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Use GIS to study the socio-economic impact on the physical environment in the eastern Aurès (Algeria)

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ABSTRACT: We propose in this study to address the impact of socio-economic factors on the physical environment, especially their spatiotemporal dynamics in semi-arid and arid zone of Eastern Aurès. Including 11 towns, this study extend over a relatively large zone of about 60,000 ha. A temporal decline is quite large; it is determined by analyzing three dates of environmental variation spread over thirty years (between 1987 and 2007). Multi-source data acquired in this framework are integrated into a geographic information system (GIS). This allows among others to calculate index and classes of zones for each thematic layer of 4 layers previously defined by a method inspired MEDALUS project (Mediterranean Desertification and Land use) (Kosmas et al., 1999). The database created is composed of four layers of information (population, livestock farming and land use). This analysis in space and time has been supplemented by a validation on ground check. After, correcting the database that has been used to develop the synthesis map, with the calculation of the index of the socio-economic impact (IISC). Cartographic materials and information resulting does not only consist to evaluate the current situation, but could be used to forecast future trends.

KEYWORDS: Socio-economic impact, spatiotemporal dynamics, Physical Environment, GIS, Eastern Aurès.

1 INTRODUCTION

The history of human societies was marked by successive steps of occupation and use of the natural environment with ways that aggravated it and have accelerated over the past centuries and led to changes in increasingly intense (Quezel, 1980; Aidoud 1994; Brahimi, 2001 Cornet and al; 2002, Wu W, 2003).

The territory of our study zone includes different ecosystems that are traditionally made of livestock zone, pastoralism, forestry, and cultures (Abdessemed, 1984; Anser, 2002).

These characteristics of the physical environment are particularly those of occupation land witch give the zone an Agro-forestry-pastoral vocation. We Based on this vocation and the diversity of this zone from the North to the South and East to the West to study the socio-economic impact on the physical environment (Bensaid et al, 2003; Benbrahim et al, 2004), we use three statistical parameters: population, livestock, crop activity in database form using GIS (ROSELT / OSS, 2004; Bensaid, 2006).

Our interests came from the lack of socio-economic impact studies especially at the local level; it has encouraged us to approach this work.

Our approach is adopted from the MEDALLUS project (1999). It is mainly based on the study of the following parameters: Population, Livestock, cropping activity and land use.

Our study reached over half of the east side of the province of khenchela.

The study focused on two aspects:

- Temporal: Based on different periods (1987-1997-2007);
- Spatial: Considering 11 towns.

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The work was performed using the software MapInfo7. The main goal is to get the socioeconomic impact map that allows us to provide answers on the main causes that led to the development of the degradation of the physical environment and how to fight against this phenomenon.

2 PRESENTATION OF THE STUDY ZONE

The study zone has a diverse natural environment but also hostile, it has the higher altitude in Northern Algeria 2326m (Chélia) and the lowest altitude (-21m South Chott Melrhir) (Ballais 1975; Berkan and Yahiaou, 2007).

The landscape of the study zone includes different ecosystems that are traditionally made up of farming zones, pastoralism, forests and crops. These characteristics of the physical environment and especially those including the land use give the zone a vocation type of Agro-forestry-pastoral.

Due to its geographical position, the study zone has a powerful originality that allowed it to keep its town names from the Roman colonization. The importance of their localization and wealth of flora, fauna and their conservation are essential for its development. We chose the limits of our study zone because it has well-defined changes in the socio-economic impact from North to South perceptible through time.

The study zone is located in the North-East of Algeria, approximately the following geographical coordinates:

- 6 ° 70 'and 7 ° 18' East (longitude)
- 34 ° 86 'and 35 ° 34' North (latitude).

Our study zone is located east of the Aures and consisting of 11 towns: Khechela, Kais, Tawzianet, Elhamma, Tamza, Bohmmama, Yabous, Chélia, M'Sara, Ouldja, Kheirane and having an surface of 2,862 km². The study zone is a part of the Atlas chain. It occupies a large part of Northern Algeria and extends beyond its borders. It is bordered to the North by the chain of Tell and South by the Sahara shield (Schoenenberger A. 1971, MARD, 2003).

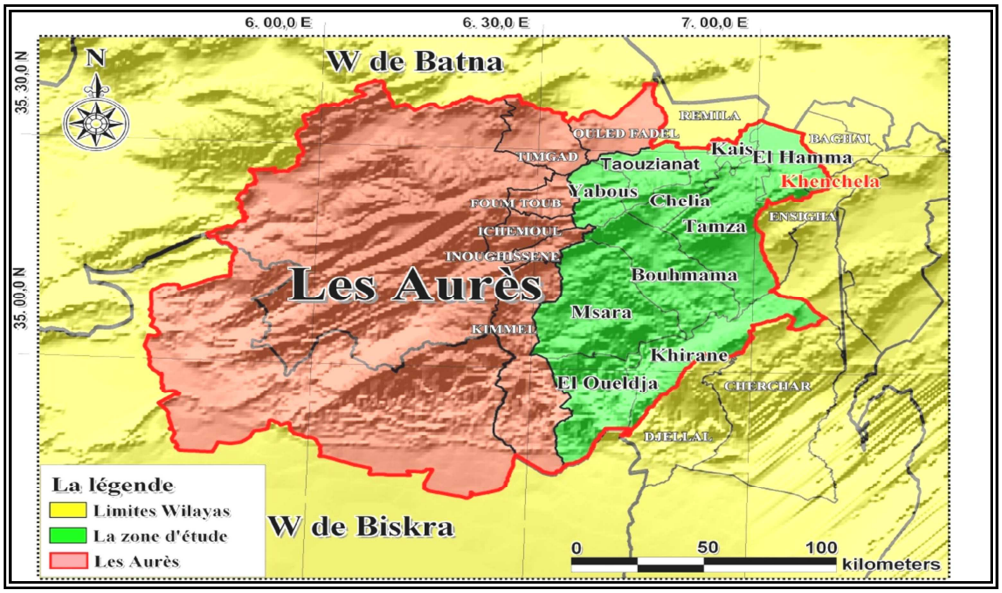


Fig. 1. Location map of the study zone

From a geomorphological point of view, the study zone has a very large surface which is characterized by mountainous relief; the main one is massif of the Aurès, which consists of a pleated structure.The location of the profiles on the map shows that the altitudes vary from North to South (Chelia towards Oueldja) and West to East (Yabous towards Tamza).

The soils are grouped into five classes from the most advanced class (brown soils) to the class of the most degraded soils (raw minerals). The soils of the region are not deep and may have rocks and crusting debris in surface and depth.

The study zone is characterized by a continental mountain climate that draws its originality from altitude which is responsible of the contrasting climatic conditions (an average temperature of 19.16 ° C, the average annual rainfall of

280.45mm), the region is under Saharan influences in its Southern part (the influence of sirocco) and in the Northern part of the rainy winds that involves spatial and temporal variations.

The socio-economic situation facing the study zone is currently characterized by diversity and extent of the difficulties in front of satisfaction of population's need.

This presentation of the study zone in its economic and social aspects as well as the appreciation of its potential certainly will shed light on the socio-economic situation (Cote, 2003; Directorate General of Forests, 2004).

This region, adding to its diversity of natural zones, is an Agro-Silvo-Pastoral vocation. This diversity, ranging from the Saharan zones to high cereal plains through the steppe rangelands and forested mountainous zone is an important natural potential and a significant advantage for the development of the region.

In addition, the potentialities of the region in soils, forest zones, water resources and perspective of livestock development in all its forms; are capable of a harmonious and balanced development of economic activity in the region. The study zone consists of three large natural areas;

- The high Northern plains.
- A mountainous region in the center (woodland to the west and degraded forest in the East).
- The steppe and Saharan region to the South.

The vocation of every physical region is closely related to the natural conditions that govern each of these zones such as relief and climate.

3 METHODS

Our approach to work is inspired by MEDALUS project (1999), it is based on the evaluation of various ecological factors, among these factors there are: soil, vegetation, climate, and socio-economic aspect. We chose the last factor to define the anthropogenic causes of the socio-economic impact in the physical environment (United Nations, 2005). These cases were divided into 4 thematic layers: populations, livestock, cropping activity, and land use.

3.1 DATA COLLECTION

The idea is to gather as much information. Indeed, the data collection is one of the most important points in database systems because of the file size and the degree of reliability that these systems must have. During this step, we collected numeric and alphanumeric data (population statistics, livestock ect), consulted basic documentation (theses, books and dissertations) and exanimate various cartographic materials (topographic maps, thematic maps and satellite images).

3.2 CREATING THEMATIC LAYERS

The collected data are classified in socio-economic layer, in our case the system is in the form of four socio-economic sub-layers as followings:

1. Population.
2. Livestock.
3. Crop activity.
4. Land use.

Our study is based on the qualification of the socio-economic impact where we compare their states in time (1987, 1997 and 2007) and in space (towns) with the help of index to obtain results more reliable, clear and as simple to analyze.

3.3 THE THEMATIC ANALYSIS

In this step we create attributes files related to the chosen themes, where for each region or unit (town) has its specific statistics.

These thematic maps allow the graphical representation and comparison of attribute data by illustrating the relationship between geographic elements and specific data.

3.4 STRUCTURING OF LAYERS OF INFORMATION AND DATA PROCESSING

It is defined by the data format (physical model), and the conceptual schema of data. It organizes data and describes the relationships between different data. It is to bring together information from a given geographical area, also to structure the information according to the recommendations built by the working group, as on both graphic and attribute level. This extraction step was supplemented by the provision of data layers in the most common used of GIS formats to make the information as accessible as possible.

A - POPULATION SUB-LAYER

For the realization of this layer we used data from different years (1987-1997-2007), these alphanumeric data are classified and coded with indications according to the effective of population and entered in three sub-layers of information where in each one match the years previously mentioned, then after the creation of the 3 sub-layers we combined it to obtain a single final layer of presence of populations in the study zone, which is classified as followings (Table 01, 02 and 03).

Table 1. Population presence index "1987"

Population presence index 1987	Description	Classes
1	Moderate	0 to 1
2	High	1 to 1.5
3	Very high	1.5 to 2

B- LIVESTOCK SUB-LAYER

In the same way as the previous layer, the data used are from different years (1987-1997-2007), that information is captured, classified and coded with indications according to the effective in order to obtain quality classes, in three sub layers, and then they are combines as well to get the final layer of the presence of livestock classified into 3 classes as follows (tables 50, 51, 52, 53 and 54):

Table 2. Presence livestock Index "1987"

Presence livestock index 1987	Description	Classes
1	Moderate	1 to 1.2
2	High	1.2 to 1.5
3	Very high	1.5 to 2

C- CROP ACTIVITIES SUB-LAYER

Despite the low yields of agricrop activity, it remains a priority speculation and has a social significance which could disturb the entire space management policy as it is usually planted there.

The data used to compile this layer set are the percentages of the surface of each crop (fallow, arboriculture... etc.) To the surface of the study zone, the data is distributed over three years (1987-1997-2007), and they are classified and coded with index to obtaining three sub-layers of information in each of the years mentioned above, then the three layers are merged and we obtained a final layer classified as followings (tables 55, 56, 57 and 58).

Table 3. Index of crop activity in 1987

Index of crop activity “1987”	Description	Classes
1	Zerol	0 to 1.00
2	Moderate	1.00 to 1.31
3	High	1.31 to 1.5
4	Very high	1.50 to 2.00

D- LAND USE SUB-LAYER

The zone of each topic of land use are derived from the land cover map of the zone developed by the classification of satellite image using remote sensing and corrected using the harvested zones according to the ONS. These surfaces are classified with respect to the total zone of the study zone and coded as quality index. The layer is classified as followings (Table 04).

Table 4. Quality index of land use

Quality Index of land use	Description	Classes
1	Good	0 to 1
2	Moderate	1 to 1.2
3	Poor	1.2 to 1.5
4	Very Poor	1.5 to 2

3.5 ELABORATION OF SYNTHETIC MAP

The objective of this step is to crossing of different layers previously created (population, livestock, cropping activities and land use) through the merge tool "Overlay", this step is set to overlay different layers of information in the MapInfo software and merge it by pairs. The first cross map that is relevant to make is for population and livestock layers, then the resulting map with the crop activity layer and finally the resulting map of three layers with the latest on of land use.

Once the final database completed, we must create a new field IIMS (Index of Socioeconomic Impact), which is calculated with the following query:

SQL formula: IIMS = (Ipop*Ilives*Icrop*Ioccup) ^1/4

Finally, the geographical zones are classified into 5 classes of impact.

Table 5. The socio economic impact classes

IIMS	Description	Classes
1	Zerol	1 to 1.2
2	low	1.2 to 1.3
3	Medium	1.3 to 1.4
4	Strong	1.4 to 1.5
5	Very strong	1.5 to1.6

The informatics technology (IT) has emerged rapidly as a tool that can help us in managing the large volume of data base that we necessarily have to handle during a cartographic approach. Also the IT and database led us to better formalize our approach just from the data entry.

Second, the IT let to get rid of purely technical or repetitive tasks and provide assisted mapping methods. We can then focus on the scientific aspects of the mapping therefore search for the spatiotemporal relations and study the socio-economic impact.

4 RESULTS AND DISCUSSION

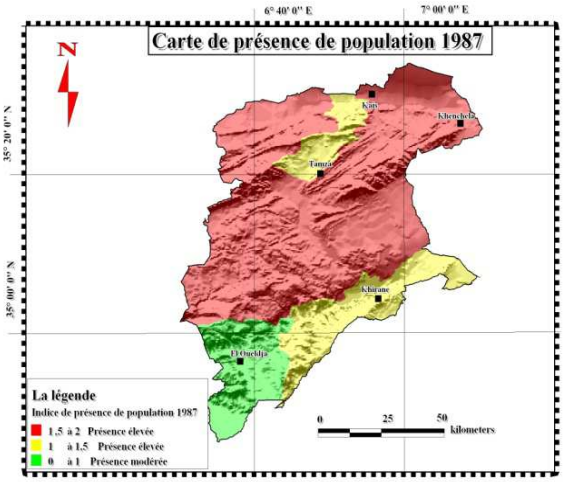
After collecting; management analysis, validation and shaping results, we performed a statistical analysis to produce maps that show the zones of the socioeconomic impact presence. Now we discuss the analysis of the results obtained by several maps.

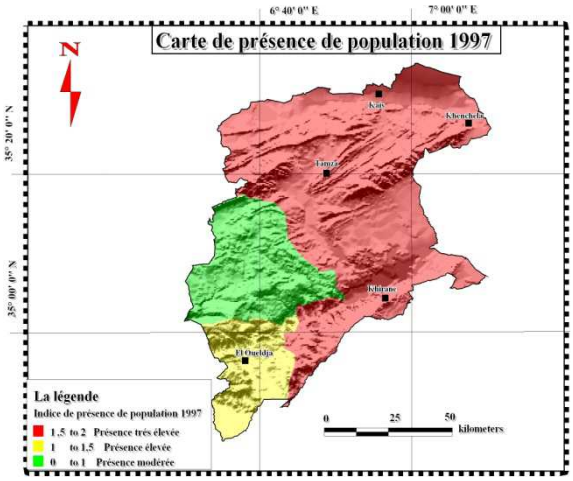
4.1 ANALYSIS OF THEMATIC MAPS

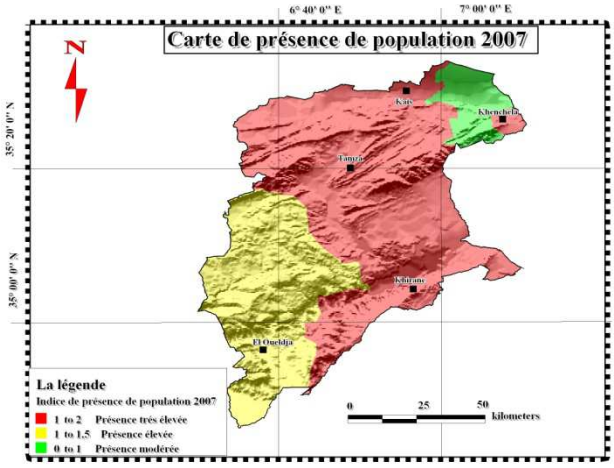
4.1.1 ANALYSIS OF THE POPULATION PRESENCE MAP

For population, we conducted a simple SQL queries, and every time we run a query is to make an update the query result table until an update of the entire database.

4.1.1.1 IN TIME





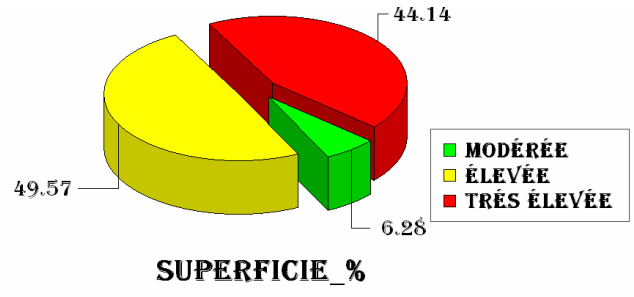


Maps (Figures 03, 04 and 05) and the index of the three years shows a chronological change of the presence of population from one year to another so that the percentage population presence index of the class (1.5 -2) which has very high description is decreased from 87 to 97 with a percentage of 2.29% and from 97 to 07 with a percentage of 36.31%.

This situation is explained by a significant exodus of the population in both periods due to development in the fields of infrastructure and the development of economic activity.

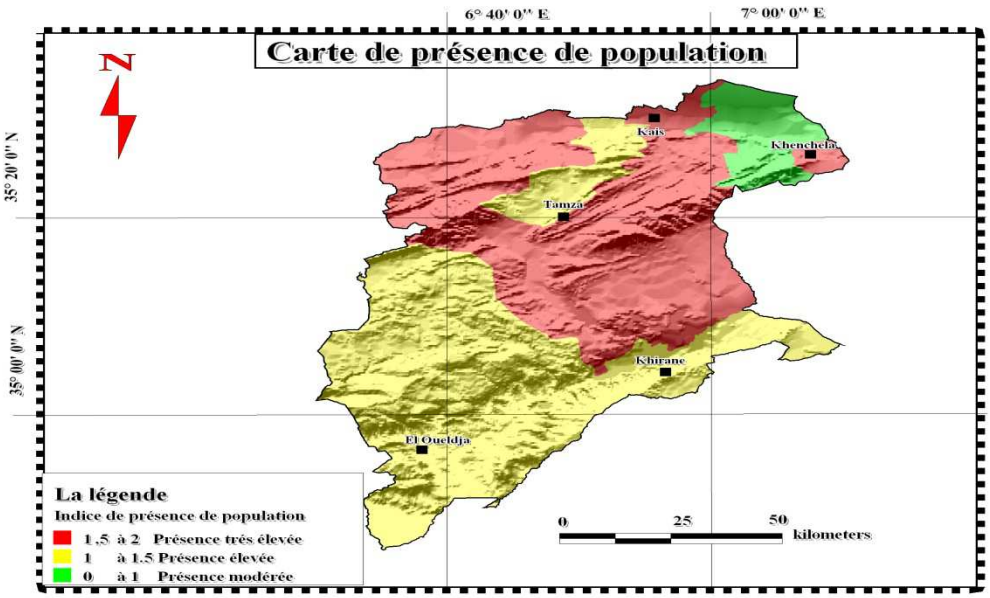
4.1.1.2 IN SPACE

Table 6. Presence population index



The first high category (class 1.2 to 2) occupies an area of 935,613 km² or 31.54% depending on the general map of population, we find that this category is common; Khenchela (capital of the province), Kais, Hamma...etc.

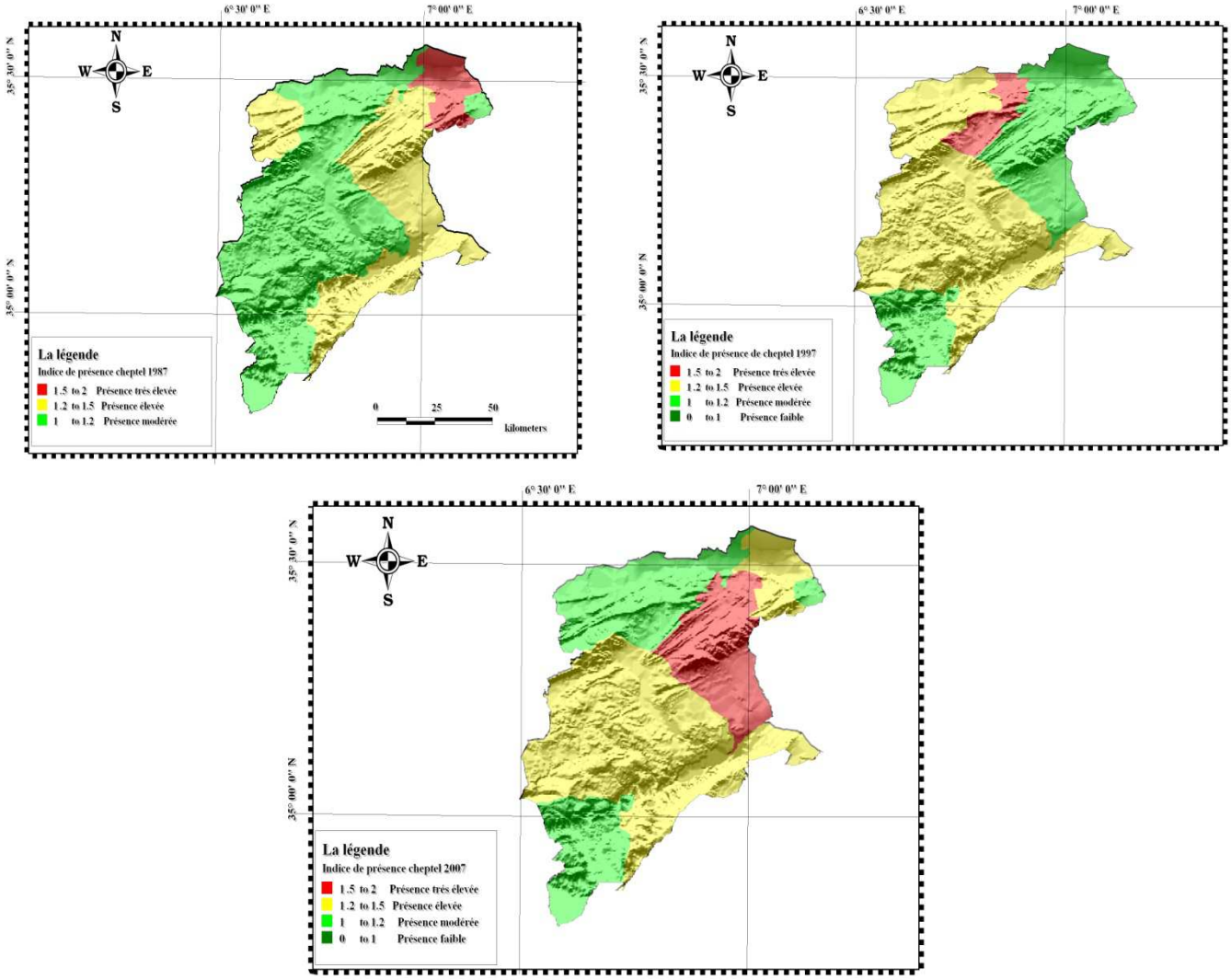
This is related to population dynamics to major urban zones seeking better living conditions.



4.1.2 ANALYSIS OF THE PRESENCE LIVESTOCK MAP

For this map, it performs simple SQL queries in the same way as the previous map that reveals the appearance of presence livestock index in our study zone.

4.1.2.1 IN TIME

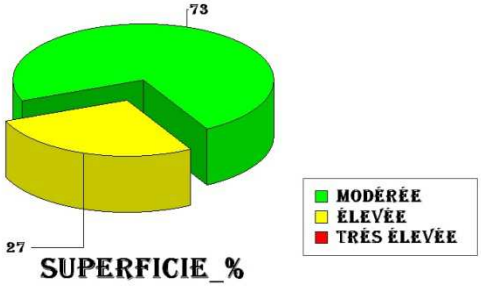


The moderate class (1 to 1.2) occupies the largest zone of 2780.35km² (64%) of the total zone in 1987 and the index increases with a zone of 1335.04km² (45%). Yet the very high class remains stable with no significant change. For the high class, there is a change of 18% from 87 to 97 and decreases by 9% between 97-07.

We can say that there is a change in the presence of livestock index probably with climatic conditions, social or economic.

4.1.2.2 IN SPACE

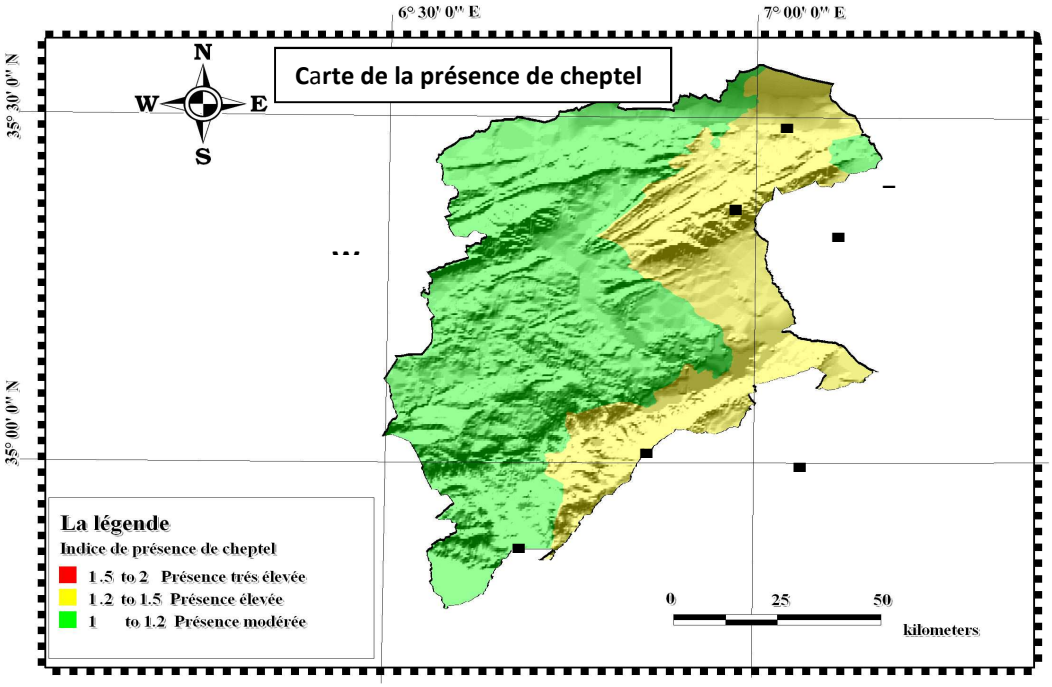
Table 7. General presence of stock index



The moderate class (1 to 1.2) covers the largest zone which is 2165.73km² (77.41%) of the total zone this class covers towns of the West (Msara). The high class is 801.02 km² (27%) relates to towns of East (Tamza) where the cereal plains, steppe and Alfa areas.

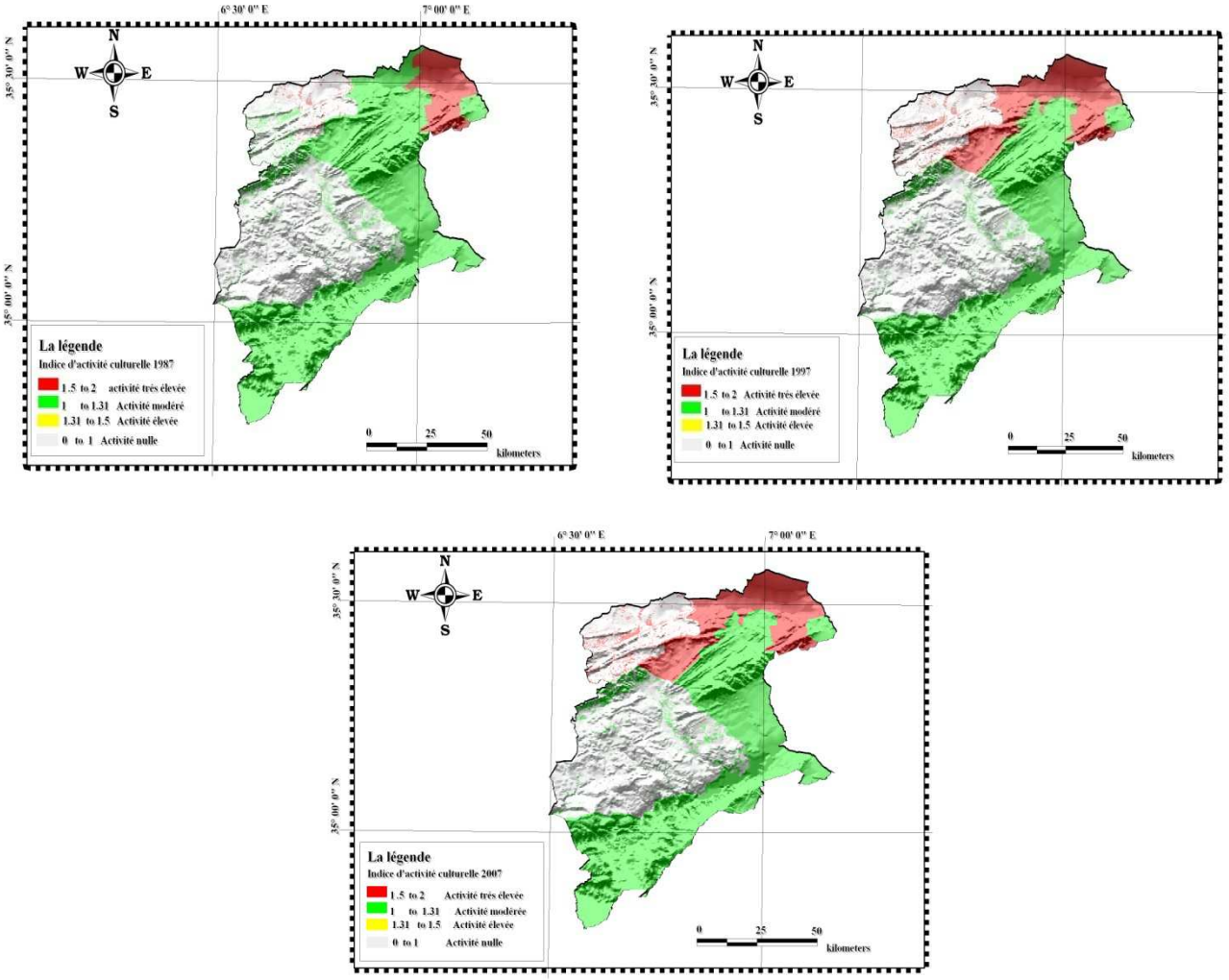
Olives	Description	Superficies (Km²)	Superficies %
1 to 1.2	Moderate	2165.73	73
1.2 to 1.5	High	801.02	27
1.5 to 2	Very high	0	0

Indeed, the majority of stock breeders are stable on the land they use; each farm or group farm has transit routes and the usual range lands. The number of livestock in many cases remains subject to the shape of the farm and to their structure (families, practice cereals and available labor force). However, despite the extensive nature of the farming, it is subject to climatic conditions which constitute a serious constraint in the Southern part of the study zone.



4.1.3 ANALYSIS OF THE CROP ACTIVITY MAP

SQL simple queries used in this map, have led to different categories of crop activity that includes:



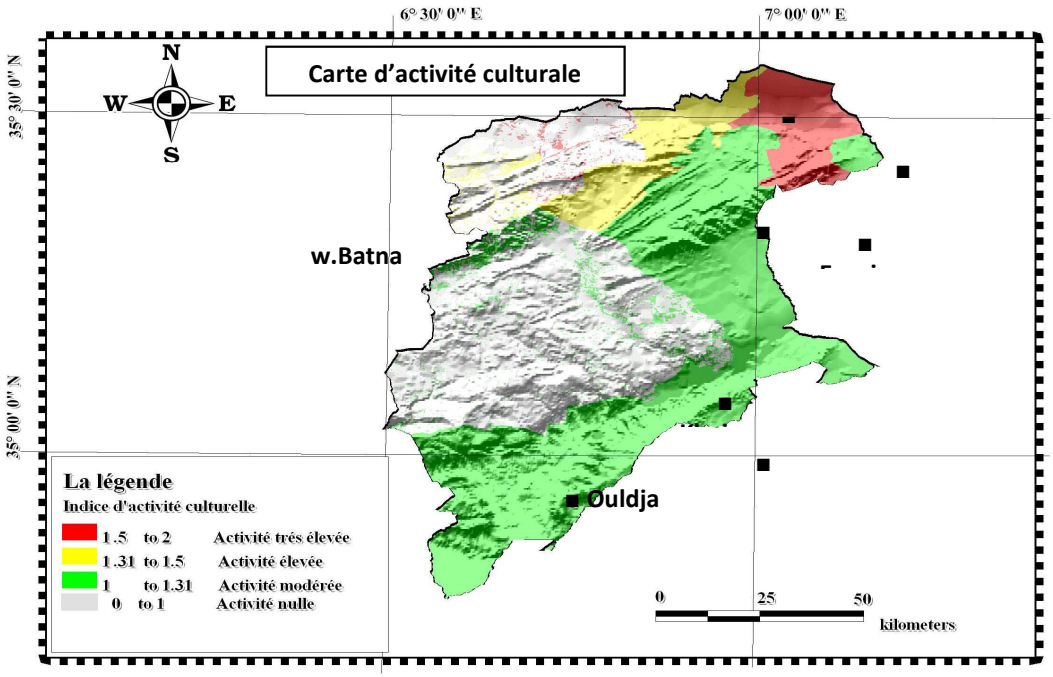
Changes in crop activity index during the three years shows that there has been a development; the class of very high index occupies in 1987 a 29.69 km² (3%) and an zone of 178 km² (6%) in 1997, the index recorded the same percentage in 2007 (6%); the same remark is recorded for moderate class changes from one year to another.

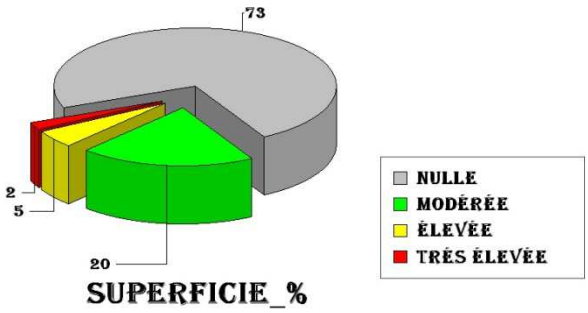
This change in cropping activity is because of the organization, yet highly modern agriculture; and the efforts and attempts to modernize the agriculture field.

4.1.3.1 IN SPACE

Table 8. Index of general crop activity

Icrop	Description	Superficies (Km²)	Superficies %
0 to 1	Zerol	2165.73	73
1 to 1.31	Moderate	593.35	20
1.31 to 1.5	High	148.33	5
1.5 to 2	Very high	59.33	2





The very high activity class ()1.5 to 2 occupies the small zone 59.33% 2%) of the total zone of the municipality concerned el-Hamma and Kais, and class of high activity (1.31 to 1.5) occupies the zone of Chelia, tawzianet, both categories occupies the Northern part of the high plain where the main activity is cereal combines with breeding livestock.

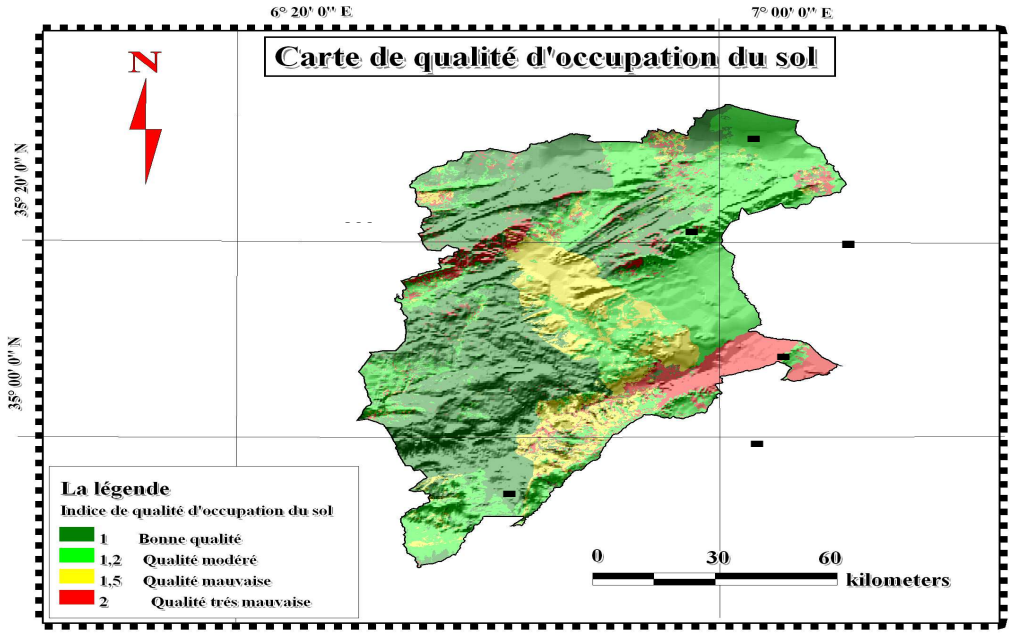
The moderate activity class represents 20% regard towns of the mountainous zones such as Tamza Chelia and Bouhmama and South towns' kheiran and oueldja. The zerol activity class occupies a zone of 2165.73 km² (73%), relates to many towns like Bouhmama, msara and Yabous. We can explain recent changes with the fact that the mountainous zone is divided into two sub-zones; the sub-zone West with large areas of degraded forests of Oak, Aleppo pine and Cedar in addition to the practice of arboriculture mainly with rustic species, and Eastern part consists of the Mountains Nmemcha with degraded forests, cereal plains and large open areas (Steppe and Alfa). The Southern zone constitutes a major resource path for feeding livestock.

4.1.4 ANALYSIS OF QUALITY LAND USE MAP

For this map, we used the satellite image ALSAT1 2003 due to lack of data in 1987, 1997, 2007. We conducted simple SQL queries in the same way that previous maps that reveal index of the quality of the land use.

Table 9. Index of quality land use

Land use	Description	Superficies (Km²)	Superficies %
0 to 1	Good	1519.908	51.23
1 to 1.2	Moderate	1034.68	34.87
1.2 to 1.5	Poor	411.827	13.88
1.5 to 2	Very Poor	0.350	0.01



With an area of 1519.908km² (51.23%) of the total surface, and a quality index from 0 to 1). Good quality class is distributed mainly in Kais, Taouzaint, Bouhmama, M'Sara and Tamza tonws because these lands are characterized by soils rich in organic material and nutrients, and well structured. These lands are covered by patrimony forest, the most important in our study zone where rainfall is important

Moderate quality occupies an area of 1034.68 km² (34.87%) of the total zone with an index class (1 to 1.2), this class represents El-Hamma , Ouldja and Tamza because these zones composed with mountains of degraded forests, the cereal plains and large areas of steppes and Alfa and also because of the oasis system in the South.

The poor and the very poor quality occupy the smallest areas since these classes represent the Alfa lands and steppe rangelands (kheirane, Bouhmama and Ouldja). We can also say that the Southern towns are pre-deserted zone with poor soils in organic materials and risk the salinity.

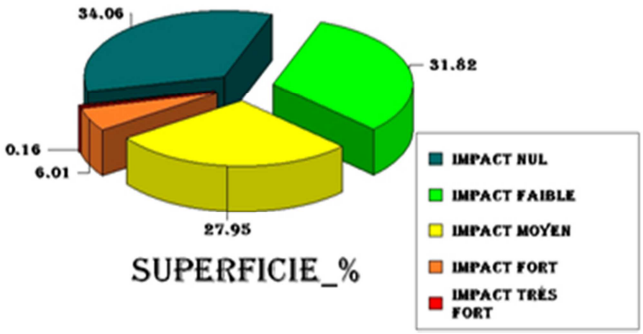
4.1.5 ANALYSIS AND INTERPRETATION OF THE SUMMARY MAP

The final map made from the combination of previous processed maps (which is the map of the socio-economic impact) allows us to understand and classify our study zone to the varied impact zones: from the hard impact zones to zones with no impact; this will help to recommend or propose solutions or improvements in management plans.

Analysis of the socio-economic impact map of the eastern part of Aures, its database and the various existing documents allows us to extract the main types of impacts.

Table 10. Index of socio-economic impact

IIMS	Description	Superficie (KM²)	Superficie %
1 to 1.2	Zero	1010.48	34.06
1.2 to 1.3	Low	944.02	31.82
1.3 to 1.4	Moderate	829.21	27.95
1.4 to 1.5	Strong	178.30	6.01
1.5 to 1.6	Very strong	4.75	0.16



The zones of strong socio economic impact have the lowest superficies of 4.75 km² (0.16%) of the total surface with a class of impact index between 1.5 to 1.6, the location of this class of impact is spotted in North of the study zone, especially in Khenchela town. The population of the town grew from 71,185 inhabitants in 1987 to 105,436 inhabitants in 1997 to 128,081 inhabitants in 2007, an average annual growth rate of 3.11% is very high compared to the national average rate of 2.15%, and even agriculture employments are as low as the agriculture sector in the town of khenchela (capital of the province) and it is essentially replaced by the industry and other sectors.

The moderate impact occupies a large zone of 829.21km² (27.95%) of the total zone, with index of (1.3 to 1.4), this class occupies towns of El-Hamma Tamza, Kheiran, Bouhmama; it is localized mainly in the mountain zone represent the scrubs, degraded and healthy forests, Human pressure is expressed here especially grazing by goats. The main factors of impact are:

- Soil erosion (use of poor land)
- The use of forest land as territory for livestock.
- The high presence of livestock especially the sheep (El-Hamma)

The low and zero impact classes occupy the largest zone that is 944.02km² (31.82%) of the total surface zone for zero impact and 1010.48km² (34.06%) with a low impact class index (1.2 to 1.3) and zero impact (1 to 1.2). At the level of agriculture activity, production is represented mainly by vegetable and cereal crops associated with arboriculture. In addition, this class represents the surfaces characterized by the good quality of land use (forests).

5 CONCLUSION

Analysis of the results shows the importance of the study of the socio-economic impact in these regions mostly degraded. It is explained by the different impact classes obtained, more than 65.88% of the areas in the zone of study was classified low and zero respectively 944.02 and 1010.48km². However (6.17%) is ranked high and very high respectively with 178.80 and 4.75 km².

Presence of population map is dominated by the class of very high with a zone of 1309.59 km² and with an index from 1.5 to 2; however the presence of livestock map represents the zone of moderate category with an index between 1 and 1.2 with total of 1631.72 km².

For the crop activity map, the classes of moderate and zero quality with a surface of 593.35 and 2165.73 km² respectively and index range from 1 to 1.31 and 0 to 1.

Good quality class occupies the largest zone of land use map that is 1519.908 km² and an index between 0 to1.

At the end of this work, it can be concluded that the development of the socio-economic impact map of the Eastern zone of the Aures was used to make clear the major traits of impact repartition in the this zone. That will help us in the future to treat and take actions after an environmental degradation.

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