NEW TOOL TO IMPROVE THE OASIS ECOSYSTEM USING QGIS. CASE STUDY: BISKRA CITY IN ALGERIA

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Abstract. The world experiences a phenomenon of accelerated urbanization since the last century to our day that poses several problems, in particular natural environment. The oasis ecosystem in Biskra is threatened or even degraded due to accelerated urban growth in recent decades. This urbanization, which takes place at the expense of the palm grove, has led to the loss of a very large number of palm trees. This prompts reflection on solutions for its sustainability. We suppose that using GIS tools helps in measuring the losses in terms of palms number in the oasis of Biskra, then we can use these founds to improve the ecosystem oasis and to reduce the urbanization impact. The goal of this work is to find a tool that helps in improving the oasis ecosystem in Biskra and corresponds to its context. Also, it attempts to prove that GIS are useful for measuring the impact of urbanization on the oasis of Biskra. The results show that using the palm modular in GIS helps to define the ratio palm number/inhabitant which is a tool that may contribute in improving the oasis ecosystem in arid and hot regions.

Key words: Palm grove degradation, oasis degradation, arid region.

1. Introduction

1.1. State of art

According to a study carried out by the United Nations specialized in economic and social affairs, which forecasts the future number of population, projections show that 2.5 billion people could increase the population in urban areas by 2050. Almost 90% of this increase will occur in Asia and Africa (VOA Afrique, 2018). According to a report released by United Nations (2019), the global urbanization rate increased from 30% to 55% from 1950 to 2018 following the population growth and it will increase to 68% in 2050 (Kuang *et al.*, 2020).

Today, built-up areas occupy up to 3% of the Earth's land surface in order to satisfy the demands of infrastructure (Almadini, 2019). That means, there will be an

increase of population needs in terms of urban space in the future with the increase of its number. Since countries are getting economically advanced, people are more considering moving to urban areas, this deteriorates environment condition (Mahmood *et al*., 2020).

Studies on the urbanization process are not a recent fact; by the way, historical data show a rapid increase of world urban population during the last century. Urban population in England increased from 25.9% in 1776 to 65.2% in 1871 (Williamson, 1988). The urban population in India increased from 160 million in 1980 to 200 million in 1989 (Buch, 1989). In Nepal, for example, the urban population increased from 12% in 1961 to 64% in 2001 (Haack *et al*., 2006). Urban population increased from 7.8% in 1921 to 51% in 2010 in Ghana (Naab *et al*., 2013). Over the past 40 years, China has experienced the largest and fasted urbanization process in the world, the urban population in China increased from 172.45 million to 831.37 million and the number of cities increased from 193 to 657 (Yu, 2021).

Today, the phenomenon of accelerated urbanization presides over the priorities of scientific subjects for the importance of its impact on the environment (Szabo, 2016). It's considered as a human fact that affects the environment locally, regionally and globally (Dutta *et al*., 2017). Then, controlled urbanization is considered to be of high relevance for global and local environment improvement and positive change (Zhang *et al*., 2020). Urbanization causes the reduction of productive agricultural lands, natural areas (forests, meadows etc.) and surface water bodies (Mundhe and Jaybhaye, 2014).

Rapid urbanization causes several problems as high consumption of resources and energy, in addition to deterioration of the ecological environment (Yu, 2021; Kuang *et al*., 2020).

Naab *et al*. (2013) confirm that agricultural lands are affected by the phenomenon of rapid urbanization and the development of industrial and commercial activities. Consequently, food security issue is of major interest because a high rate of population growth in a fragile ecosystem causes a problem of food production (Bai, 2012; Szabo, 2016; Siddique and Mukherjee, 2017). Tang *et al*. (2020) said that China testified an important change of agricultural lands to urban land which causes the environment degradation. Besides that, urbanization is considered as a major driver that can threaten vegetation growth process in the urban environment (Li *et al*., 2020).

Urbanization influences not only the productivity of agricultural land and the food security, but it has an important role in urban climate change due to increase of impervious surfaces and construction materials characteristics. It accentuates the effects of the urban heat island phenomenon and causes some changes of the thermal temperature (Jauregui, 2004). Recent studies show that urbanization increases the heat waves in urban areas (Wu *et al*., 2020).

For this, urbanization has become a consideration for sustainability efforts (Zhang, 2020). Understanding this phenomenon is relevant for promoting a suitable form of urbanization and sustainable development projects because, the foundation of sustainable cities lies on the planning and controlled

management of urban growth (Dutta *et al*., 2020) all the more in an oasis.

It must be admitted that sustainable development must be incorporated globally in the planning of all cities in order to face the ecological crisis. Urban green spaces are considered as an important element for sustainable urban areas and cities (Du and Zhang, 2020; Badiu *et al*., 2016) and environmental sustainability (Heikinheimo *et al*., 2020). Then, for some researchers, the conservation and the enhancement of the Green Infrastructure is a way to improve the sustainability of urban development (Ferrari *et al*., 2019).

Amado *et al*. (2020) used different levels of information in order to propose a strategic green infrastructure to be implemented into the Luanda General Master Plan in order to face urbanization growth issues. Petrişor *et al*. (2016) reclaim the necessity of planning measures to face environmental issues caused by the urban sprawl. Others focus in the study of ecosystem services in order to get sustainable land practices (Mora-Garcia *et al*., 2020).

Some researchers invite to integrate farmland in urban green infrastructure planning, which is the case in Germany (Rolf *et al*., 2020). Some cities in China developed a new form of urbanization that stresses improvements in the quality, of ecological environment (Yu, 2020).

Seen the importance that researchers give to the planning of look at specific sustainable cities like delta or desert cities which face more violently to climate changes pressures, it is seems thus necessary to put in place solutions to deal with the urbanization effects that cause the degradation of oases.

The oasis is an ecological aberration in the middle of the desert and it presents the archetype of natural anthropized system (Battesti, 2005).

The oasis is a form of human settlement in which the association of agricultural land and a water resource is a necessary condition for its stability. It can be considered in general as a place to live in an arid and isolated environment, with a strong possibility of planting, near to a water spring, for irrigated agriculture (Kouzmine, 2007). As Cote (2012) quoted, the oasis is a composition of three inseparable elements: water, habitat and palm grove where man is a fundamental component of this particular and fragile ecosystem (Bouzaher, 2015; Kouzmine, 2007).

Today, a lot of oases are in danger due to several factors responsible for their degradation all over the world. Among these factors uncontrolled urbanization is one of the major phenomenon's that threat the oasis ecosystems.

In fact, the degradation of the oasis is a phenomenon that threatens its life on a global scale; several oases are affected by rapid and uncontrolled urban development. For this, the impact of urbanization on the oasis became a theme that arouses interest and scientific debate all around the world.

Several oases in China are actually affected by the land use dynamics over time; the urbanization processes of oasis dynamics affected its environment and the configuration of its landscape (Jia *et al*., 2004; Xie *et al*., 2019). Zhang *et al*. (2008) and Zhang (2014) found that human activities such agriculture, urban and human growth are one of important factors behind the degradation of oases in

China that affect their sustainability. Qi and Li (2010) and Qi *et al*. (2007) confirmed that population development and increased human activities have influenced the agricultural landscape of some oases in China and led to its degradation.

Population increase is one of the most important factors influencing the agricultural and natural vegetation cover in the Saharan oases (Almadini and Hassaballa, 2019). Large agricultural lands in the oases are now occupied by urban lands and by consequence this change due to urban development affects the previous economy model (Almadini and Hassaballa, 2019; Liu *et al*., 2019).

The oases transformation has caused a series of social and environmental problems, especially in arid and semi-arid regions such the Saharan oases in Algeria. For this, it's necessary to think about ecological protection and human well being seen the damages that causes the excessive urban development, especially in oasis ecosystem (Xie *et al*., 2018).

The reduction in the area of vegetation would have negative implications on the local environment and the social life of the inhabitants, so it should be taken into account in future planning, especially in arid regions (Almadini and Hassaballa, 2019). Indeed microclimate of the oasis especially in arid regions is affected by the process of these changes for this reason, some researchers attempted to evaluate the climatic and ecological effects of on oases (Bie *et al*., 2019). Some find the need for a new, innovative oasis urbanization model to be adapted to the arid oasis areas, as is the case in China (Ma *et al*., 2018).

At the national level, the Algerian interior ministry gave an instruction on 2019 about green spaces, for its development and planning. It is recommended to develop 10m² / inhabitant of green space in order to contribute to the achievement of sustainable development objectives (instruction n° 2304, 2019).

The current city of Biskra might be considered as the product of the inappropriate instructions giving by the public authorities and an inadequate model, imposed by the state (Farhi and Hadagha, 2018). Bouzaher and Alkama (2017) estimated a ratio of 19 palm trees per person as a tool for local development in the Biskra region.

Then the ratio giving by the ministry may not be suitable to develop sustainable green spaces in urban areas in arid region which is the case of Biskra city, so we are looking for an alternative.

For this reason, several methods and technological devices are needed to support decision making. Abutaleb *et al*. (2020) found that estimating urban greenness index using remote sensing data is useful for designing a new urban planning for the city of Johannesburg. GIS tools and methods are widely used to assess environmental phenomenon (Attoui *et al*., 2020). In fact, GIS are used like decision support tool that helps to predict future urban growth (Alzamili *et al*., 2015; Baba *et al*., 2019).

They are widely used to assess different impacts of urbanization on environment and to show the process of urban development over time (Jat *et al*., 2009; Bello *et al*., 2014; Brovelli *et al*., 2016; Baba *et al*., 2019). That means, they make it possible to assess the impact of urban development on the vegetation cover by

following its process (Weber *et al*., 2005). In other words, the process of urbanization can be observed by maps created on GIS. Especially that mapping is widely used to analyze the human activities impact in natural areas (Eskandari and Moradi, 2020).

Then, GIS are useful in assessing the urbanization impact in the oasis of Biskra and in analyzing the decrease of its Palm grove surface due to urban growth.

Unfortunately, the city of Biskra lost its vegetation cover which is the palm grove during its growth because of urbanization and its oasis is degraded (Hadagha *et al*., 2019). The number recorded of palm trees/person is about 24 in 1904 while this ratio reached 1 palm/person in 2009 which means a deficit of 23 palm trees from 1904 to 2009 per person (Alkama and Hanafi, 2017).

1.2. Research questions

The question of this research is how to measure quantitatively the impact of urbanization on the oasis using GIS? We suppose that using GIS tools helps in measuring this impact through the estimation of the loss of palms between 1956 and 2018.

Since the goal of our work is to contribute in the quality improvement of the oasis ecosystem in arid region such Biskra city, this leads to pose a second question: how can we use the research's results in order to decrease the urbanization impact and to improve the oasis ecosystem? Then, we suppose that, using the palm's number lost may help to estimate more precisely the green area needed to develop in order to reduce the urbanization impact and to improve the oasis ecosystem in the city of Biskra.

Thus, the main goal of this study is to propose a tool that (1) helps to improve globally the oasis ecosystem which corresponds to the specificities and context of the Saharan regions ; (2) might be used in other oases locations.

2. Materials and methods

2.1. Materials

2.1.1. Study area

Biskra is the capital of Biskra Province which is located in the south east of Algeria, covers an area of 21,509.80 km², and is administratively limited by the province of Batna in the North, the province of Khenchela on the North-East side, province of Souf in the South, the province of Djelfa on the South-East side, and the province of M'sila on the North-West side. "Protected by the last foothills of the Aures, at the southern limit of Roman Africa, Biskra opens up to the Saharan vastness" (Pizzaferri, 2011).

The city of Biskra covers an area of 127.70 km², is located at an average altitude of 87m from a topography which is gradually decreasing from north to south. "The site of the city is in the form of a basin limited by mountainous relief, notably the Saharan Atlas to the north and the Zab chain to the west. Biskra is also crossed by two (2) rivers: Oued Biskra and Oued Z'mor respectively to the east and West of the city" (Sriti, 2013). The city is the capital of the province and it is located 400 km south-east of the capital, Algiers.

The palm grove constitutes the backbone of the oasis ecosystem and the agricultural character of social life in the Biskra region. It is the source of life for the inhabitants and plays an important role in controlling economic, social and

environmental growth. For this, the palm tree is a very important element of local and sustainable development in Biskra region (Bouzaher and Alkama, 2012).

The climate of Biskra is like all the Saharan territory, is characterized by drought and low rainfall, strong sand winds and low atmospheric humidity, that makes it an arid and desert climate (Zerdoum, 2002).

2.1.2. Study area limits

The oasis ecosystem is the first urban nucleus of development in the city of Biskra, also known by the name of "Old Biskra". Located in the south-eastern part of the city and includes seven districts: M'cid, Beb El Feth, Beb El Derb, Ras El Gueria, Gueddecha, Medjnich and Corra.

The oasis is limited by the river "Oued Zerzour" in the east, and by the colonial district in the north. The traditional oasis of Biskra remains a particular case compared to other Saharan oases, in terms of its districts development, where the traditional constructions are integrated inside the palm grove according to the logic of a very judicious spatial distribution and reflect a model of a green and sustainable urban form due to the presence of water. In fact, the houses are integrated inside gardens and roads are parallel to irrigation water channels, this gave an organic urban composition different from other oasis urban forms.

Maps of localization and the produced maps used for spatial refer to the oasis districts that represent the old (traditional) Biskra city and a larger area covering the entire colonial old Biskra city (during French colonization) are shown in Fig. 1 and Fig. 2.

2.1.3. Data

In this research, demographic and geographic data were used in order to analyze several aspects.

Demographic data: were obtained by investigation from several bibliographical resources such Farhi (2002), and the national Census (2008). Population number in the oasis districts for past years was obtained from the commune of Biskra.

Plans and cartographic products: the master plan of urban planning, PDAU (2008) was provided by the local agency of construction and urbanism in Biskra city.

These data were used to assess the demographic progression in the city. It's necessary to admit that the data related to 1956 and 2018 (in the city) were obtained by calculating the number of population using the growth rate. Because the last national Census (2018) is not yet available and historical demographic data are hard to find.

Geographical data are constituted by some historical maps (1956 (2), 1963, and 1966) and satellite image from Google Earth. These spatial information products were imported into Qgis for land change mapping between the past and current period (1956 and 2018). All historical maps don't contain coordinates except the map of general affairs from the French army. Thus it was used for georeferencing other maps. These maps are in format JPG and PNG except the image in Google Earth.

The cartographic data used in this research are listed in the Table 1.

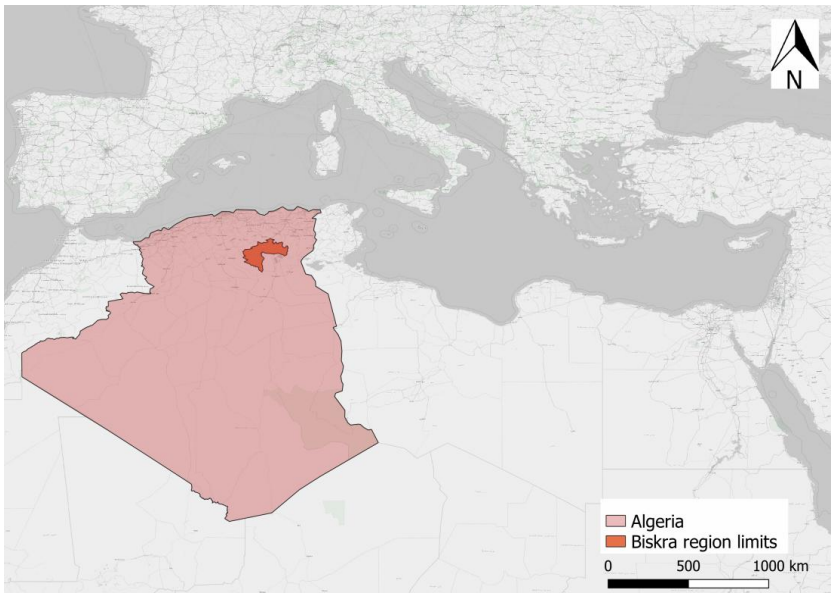

Fig. 1. Location of the Biskra in Algeria. Source: author (2020).

Fig. 2. Location map of the oasis districts in Biskra. Source: author (2020).

Table 1. Graphical data used in this research.

N°	Image/map type	Source	Acquisition date	Scale	Georeferencing system
1	Map of general stuff (topographic)	French army	1963	1/200000	The North of Sahara 32
2	Map of the old Biskra (urban)	Michelin	1956	1/500	Without coordinates
3	Map of the colonial district	Michelin	1956	1/300	Without coordinates
4	Map of canal water in Biskra city	Department of Constantine topographic service	1966	1/20000	Without coordinates
5	Satellite image	Google earth opened on QGis	2018	_	WGS changed to The North of Sahara 32

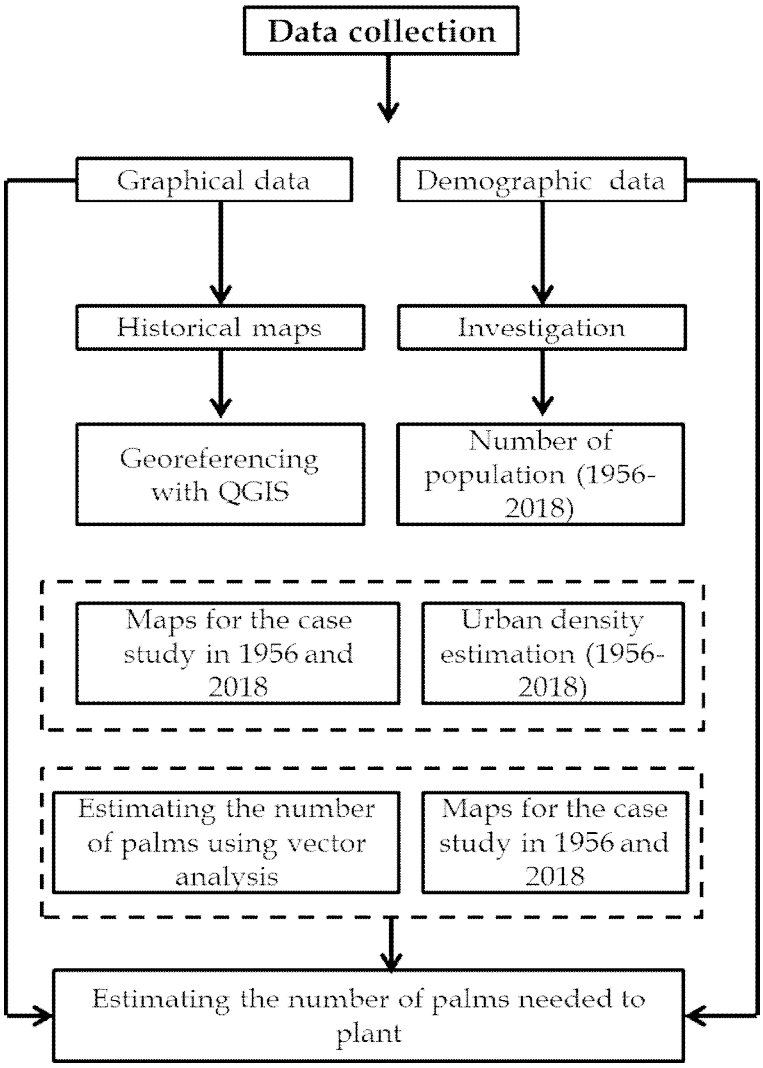

Fig. 3. Work methodology.

2.2. Methods

Spatial information and creating maps for the urban growth are needed for study in the oasis of Biskra. The lack of statistical and historical data's about vegetal cover and urbanization dynamic from 1956 to 2018 lead to a specific methodological design in order to compare the initial period and present case.

In order to answer to this research questions, the adopted method is very simple. It is based on the collection of data, their analysis and interpretation, then the proposal of solutions. Firstly, demographic data were used in order to estimate the population growth in the oasis of Biskra.

Cartographic references were used to create historical maps for the oasis. Then, a simple investigation was done in order to enter data into Qgis, then to estimate the number of palm trees in two different periods (the past and the actual period) using Qgis vector analysis. In the end, some formulas were proposed in the aim of ecosystem enhancement by planting palm trees.

The methodological approach adopted in this research is summarized in the following diagram shown in Fig. 3.

2.2.1. Demographic data processing

In order to evaluate the population growth in the oasis of Biskra, an investigation was done to collect demographic data as explained in the previous part. Since the data that refer to (1977-1988-1998-2008) (sources are cited in the following parts) are available, we tried to estimate the demographic growth rate progress and to use it in order to estimate the population number on 1956 and 2018 (ratio: 2.5, 3.2).

The annual growth ratio was estimated based in this formula:

T= [(indicator year n - indicator year n-1) / indicator year n-1]/ n Years x 100.

Then, the dynamic of urban density between 1956 and 2018 was estimated in order to see how the urbanization influenced the vegetation cover of the oasis in the next points. For this, four indicators were used in order to do the estimation: the population number in the study area for two years, 1956 and 2018, the surface of the area study, the actual surface of the whole city and the number of total population in Biskra city in 2018. For this, the formula used is:

Urban density= Population number on X year/ Surface of study area on X year.

2.2.2. Cartographic reference

A final map produced and georeferenced with Qgis was created using the historical maps listed (Table 1) and adding descriptions of some authors (Michelin, 1956; Zerdoum 2002).

To create a map that represents the oasis configuration in 1956 several vector layers were created representing, water canal, green area and built up area. For these purpose four historical maps were used: 1) Map of general stuff produced by French army 1/200000 on 1963, 2) Map of the old Biskra produced by Michelin 1/500 on 1956, 3) Map of the colonial district produced by Michelin 1/300, 4) Map of canal water in Biskra city 1/20000 produced by the Department of Constantine topographic service on 1966.

The first map was used for georeferencing all the others. The objective was to create a map for the oasis city during French colonization (Fig. 4). The coordinate system used in that case is: The North of Sahara 32. The second map representing the present case of Biskra city is produced by delineation of the Google Earth image (2018) (Fig. 5).

2.2.3. Palm trees estimation

Estimation of palm trees number was based on the number of regular location points calculated in polygons by vector analysis. It is assumed that the distance between two regular points represents the distance between two palms measured on Google Earth is about (6*6, 7*7, and 10*10 m) (personal measurement). The Modular of palm trees runs three models (3*3, 5*5, and 7*7m) according to Bouzaher and Alkama (2013). (6*6m) is the model chosen for estimating regular points because the majority of modules palms are between (5*5 and 7*7m) on Google earth. According to the palm modular (6*6); the distance between two regular points is fixed to (6*6). Then, it gives the number of the entire points trapped inside the polygon as it's shown in the Fig. 6.

Then, the measurement of the number of palm trees was estimated using vector tools on QGis. In this case two tools were chosen, the search tools and the geoprocessing tools. We have introduced the vector layer of the garden in shp

format, and choose the "regular points" tool from the search tools. To delimit the area of palm trees regular points, we used the layer's grip as an option to avoid having too many points outside the polygon that represents the garden.

The number is estimated approximately by considering the distance between two palm trees which is equal to 6 m.

After, we used 6 m as the spacing between each two regular points with determining the georeferencing system which is in our case, the system of North Sahara 1959, zone 32. Therefore, a layer of the regular points helds throughout the canvas, to further delimit the points held in the polygon representing the garden; we used the "Cut" tool among the geoprocessing tools, choose the layer of regular points as source layer and the garden layer as an overlay layer. We had a new substantial "cut out" layer which we used to calculate the number of points which represents the total number of palms in the garden through the use of the attribute table.

2.2.5. Ecosystem enhancement by planting palm trees

Bouzaher and Alkama (2012) confirmed that the relationship between palm trees number and the population growth is proportional. They tried to identify a ratio (palm/person) and considered it as a sustainable element that can be used for urban planning. Their work was based on comparing between two states of the oases (1904 and 2009) which the first one is the initial case of the oases.

In our case, the measurement of the palm trees number needed in order to improve the oasis ecosystem was done using the state of the oasis in 1956 and 2018:

- Population estimation: population number in 1956 in the study area, population number in the city in 2018.
- The number of palms estimation in 1956 in the study area and the surface of green area in 1956).

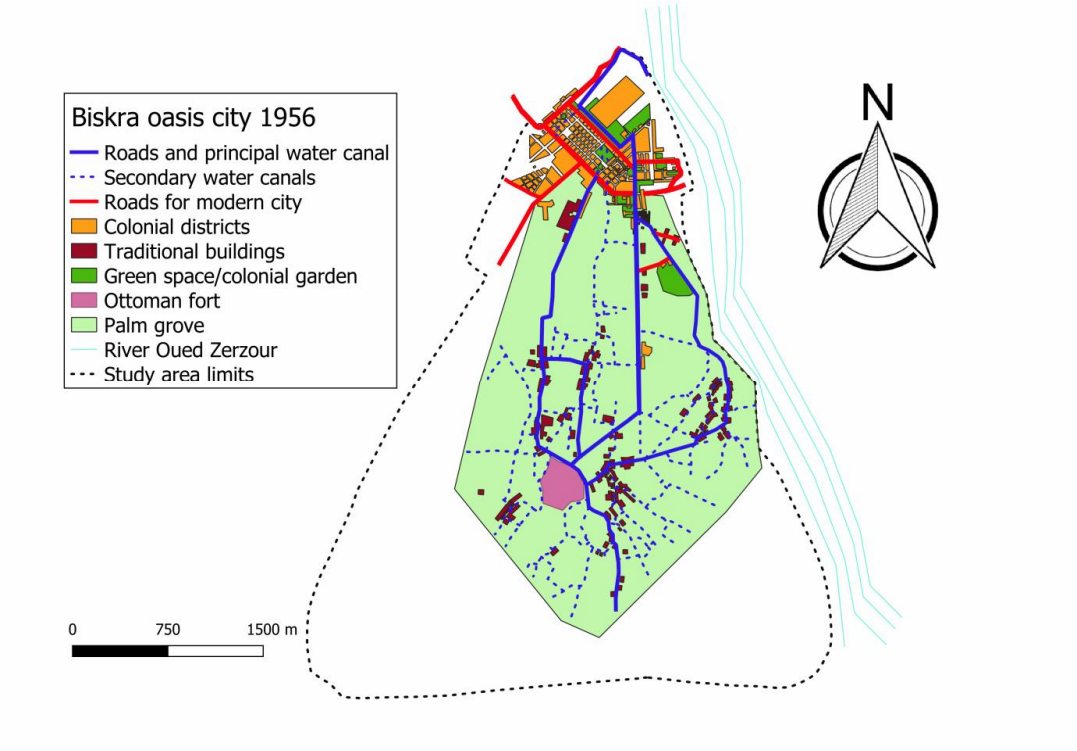

Fig. 4. Map of Biskra oasis city on 1956. Author (2019).

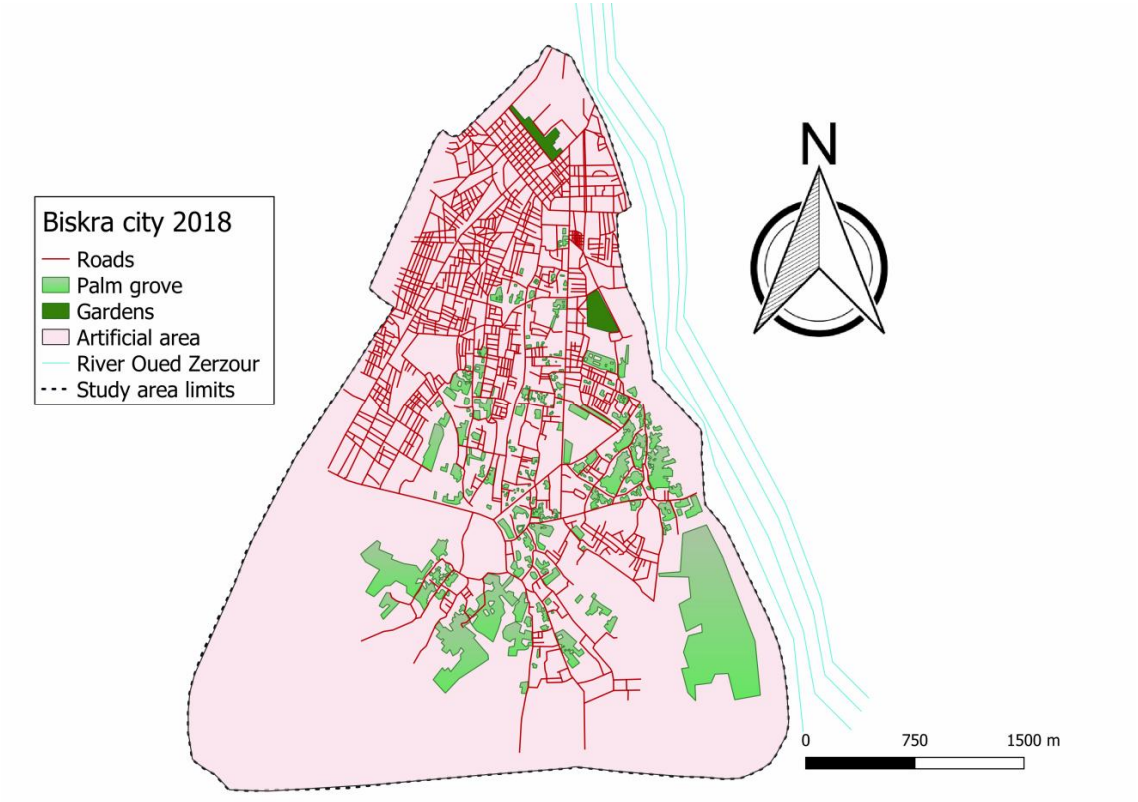

Fig. 5. Map of actual development of Biskra city. Author (2019).

Fig. 6. Point's grid representing palm trees distribution (Gueddacha district).

This measurement is based in these formulas:

Total palms number needed by total population / Biskra city= Population number X Ratio (palms /inhabitant)

Palm number needed to plant= Total palms number – existing palm number

Green area needed to be added= Population number X Green area / inhabitant (m²) - existing green area.

3. Results

3.1. Accelerated population growth and its pressure in the city of Biskra

"Since 1962, the city of Biskra has never ceased to experience mutations and above all a limitless rural exodus with all that this entails as a change in mentalities, standard and lifestyle" (Zkiri, 2015). In 1974 Biskra experienced a strong population increase because of economic

settlement, location of new executives and creation of the industrial zone. This increases the chances of employment (Zkiri, 2015). The urban population has not stopped growing since 1966 to the present day. According to the Table 2, the data collected reveals that population in the same study area increased from 58724 inhabitants in 1956 to 101314 inhabitants in 2018 while the population in the whole city of Biskra has increased from 58724 inhabitants in 1956 to 205978 inhabitants in 2018 as shown in the Table 3.

Table 3 represents the demographic dynamic in Biskra region by comparing between three indicators; the number of population in the city of Biskra, the total number of urban population in the region of Biskra, the total number of population in the Wilaya. We note that the population in the city of Biskra constitutes more than half of the total urban population (in the region of Biskra, especially from 1977 to 1998) and this reflects the excessive demographic growth in the city of Biskra.

These results prove that Biskra city testified to a demographic increase due to rural exodus and arrival of new workers from other parts of the region and others cities. This demographic situation was in need for more urban space to be stabilized in the city of Biskra.

Table 2. Dynamic of the urban population in the study area (1956-2018). Source: author (2020).

Years	1956	2018
Area (km²)	6726	6726
Pop number	58724	101314

Following the demographic progression influenced by the change of the economic situation (new industrial zone, new administrative jobs), the city of Biskra faced an accelerated urban growth because of people coming from abroad, locking for opportunities and better life conditions. The density of the urban population was estimated at 8.7 inhabitants / km² in 1956 and increased to 15.06 inhabitants / km² in 2018 in the study area while it increased to 16.35 inhabitants / km² in 2018 in the whole city as shown in the Table 4.

3.2. Palm grove degradation

By using Qgis software it was possible to estimate the areas of built up spaces and palm grove from 1956 to 2018 in the oasis districts as shown in the Table 5.

According to the Fig. 7 we can notice that the built space increased at the expense of the palm grove between 1956 and 2018.

Table 4. Dynamic of urban population density in Biskra (1956-2018). Source: author (2020).

Years	1956	2018
Study Area (km²)	6726	6726
Density (inhab/km²)	8.7	15.06
City of Biskra (km²)	6726	12770
Density (inhab/km²)	8.7	16.35

The phenomenon of excessive urban growth destroyed the gardens which dotted the oasis districts. The district Ras El Gueria is in a state of significant deterioration, of which 10% of the total surface represents the surface of the remaining gardens. It is only the district El M'cid that persists in the face of this deterioration, 56% of the total area of which is devoted to gardens. This is due to the efforts of its inhabitants for its preservation comparing to the rest of the districts whose gardens are still present but social preservation initiatives are absent.

The followings maps shown in the Fig. 8 and Fig. 10 represent the vector layers for green and built up areas for every oasis district in the past (1956) and present (2018).

Table 3. Demographic data for the region of Biskra from 1956 to 2018. Source: Estimation by author based on collected documentation (Farhi, PDAU, Biskra Monograph, and National Census).

Years	**1956**	**1966**	**1977**	**1987**	**1998**	**2008**	**2018**
Population number in Biskra city	58724	59000	87200	129961	172905	205608	205978
Increase ratio %	_	2.5	2.5	4.2	3.9	3.2	3.2
Urban population	___	_____	118 421	235 655	333 203	489 391	490891
Population / Wilaya	___	_____	329 912	402 429	575 858	721 356	735905

Table 5. Dynamic of built up and green areas in the oasis districts (1956-2018). Source: author

Years	**1956**				**2018**			
Area	Built up area (m^2)	%	Green area (m^2)	%	Built up area (m^2)	%	Green area (m^2)	%
Hai Medjnich	37773.28	12	285741	88	142805	65	76403	35
Hai Beb El Feth	5976.42	1	628755	99	51817	11	420436	89
Guedacha	17562.60	5	352882	95	81032	29	196965	71
Hai Beb Derb	12001.68	9	123021	91	113962	77	34908	23
Hai M'cid	42260.51	9	419182	91	239791	56	303657	44
Ras El Gueriah	14747.95	3	546351	97	379273	89	44781	11
Total	130322.44	6.5	2355932	93.5	1008680	54.5	1077150	45.5

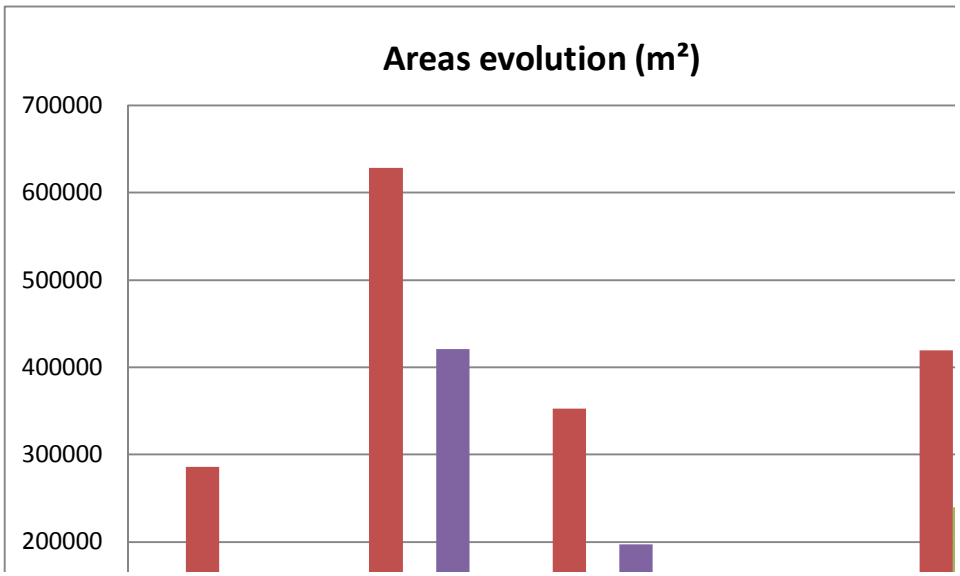

Fig. 7. The dynamic of the built and green area between 1956 and 2018. Source: author (2019).

According to the Fig. 8 and Fig. 9, the area of palm grove has been reduced due to urban growth. This massive urbanization at the expense of the palm grove is justified by the efforts made in the housing sector to meet the demand for housing.

The imbalance caused by economic change and accelerated population growth are major factors that have resulted in urbanization in the city of Biskra (Adad, 2002). The housing deficit has prompted residents to invent a modern type of housing that does not meet construction standards in the Saharan. In fact, because the number of population asking for housing was more than the number of offered and achieved housing, the inhabitants tried themselves to build their houses without any reference. This process of urban densification in the oasis districts has led to the degradation of the palm grove.

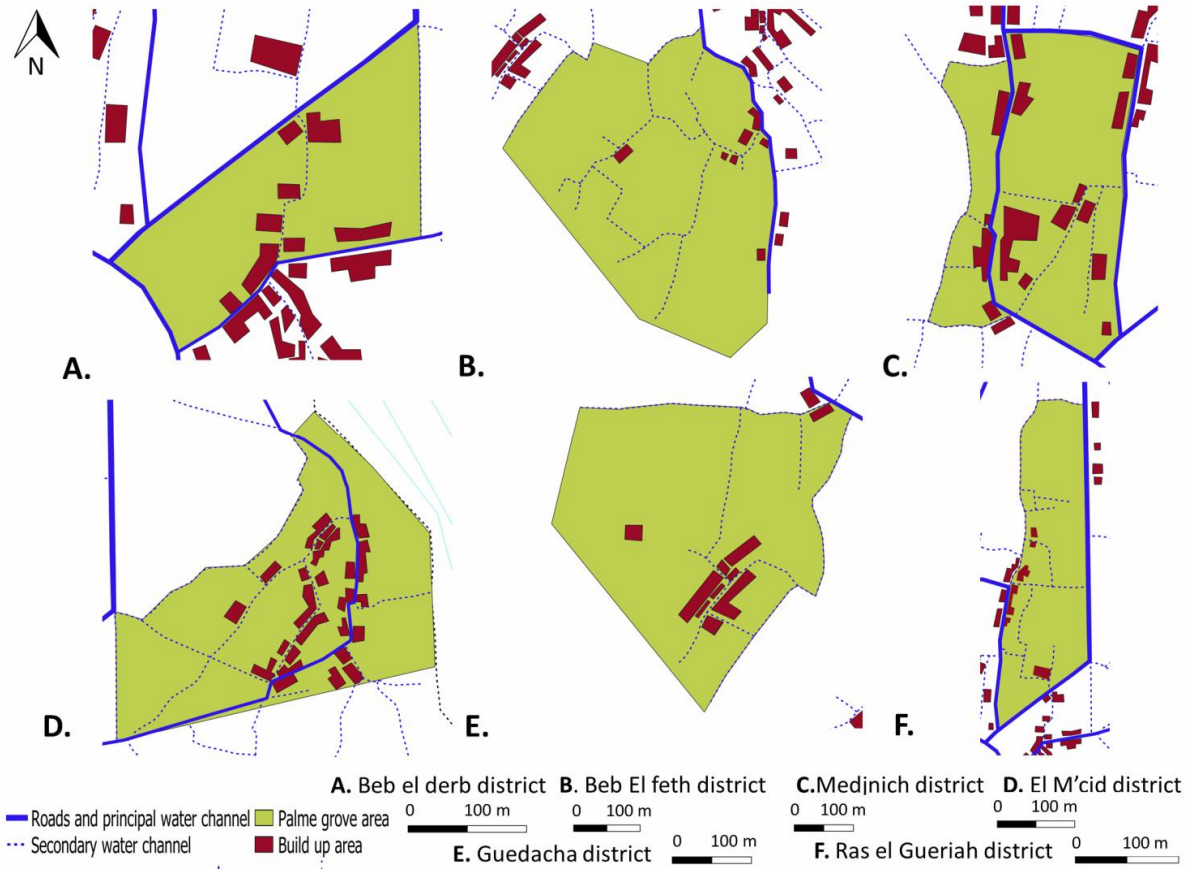

Fig. 8. Maps (Built up area/ green area) for oasis districts on 1956. Source: author (2019).

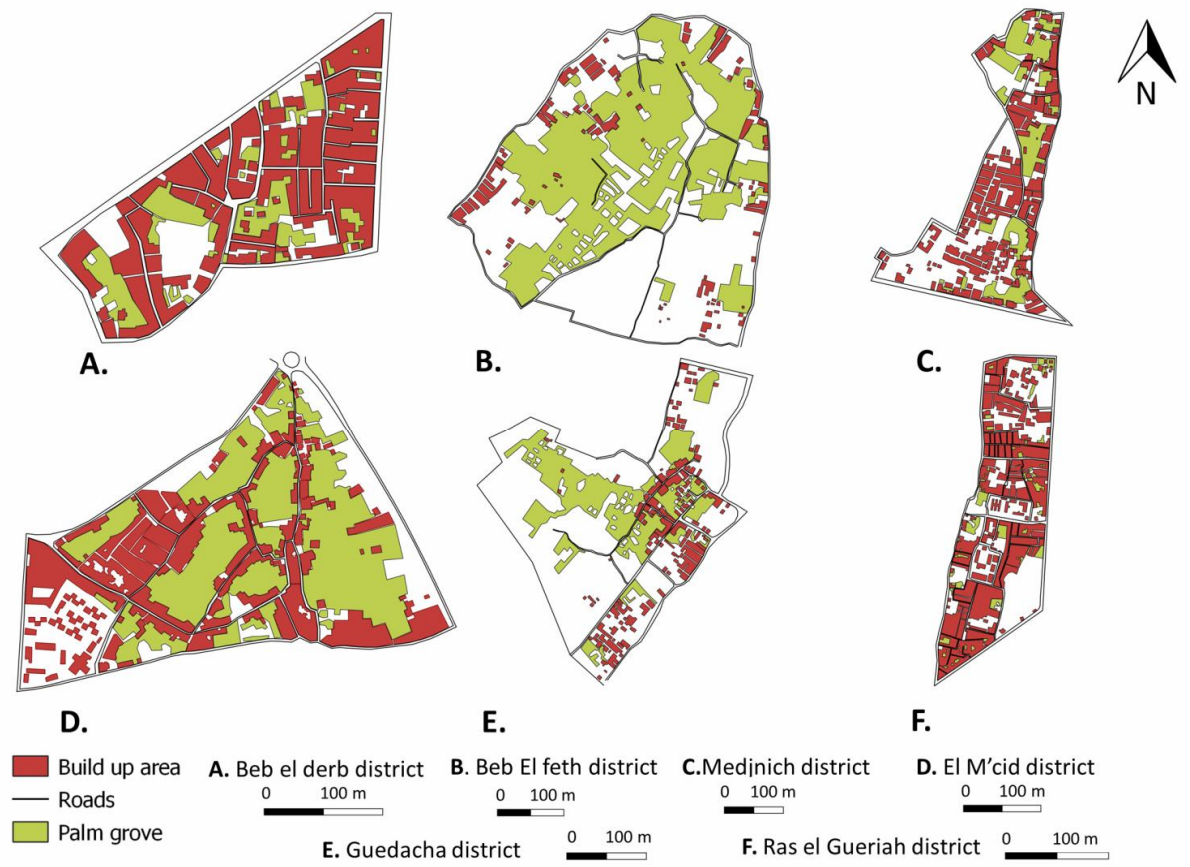

Fig. 9. Maps (Built up area/ green area) for oasis districts on 2018. Source: author (2019).

By using Qgis software, it is possible to estimate the number of palm trees that the oasis of Biskra lost between 1956 and 2018 shown in the Table 6. We have estimated a loss that exceeds 35,000 palm trees over the length of this period. In addition, according to the field work, the tiered cultivation system has disappeared; it's about a composition of three elements, in the first place, the palm tree that it's the tallest one so it brings shadow to the inferior parts, the second place is for fruit tree, the third place is for herbs.

Today we find that in some parts of the oasis, even if palm trees remain standing, trees and other plants are degrading more and more. The majority of gardens have lost their floristic richness. Besides the palm trees, these gardens contained before several and different types of trees and herbs such lemon, apple, grape, figus, pomegranate trees.

Table 6. The dynamic of the palm trees number in the oasis districts (1956-2018). Source: author (2019).

District	1956	2018
Hai Medjnich	7621	2127
Hai Beb El Feth	17492	11702
Guedacha	9805	5464
Hai Beb Derb	3435	1053
Hai M'cid	11684	8427
Ras El Gueria	15171	1260
Total	65208	30033

3.3. Solution to develop and improve the oasis ecosystem

In order to estimate the number of palm trees needed to ameliorate the oasis ecosystem of Biskra, it was helpful to make a ratio from the previous results that represents the number of palms and the green area needed by one inhabitant. The green area ratio was chosen from the previous results that represents the total of the green area ratio in all the districts. The results are shown in the Table 7.

Ratio palm/inhabitant = green area /inhabitant (m^2) / (6*6) (m^2) * 4.

Table 7. Green area and palms number needed by one inhabitant in the past. Source: author.

Year	1956
Population number	58724
Palms number	65208
Green area (gardeens) m^2	2355932
Ratio (palms /inhabitant)	4.45/inh
Green area / inhabitant (m^2)	40m^2/inh
Green area ratio (%)	>45.5%

According to this table data, it's possible to suggest the number of palms needed by inhabitants and also the green area ratio for the actual period following the previous formulas mentioned in the methodology part. The results are shown in the Table 8.

Table 8. Green area and palms number needed by total population in 2018. Source: author.

Population number	205978
Palm trees number estimated (2018)	30033
Total palms number needed by total population / Biskra city	916602
Palm number needed to plant	886569
Green area needed to add (gardeens) m^2	7161970

From these results, we can see that the surface of green area needed to be added in the city of Biskra is about 716 hectares while the palm number needed to plant is about 916602 palm trees.

This estimation presents the needs of actual population in terms of green area and palm trees at present. So, to estimate the future needs it's possible to use the ratio Green area / inhabitant (m^2) that corresponds to 40m^2/ inhabitant, in parallel with the estimation of future number of population and the number of

palms needed for the future to plant in the city, its periphery or its surroundings.

4. Discussions

Analysis of the data from this research reveals that it is possible to propose a tool to improve the oasis ecosystem by using GIS in the assessment of urbanization impact, which partly confirms the hypotheses of this research.

It proves that using the proposed GIS tools helps in measuring the number of palms that the oasis lost between 1956 and 2018 because of urbanization. This led to the reduction in the number of palm trees. It can be used to estimate more precisely the green area needed to develop in order to reduce the urbanization impact and to improve the oasis ecosystem in the city of Biskra.

By using QGis tools, it was possible to measure the number of palm trees that Biskra oasis lost between 1956 and 2018 due to uncontrolled urbanization. This urbanization took place at the expense of the palm grove following accelerated population growth. This led to the reduction in the number of palm trees.

Indeed by estimating the number of palm trees and the total area of the palm grove in 1956, it was possible to determine the ratio (palm tree / inhabitant) and the green area / inhabitant. These results helped us to estimate the number of palm trees to be planted in the city of Biskra in order to improve the oasis ecosystem in the current state.

This solution is proposed to reduce the impact of urbanization which has had a negative influence on the oasis ecosystem (decline of the palm grove, significant reduction in the number of palms and trees, impoverishment of oasis biodiversity, life style change, problem in waste management and the micro climate change).

But the results of this research should be interpreted with caution, however, since the palm module in traditional gardens is not just palm but other trees and plants as well. In fact, between two palm trees there was place for a fruit tree previously with presence of diverse plants on the ground.

This composition is an expression of a high plant density that characterizes the traditional oasis ecosystem, punctuates its landscape and also contributes to the cooling of the urban climate.

Thus, it is interesting to propose a development module with the same plant formation, according to three strata, palms, trees and plants. It could become a planning tool in public spaces in Saharan cities.

According to the instruction given by the interior ministry in Algeria, one of the objectives of creating green spaces in the cities is to reduce the effects of the urban heat island.

It would be interesting to study a plant formation of the palm module by type of trees that we can plant in the Saharan regions in order to contribute to this climatic issue. The study of the palm modular might be used to work on a variety of categories depending on the type of green space, from private to public and from vegetable to decorative garden.

This work opens new perspectives towards research on (1) the contribution of palm modular (plants) in the reduction of urban greenhouse gas emissions phenomenon in the Saharan environment and also (2) towards the study of oases landscape composition according to various types' composition of green space and gardens related also with food security.

Also, the increase of urban space may complicate the process of creating the needed green areas and their localization in the city, so, it's important to think about classifying green spaces into types according to their localization in order to make a good planning, then to think about their benefits for the oasis ecosystem according to every type characteristics.

In conclusion, the results clearly show that it is possible to improve the oasis ecosystem by proposing a planning tool using GIS, which confirms the hypothesis of the present research. However, it is not clear what plant composition is suitable for the development of green spaces in the oases and Saharan regions to reduce the effects of the urban heat island and face climate change effects.

This composition therefore needs to be examined more precisely in order to achieve the objectives of sustainable development in Saharan, hot and arid regions in the climatic issue.

Since the urban space is increasing, it's good to make a prospective study about programmed green areas in the future according to the number of population. This study shows their type's classification, localization and their benefits for the oasis ecosystem in arid regions.

In addition, the differences between the ratio found in this research and the previous ratio (Bouzaher and Alkama, 2017) may call for a study about several oases in Biskra city to find the appropriate one (ratio).

5. Recommendations

This research reveals that the modular of palm is an efficient tool that we can use for planning prospective and suitable Saharan cities, also for enhancing especially the oasis ecosystem.

In order to ameliorate oasis ecosystem in the city of Biskra, the total number of palm trees needed to plant is about 916602 that corresponded to 716 hectares of green area. For this reason, the following solutions are suggested to achieve this goal:

Local authorities, city planners, design offices and different public administrations of planning like the urban planning direction and the direction of urbanism and construction should consider the ecological environment condition of Biskra city in order to increase the green area and to reduce the urbanization impact in the ecological environment.

Encourage the using of this information in the urban planning documents and in the conception of neighborhood projects. Besides policymaking about green spaces, it might be efficient to support projects about urban agriculture and vegetal densification.

For this, the ratio of palm trees should be taken into consideration in the technical documents of planning during

the process of urban management, like the master plan for development and town planning (PDAU), the land use plan (POS), the development plan of Wilaya (PAW) and the specifications document.

The master plan for development and town planning (PDAU) should reserve spaces for green areas in the short and long terms based in this ratio.

The land use plan (POS) should estimate the green area needed for every district based on its inhabitant's number taking into consideration the future extension of districts.

The development plan of Wilaya (PAW) should take into consideration the extension of the city and estimate the future area needed in its program.

The specifications document must contain this ratio in the part reserved for the applicable criteria on exterior development in the context of sustainable neighborhoods or buildings creation.

In terms of oasis ecosystem improvement, this ratio might be used according to a multiscale approach with the aim of a green development at different scales of the region. Then, the green improvement of the exterior of Biskra city could influence positively the oasis ecosystem. In other words, the city planners can think about a green dam around the city of Biskra in order to improve the oasis ecosystem.

Because the oasis city is a large ecosystem, it's possible not only to plant inside the districts zones but in the periphery of the city in case if it's not possible to find enough empty spaces. For this, a list of all the empty spaces in the city and the number of trees needed to plant in every space using GIS and remote sensing tools could be useful.

It's better to organize citizenship competitions like planting companion and coordinate with scholar establishments to organize planting companion for students in their schools.

Encourage research about the vegetal composition of palm modular that can be used for green planning in Saharan cities and especially when it's about facing climatic problems and give importance for modern, rational and economical management strategies of water which is the main problem in hot and arid regions.

6. Conclusion

To conclude, this study confirms that using GIS is useful for measuring the losses of the oasis ecosystem in Biskra in terms of the palm's number. With using the palm modular it was possible to estimate the number of palms that the oasis of Biskra lost between the past and present then to estimate the ratio palm's number or green surface needed per inhabitant. This last corresponds to 4.45/inhabitant and a surface of 40m²/ inhabitant.

These results help in improving the oasis ecosystem in hot and arid regions and present a tool that corresponds to the Saharan context. This tool can be also useful for planning to improve oasis ecosystems and sustainable Saharan cities in the future. But it needs to be developed in a way that explains the types of trees needed to plant in order to face the climatic and ecological issues in arid and hot regions. Also, this tool leads to think

about classifying the green spaces into types according to their localization and to search about their climatic benefits for the oasis ecosystem in arid and hot regions.

This research opens up new avenues for future work about the vegetal composition of palm modular and its contribution to face ecological issues in arid and hot regions.

The results of this research are important for the international research audience because these founds can be transferred and applicable in other hot and arid regions in the field of planning and urban space improvement. This ratio might be interesting because it aims to improve the ecological environment of Saharan cities in the context of sustainability.

Generally, these results can be used in order to reduce the urbanization impact in oasis ecosystems or to create Saharan green cities. We suggest that city planners in arid and hot regions should take into consideration the increase of urban societies and the ecological problems related to accelerated urbanization and think about using such a tool in the urban planning process.

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