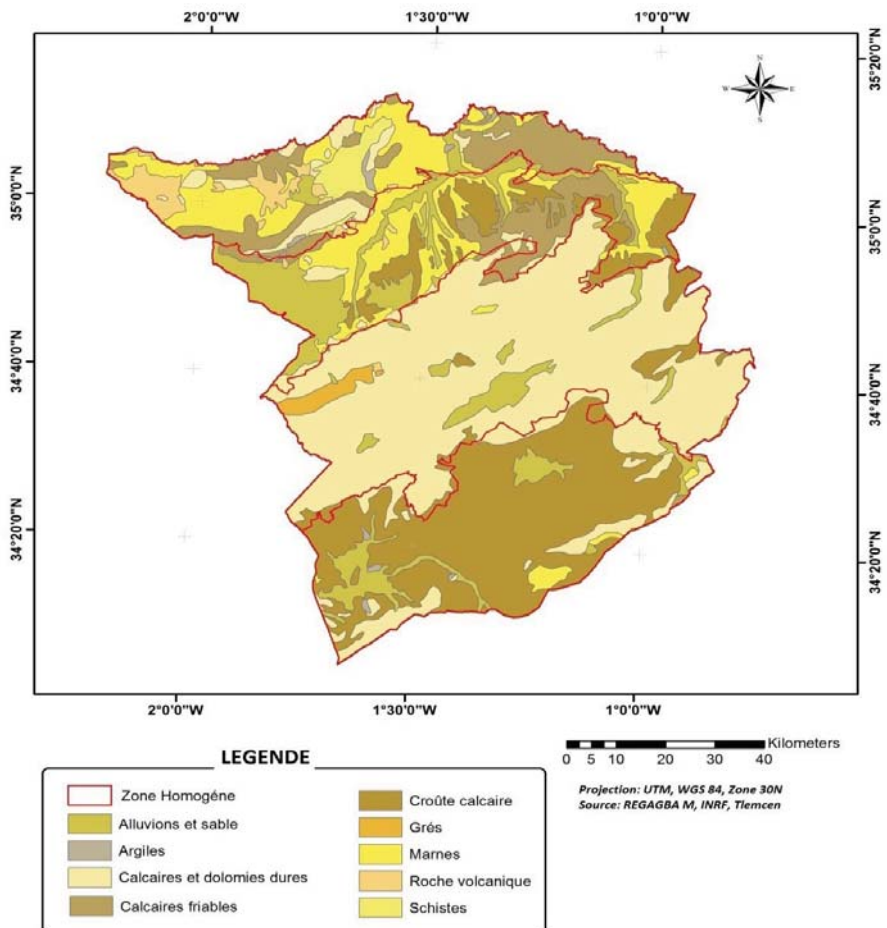


Figure 8: Lithological map of the Tlemcen wilaya

Zone	Lithology
Traras Mountains: 160 400 Ha	- 40% Marls. - 30% friable limestone. - 10% limestone and hard dolomites. - 10% volcanic rocks.

	- 10% Schists. (Figure 8)
Tellian Plains of Maghnia-Tlemcen Remchi: 180 200 Ha	- 40% marls. - 25% Alluvium. - 15% friable limestone. - 10% limestone and hard dolomites. - 10% calcareous crusts. (Figure 8)
Tlemcen Mountains: 327 400 Ha	- Hard limestone and dolomites.. - Alluvia and sands (Figure 8)
High Plains Steppiques-Sebdou-El Aricha: 238 100 Ha.	- 95% calcareous crusts. - 5% limestone and hard dolomites (north-east periphery of the area). (Figure 8)

• Climate:

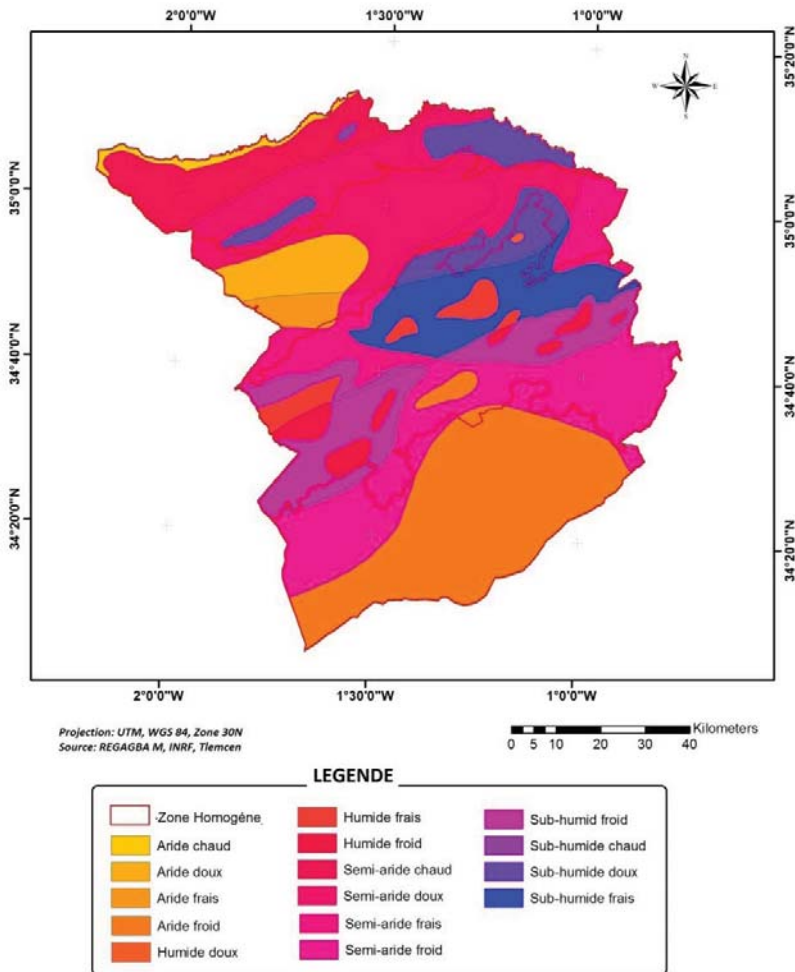


Figure 9: Climate map of the Tlemcen wilaya

Zone	Climate
Traras Mountains: 160 400 Ha	Bioclimatic level: - Mild semi-arid. - Temperate semi-arid... Rainfall: 400 to 500 mm/year on the coastal fringe North. 500 to 600 mm/year on the southern fringe (Figure 9)
Tellian Plains of Maghnia-Tlemcen Remchi: 180 200 Ha	- Bioclimatic level: - Fresh semi-arid 25%. - Temperate semi-arid 75%. - Low rainfall in the West (300 to 400 mm/year) and higher in the east (500 to 600 mm/year). (Figure 9)
Tlemcen Mountains: 327 400 Ha	Average annual rainfall greater than 600mm/year. - Bioclimatic floor - 67%: Fresh subhumid. - 33%: Fresh semi-arid. (Figure 9)
High Plains Steppiques-Sebdou-El Aricha: 238 100 Ha.	80% Arid cold. - 20% Cold semi-arid (North zone). Rainfall: 200 to 300 mm/year. (Figure 9)

4. CONCLUSION

The use of geomatics techniques for zoning mapping is technically feasible and the results obtained are encouraging. All topographic, satellite and auxiliary data was analyzed, processed, stratified into independent information layers in mesh mode and combined within a GIS.

The exploitation of the spatial analysis made it possible to establish crossing scenarios for the mapping of homogeneous zones.

This method allows the production of thematic maps, according to interlocking landscapes/biotopes/habitats, compatible with GIS.

The approach is proposed by emphasizing as a priority the monitoring of biodiversity.

The results obtained validate the overall approach and raise technical or thematic limits to be noted. The main difficulties lie in the methods of using remote sensing for the spatialization of biotopes in desert environments, which still need to be improved. It is strongly recommended to acquire in the future fine resolution images (5 - 10m), which alone can allow the detection of all the ecological variables sought.

Overall, the method makes it possible to integrate all levels of analysis consistent with the multidisciplinary monitoring of biodiversity.

This methodological approach, unless revised, brings us satisfactory and practical results to comfort the GIS and proceed on medium and large scales to drape the potential indicators for monitoring biodiversity.

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