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Quantitative and qualitative assessment of urban green spaces in Boussaada City, Algeria using remote sensing techniques

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A central issue for the Algerian city, in the dry environment, is awareness of the establishment and preservation of particular green spaces within the framework of sustainability. The overall goal of this study is to concentrate on the issues of green space provision in the city of Boussaada. Boussaada is a complex and fragile city with a rich history, archeological and natural diversity, and is under tremendous anthropogenic stress. The city of Boussaada has long had issues with the availability of green areas, a situation that is attributed, among other things, to a flawed urban design that places a premium on the environment. We attempted to define the quantity of green spaces in the city and quantify their richness through this study. The qualitative and quantitative study was carried out with the help of the normalized difference vegetation index (NDVI) and qualitative analysis and more specifically the species of trees in the new town of Boussaada.

Key words: Green spaces, Boussaada, Natural Heritage, normalized difference vegetation index (NDVI), the species of trees.

INTRODUCTION

Public green spaces are the main islands of high-surface nature in the urban fabric. Maintained to varying degrees, they can house a relatively large number of plant species, planted and/or spontaneous, and thus potentially represent an important pole in maintaining biodiversity (animal and plant) in an urban context (Philippe, 2007). Maintaining this diversity has been recognized as a major environmental issue and priority at both the international and local levels (Philippe, 2007). Green areas have a positive effect on the quality of life of residents in urban areas (Porcherie et al., 2021), through their benefits on health (Faure et al., 2019), social cohesion and the environment (Dehimi and Hadjab, 2019). Green areas represent a natural heritage by creating an urban landscape which can reinforce people's sense of belonging and identity and protect vulnerable areas (Minzhanova et al., 2021).

Trees and plants, as important components of the earth system, are helping to regulate urban conditions and to reduce urban heat on the island by creating a cool effect through oxygen, carbon dioxide absorption, solar ray's minimisation and interception, shadow creation and

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radiation absorption (Gherraz and Alkama, 2020). The progressive degradation and weakening of natural elements from a physical and chemical point of view can lead to instability and fragility of structures associated with such landscapes, and is responsible to a higher degree, for the vulnerability of natural ecosystems (Cocean, 2020). In terms of quantity and quality, Algerian cities have several green space issues. Law No. 07-06 of 25 Rabie Ethani 1428 corresponding to 13 May 2007 proposes a standard of 6.8 m2 per habitant, but that standard was never respected and green spaces do not have priority for city development in order to define rules on management, protection and development in a sustainable development context.

Several studies state that the Algerian city also performs poorly in terms of the preservation of its natural heritage, urban forestry and preservation of biodiversity. The situation has occurred as a result of expanding urbanization, which has led to a lack of available space, land pressure, and a strong influence of minerals on the vegetation. Higher management of town and property of urban development and due to inadequate designing, accelerated urban growth, and a substantial loss of inexperienced areas have resulted in the mobilization of quantitative and qualitative strategies by proposing approaches to call support. Special detection will facilitate decision-makers and planners to perceive factors and changes within the use of vegetation cover so as to require effective and helpful measures (Shahabi et al., 2012). In recent decades, several vegetation index types have been developed to facilitate vegetation detection in relation to other soil cover types (Roy, 2008) such as the normalized difference vegetation index (NDVI).

We have targeted the city of Boussaada by a quantitative and qualitative examination of green space. This city has an associate degree of exceptional tourism and heritage potential, and has a full-fledged accelerated urban growth. The study attempts to bring an improved data on the issues associated with their development, by completing an identification of those areas within the city of Boussaada so as to answer these queries that pass through the assembly to map the vegetation of Boussaada town from the employment of a vegetation index applied to an image with medium resolution MODIS. The study also examines tree species as well as how it fits into the region's climate by knowing their properties. The importance of this research lies in identifying the highlights of the green spaces and their various benefits in cities with semi-arid climates, while showing the importance of focusing on the qualitative side of them through restoring the green spaces in residential neighborhoods in particular and the city in general. The study will also focus on the necessity of selecting of trees species that are suitable for climate data, while also paying attention to the oases, which represent an excellent natural heritage. In this context, two questions were asked: quantitatively, is the amount of green space in Boussaada city enough? Qualitatively, are tree species compatible with the region's climate?

BACKGROUND

There is a lot of research on the topic of quantitative analysis of green spaces in many cities around the world, but very few studies have analyzed the quality of green space on arid cities especially species adapted to this climate. This research is based on several sources, but mainly on research that is complementary and quite convergent. It is in this favorable general climate that we see a very marked increase in the number of research carried out on the subject, particularly the work of the Dialog-Citizens Committee (Report of the Table on Ecological Areas in 2008) which has presented a very clear categorization of green spaces, a categorization based on several criteria: geographical location, accessibility, size and vocation. The first category corresponds to islands of greenery. They are "green spaces of limited size, natural or fitted out, intended for greening or for connecting two spaces and which can be used for relaxation". This category includes street trees, municipal flower boxes, floral structures, roofs and plant walls, urban wasteland or even areas of spontaneous vegetation. The second category corresponds to recreational areas. These are "demarcated and regulated green spaces, more or less large, for recreational, sport or leisure activities" such as municipal parks, community gardens, playgrounds, areas for skiing, hiking or sports grounds are included in this category. The third and last category corresponds to ecological areas. Green spaces are, according to Bonhomme (2012), geographically defined, accessible to citizens in whole or in part according to protection needs, which are regulated and managed in a sustainable way in order to achieve objectives of preservation and maintenance of biodiversity and its related developments respecting the natural character of the sector and are harmonized with it. "This category includes protected areas, buffer zones, ecological corridors, etc.

Several researchers claim that urban vegetation makes the urban environment healthier and that it regulates climate variations and provide a favorable environment for the development of biodiversity according to Manusset (2012). Local availability of green space has been associated with a wide range of health benefits (Richardson et al., 2013). The presence of green spaces brings several benefits to the inhabitants. The physical and psychological balance of the city dwellers often compromised by the urban environment, foster exchanges, contacts and social encounters, especially a young people squares and recreational areas (Flouri et al., 2014). This strengthens the bonds of the society, the green space is a space to get fresh air and to engage in fun and recreational activities and to make the city

pleasant to live. Donadieu Pierre always follows the same logic, and explains: "The plant is not only a regulator in the city, it is also a social mediator, that is to say, what the identity and quality of the city is, what makes the agglomeration appropriate or appropriable by the inhabitants" (Donadieu, 1996).

Green spaces also have an impact on the public's perception of safety and sense of security. Some authors suggest that "the presence of trees improves the control of outdoor spaces and the supervision of children in disadvantaged urban environments" (Vergriete and Labrecque, 2007). They play a significant role in arid and semi-arid cities (this is the case of our study), where rainfall is low/irregular and the actions of winds are remarkable and harmful (Gherraz and Alkama, 2020). Researchers have proven that vegetation is the best filter-exchange screen for wind erosion control, soil surface maintenance and particle retention (Wolfe and Nickling, 1993). Green spaces also play a thermoregulatory role, they allow to fight against the effects of heat islands and the creation of cool beds in arid areas (Shiflett et al., 2017). This cooling of the ambient temperature is due both to the shade provided by trees and to evapotranspiration (François, 2010) and large parks where residential neighborhoods with extensive vegetation can produce air temperature reductions as much as 10°C (Boudjellal, 2009). When planning for species trees that may face future climatic scenarios that are anticipated to be warmer and drier, information on seasonal adjustment of species will be useful (Iverson et al., 2019). Some research studies have discovered selected tree and shrub species should be suitable to the future climate, to the context and to the needs of the urban environment

Relation between urban heat and oasis effect in arid and semi-arid urban environments

A group of researchers in a paper titled Green infrastructure performance in arid and semi-arid urban environments (2021), survey more than 9 studies and they all confirmed the relationship the oasis effect and cooling effect, that vegetation reduced temperatures in the surrounding area, especially from larger shade trees. Shade trees perform particularly well vis-à-vis other vegetation like grass as an urban heat mitigation strategy when water use is taken into account. For arid environments, where water is limited, there may be a real tradeoff between vegetation benefits and irrigation requirements (Meerow et al., 2021). In a study, Shiflett et al. (2017) confirms that taller trees with a blocking sunlight showed the greatest air temperature difference (mean of 4°C at 0.1 m height) compared with bare soil. The difference was mostly pronounced around midday (mean of 6.9°C) and lowest in the late afternoon (2°C). Plots with shorter trees and grass were only consistently cooler than bare soil in the middle of the day (an average of 4.6°C for short trees and 4.1 for grass). Feyisa et al. (2014) confirmed that the cooling benefit provided by trees varied by species and by characteristics (size, shape, and vegetation), but overall they calculated an air temperature drop of 0.2°C for every percent increase in overall tree canopy cover. Parks with more tree canopy cover and larger areas had a more powerful cooling impact that lasted beyond the park's limits (Meerow et al., 2021). As a result of the foregoing, it can be concluded that vegetation plays a significant role in cooling the urban environment, this effect varying depending on the kind, density and length of trees.

METHODOLOGY

Our study is based on several sources, but mainly on research that is complementary and quite convergent. It is in this favorable general climate that we see a very significant increase of research in Algeria (books, memoirs and theses, article) on the subject in at hand. The first step is to investigate in the theoretical field by a bibliographic search and a reading of various works, whether paper, online, CD-ROM or database, book, theses, official journal, journals, articles, periodicals, encyclopedia, dictionaries, websites, on the subject studied "green spaces". The second stage consists of a set of direct observations, which are taken in the field in order to obtain objective information that can be categorized and analyzed statistically. The quantitative spatial analysis was performed using the normalized difference vegetation index (NDVI). Normalized Vegetation Index (NDVI: Normalized Difference Vegetation Index) is based on an empirical approach based on experimental data (Baghiani, 2006). The calculation of this index is mainly based on reflectance differences found in different spectral bands and on the variability of reflectance within the same spectral band, which reflect surfaces of different natures. NDVI is the most commonly used vegetation index for satellite image analysis. Thanks to the strong reflectance in the near infrared chlorophyll, this index effectively detects the green status of plants. Vegetation indices are widely used, on the one hand, to identify and monitor vegetation dynamics, but also to estimate certain biophysical parameters characteristic of plant cutlery, such as biomass, leaf area index, active photosynthetic radiation fraction. It takes values between -1 (water) and 1 (intense vegetation) and is calculated using the NIR (near infrared) and R (red) bands, according to the following formula.

$$NDVI = (NIR - R) / (NIR + R)$$

IR=infrared pixel values ; **R**= pixel values of the red band.

It is enough to raise the population figure by age group and to assign it the category of green space that corresponds to the needs assessed by the grid of norms and also offer is to be related to the real demand of the inhabitants.

PRESENTATION OF THE CITY

The city of Boussaada

The city of Boussaada is the first oasis found in Algeria. It is located in the south-east of northern Algeria and 250km from Algiers and covers an area of 225 km². It is considered a real crossroads between the Mediterranean

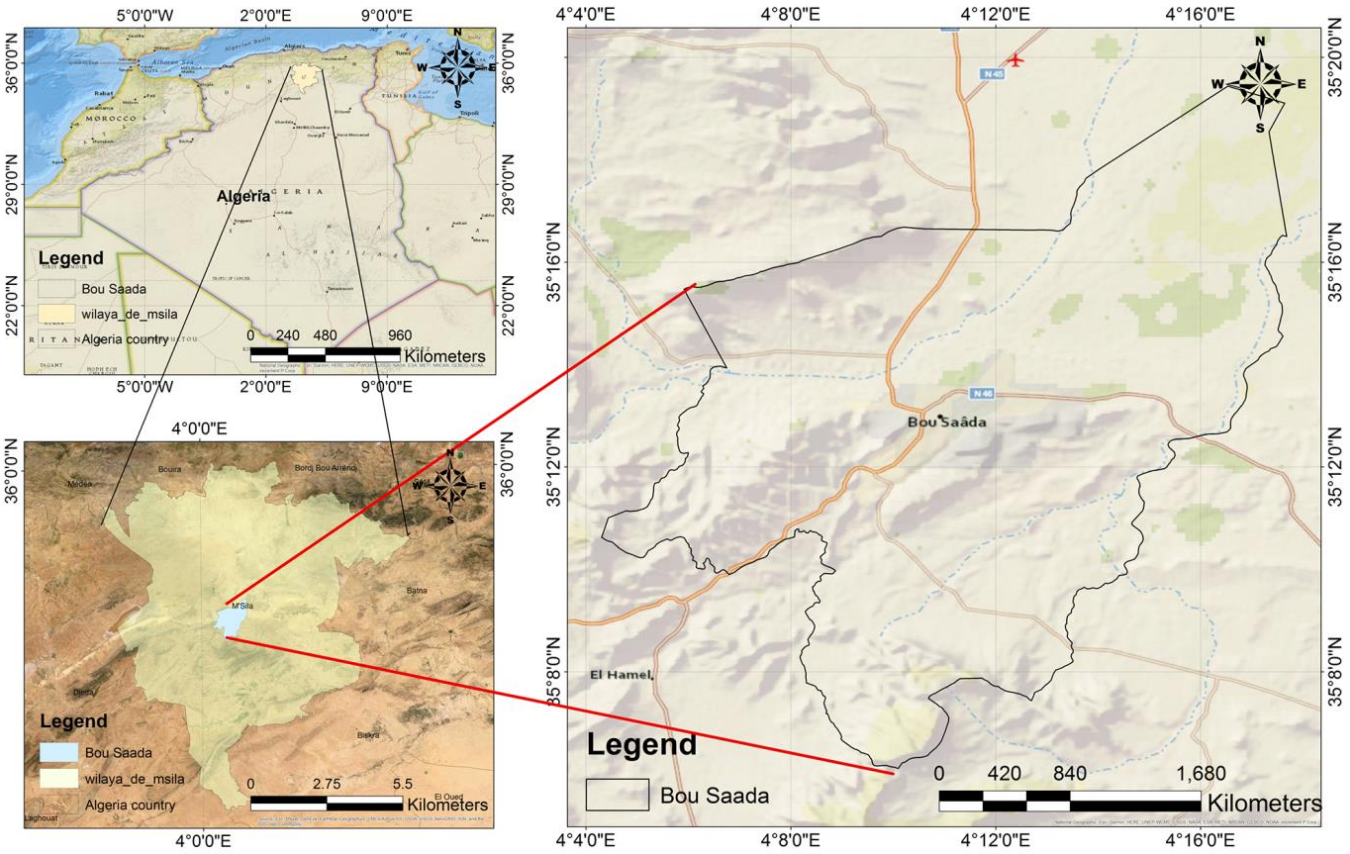

Figure 1. The location of the city of Boussaada.

and the Sahara. Locally, the capital of the Daira de Boussaada is located south of the Wilaya of M'sila (Figure 1).

The town of Boussaada is located in the south of the Wilaya of M'sila (Figure 2). The city of Boussaada is surrounded at the: North, by the commune Ouled sidi brahim and south-east by the commune Oultem and Hamel; North-East, by the municipality of Maarif; and East, by the municipality of Houamed and west by the municipality of Tamsa.

Climate

Climate is a very important factor in urban studies and any planner needs to know the climate data of the city where he intends to build (the temperature and humidity regime of the air, the regime and the nature of the precipitation, the sunshine, the regime and the nature of the winds during the annual cycle). Boussaada belongs to a semi-arid (Figure 2) zone according to the map of the bioclimatic stages below, between temperate and tropical climates, characterized by a drought thus winter, spring and autumn precipitation that are rare and irregular the average being 178.95 mm per year (this data recorded at the weather station of Ain Diss and the agency of theresources in water in the period 1971-2012).

The city is located at the edge of a high plateau and deserts, therefore a very hot climate in summer with a very strong and intensive solar brightness, variations of temperatures between day and night are between 4 and 8°C; winters are cold, temperatures can go down below zero degrees Celsius. In order to better define the characteristics of the climate of the city of Boussaada (external conditions), it is useful to refer to monthly weather data collected at the weather station of Ain Diss over the period 1971-2012. Figure 3 shows the Ombrothermic Diagram of the city of Boussaada based on monthly average rainfall and thermal data over a period of 41 years. (1971-2012). Figure 3 shows that the dry season extends from mid-May to late August.

Climate data

The territory of the city of Boussaada is a varied but overlapping territory, characterized by ecological elements, very varied landscapes, complex and fragile subject to strong anthropogenic pressures "The wadi, the mountain and the dunes have therefore imposed it where

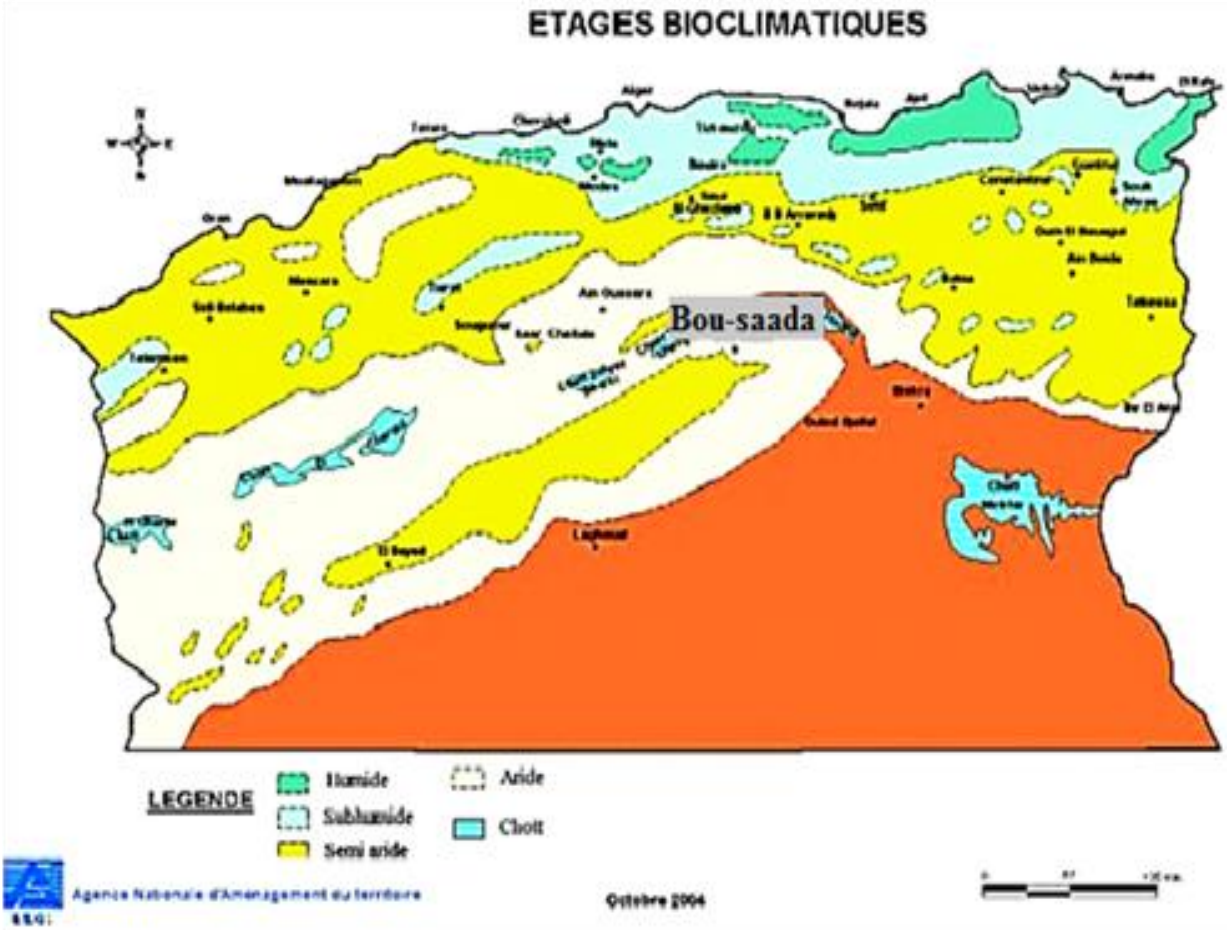

Figure 2. Bioclimatic stage of Boussaada.

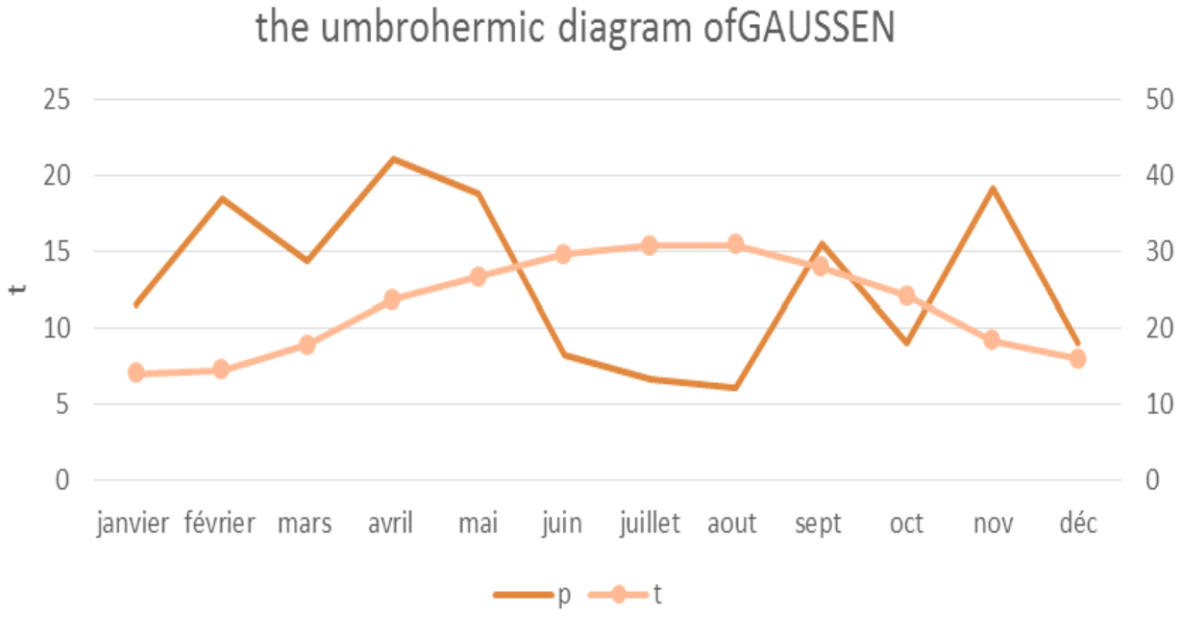

Figure 3. The umbrohermic diagram of GAUSSEN.
Source: Authors.

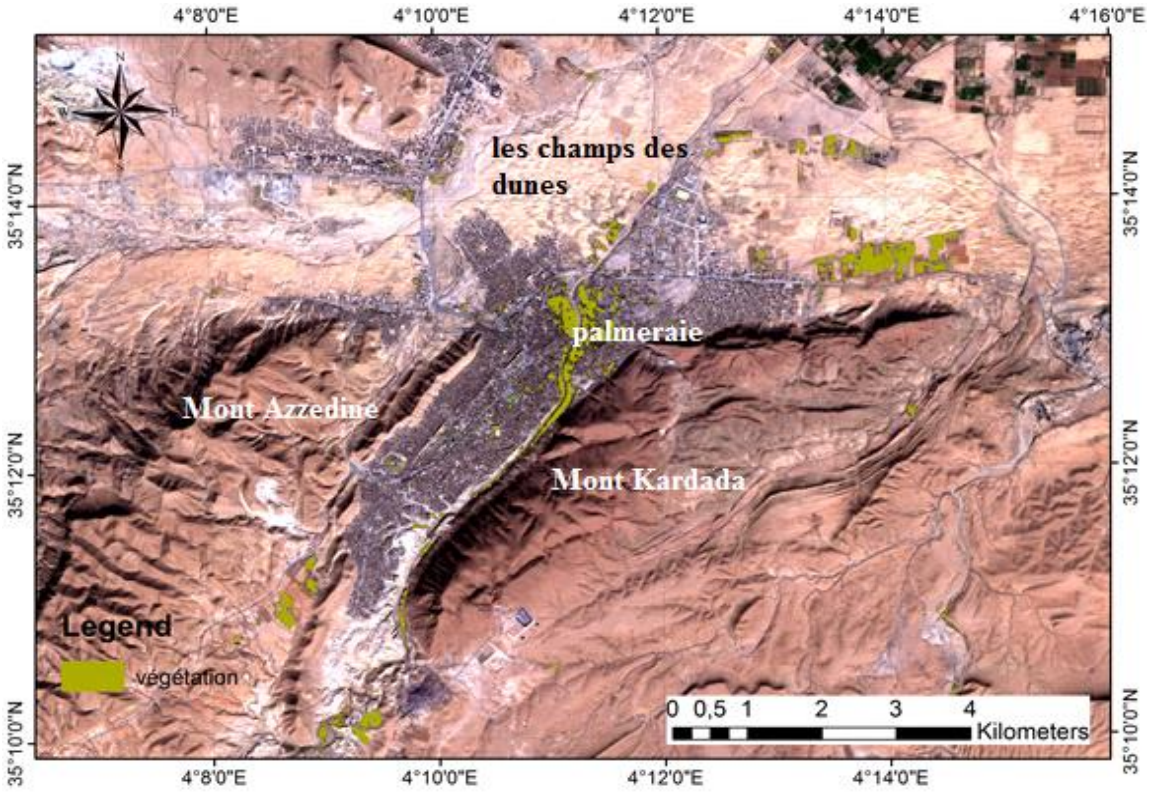

Figure 4. Vegetation in Boussaada city.

it is, in gradient towards the palm grove (Nacib, 1986).

DISCUSSION

Outstanding green spaces in the city of Boussaada

The small green spaces in Boussaada city, represent 2.0796 hectares, or 0.036% of the total area of the municipality, making the ratio of square meters of green spaces to the number of inhabitants in the municipality of Boussaada (The municipality of Boussaada extends over 111 km² and it encompasses 16042 9 inhabitants according to DPSB 2017), the result is 0.01 m² per capita, a figure much lower than the 10 m² per capita recommended by the World Health Organization (Bougé 2009). One observation is clear; the green spaces in the city of Boussaada are shrinking and today represent only a small part of the total area of the city

Calculation of the normalized difference vegetation index (NDVI)

The green space affected by the analysis is dark green in Figure 4. This spatial analysis tool, combined with a database treatment, enabled the NDVI index to be calculated. This value of NDVI is done by dividing the surface of the green space in the city of Boussaada (0,78km²) by the total surface of the city (23 km²), which gives 0.33. Pixels with an NDVI value of < 0.2 are included in a "surface without vegetation cover" mask. This NDVI value is in the range 0.2 to 0.65, so it corresponds to partially vegetated surfaces. The vegetation in the town of Boussaada is unevenly distributed over the whole city (Figure 1), several large spots are located in the city center such as the palm grove and trees of alignment and 3 gardens. Based on the value of the category surface in Table 1, it was noticeable that the majority of urban spaces were consumed by the building compared to other spaces such as green spaces. According to the visual comparison of the NDVI, there is a very uneven distribution of green spaces in the urban space of the city of Boussaada, where the highest rate of green spaces is located in the central districts and urbanization is already significant. This is the disparity between the center and the periphery. Beyond that, it seems useful to us to emphasize that the phenomenon of disparity in the city of Boussaada has several scales, starting with the absence of green spaces and the differentiation of physical and geographical conditions, arriving at a minimal socio-economic situation characterized by a high concentration of low-income households. Under the silence of the local authorities, two phenomena have evolved over time in the city of Boussaada: desertification and siltation (Figure 5) due to increased pressure from populations on already

Table 1. Percentage of green spaces.

Categories of urban spaces	Built-up surface		The surface of green spaces		Free surfaces		Empty communal surfaces
Surface de milieu urbain	Surface Km	Surface %	Surface Km²	Surface %	Surface Km²	Surface %	88 km²
	12.73	55.34	0.78	3.39	9.49	41.25	
Total urban area	23 km²						
Total communal area	111 km²						

Figure 5. the silting of the town of Boussaada.

fragile natural resources to meet their basic needs such as construction on sandy land that increases sand mobilization. Vegetation is considered a soil protector by decreasing wind speed, fixing and restoring the land.

Quality of green space in new city of Bousaada

In the late 1970s, in order to meet the pressing needs of the urbanization of the city of Boussaada, an important Urban Habitat Area New (UHAN) was built in the south of the city, located on nearly 5 km north of Boussaada. In 1993, the latter constituted a new urban pole. It is commonly called the "new city". It covers an area of 115 ha. The UHAN Boussaada suffers from lack of infrastructure and green spaces "a less well-served space" as shown in the map (Figure 6), with a syncopated rhythm that only has a dominant function (housing) "dormitory cities".

Tree species

Selecting appropriate trees for urban and suburban areas depends on a number of factors; it should bind fine particles, ability to adapt to climate change, and improvement of the urban landscape (Sjöman et al., 2018). Trees in Boussaada city, with a semi-arid climate, must be able to endure the drought and heat that exit in this area, in addition, well-placed trees can provide shade and reduce the heat felt due to global warming (Figures 7 to 10). Field observation revealed the presence of 3 tree species array of trees in the area sampled in this study.

1. *Nerium oleander* is an ornamental species of high aesthetic value, grown in arid and semi-arid regions because of its drought tolerance, which is also considered as relatively resistant to salt.
2. *Eucalyptus* is a highly adaptable tree, often fast-growing trees that vary greatly in adult size, flower color,

Figure 6. Green space in the urban habitat area new.

Figure 7. Genus :Nerium L/species : Nerium oleander.

Figure 8. Eucalyptus.

leaf shape.

3. *Casuarina equisetifolia* is very similar to a conifer. It is a very beautiful and resistant tree that grows in both sandy and poor soils, and also produces very small flowers.

In spite of adaptation of tree species with urban climate in the study area, the diversity of the trees was poor and the facilities of the green spaces are rudimentary. They should be improved on in order to encourage users to frequent them.

The palm grove: fragmented green elements

The palm grove has long played an important and beneficial role in the city of Boussaada at the same time, historical, social and economic, as a friendly space, creator of landscape and refreshments in short (Encyclopedie consulted 22/12/2015). The palm grove is a great collective heritage (Figure 11), but the inhabitants do not have the information available on the palm grove

Figure 9. Casuarina equisetifolia.

Figure 10. poor quality of design /lack of accessibility and conviviality.

state which does not allow building their perceptions as well as the problems of degradation and deforestation. The palm grove of Boussaada covers 120 h and had more than 30,000 palm trees and other crops (vines, fig trees, cognassier, apricot trees, etc.), it presented a real source of labor for 857 employees in agricultural activity, so we can say that the population of Boussaada lived more on agriculture than from crafts. The palm grove offered other benefits, it also supplied fruits and vegetables for barter with other products, it also offered a raw material (wood especially) for the construction of buildings (arches, beams). Figure 12 shows the reduction of the surface of the palm grove in favor of urbanization, three very negative phenomena have been observed: decline in favor of urbanization: the transformation and deforestation of palm trees in this case we call it "Beast of the palm grove"; "disinterest of the population": the links between the inhabitants of Boussaada have become close in a way "a detachment of the inhabitants to its palm grove"; the palm grove becomes fragile and weak in terms of use and productivity.

RESULTS

The territory of the city of Boussaada is characterized by ecological elements, very varied landscapes, complex and fragile subject to strong anthropogenic pressures. El Maader is an agricultural land located 8 km from Boussaada, it contains a wide range of fruits and vegetables. Ecological continuity has become a central issue due to the acceleration of urbanization in the city of Boussaada. The quantity of green spaces in the city of Bousaada is unrelated to the particular situation of the cities, which is the size of the city and the number of inhabitants. There are two distinct areas: one in the city center with a concentration of gardens and tree-lined arterial roads with monospecific plantings, and the other on the outskirts with few arterial roads, gardens, and tree-lined yards. This disparity can be explained by historical facts as well as the current urban environment's organization between the center and the outskirts and heterogeneous distribution of tree types in different neighborhoods. The administrative centre has benefited from the planting and maintenance of trees to combat wind and erosion, to provide shade and to beautify the city. Also, the floristic inventory reveals 3 species belonging to the sites studied, which constitutes a low diversity of the tree flora of the city of Boussaada. 5 additional species were observed outside the selected sites. A clear observation: the green spaces in the city of Boussaada are shrinking and today represent only a small part of the total area of the city.

Few trees on the public domain and some trees on the private domain bring greenery to the public space. Green spaces in the city of Boussaada are rare and often in very poor condition. The lack of supervision of urbanization and legislation remains weak, scattered and fragmented and exacerbates these problems. We also note that the quality of the design of these green spaces did not meet the needs of the users who use them. The decline of the vegetation in the palm grove is mainly due to the change of the way of life including the new technologies which have pushed the peasants to leave the palm grove and move to other profitable and advantageous sectors, in addition, the remote level of local/national tourism and the lack of recreational activities or the reduced accessibility due to privatization of the land. The detachment of the inhabitants to their palm grove has several signs, among the most striking is the proliferation of waste within the palm grove, the inhabitants who have thrown the waste illegally do not have sufficient culture and knowledge. Like this case, associations, mosques and schools must transmit and enrich culture by giving everyone access to knowledge, that is to say, to cultural, intellectual and natural heritage.

Figure 11. Palm grove.

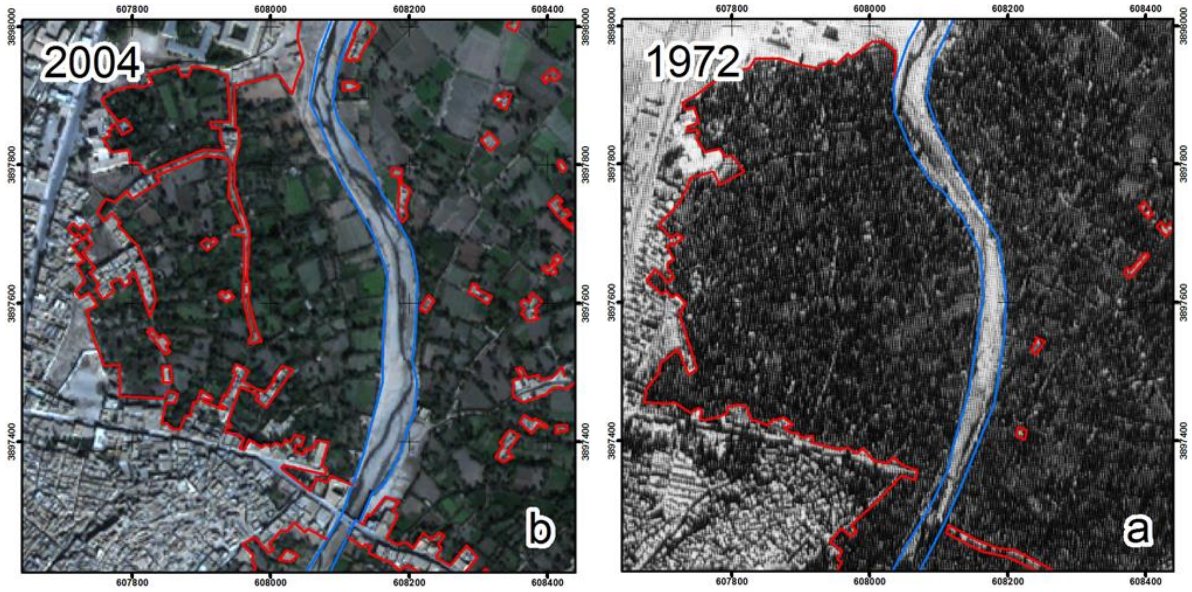

Figure 12. Decrease in green space in the palm grove.

CONCLUSION

Through this research, we have shown the importance of vegetation on the formation of microclimate, by its ability to reduce the impact of sun rays and winds, as well as its effect of cooling the air by the action of evapotranspiration and the reduction of heat pressure during the summer period. Green spaces also have an aesthetic and decorative, hygienic and sanitary role and a social and educational role (Fadel et al., 2016). Among the indicators used to compare the vegetation situation in the city of Bousaasa is the ratio of square meters of green spaces and the normalized difference vegetation index (NDVI). It is important to note that the normalized difference vegetation index (NDVI) is an effective tool for improving the quantity of green spaces and its distribution throughout the urban area. We have shown that through the quantitative research of green spaces, the city of Boussaada has nearly 0.1 m^2 of green spaces per capita and with a proportion not exceeding 3.5% of the city's surface; that is to say, it is poor compared to the national standard which is about 10 m^2/inhabitant. It should be noted that this small presence of green spaces does not allow the preservation of the natural heritage (the palm grove). It is therefore necessary to think about creating and developing new green spaces in the city and restoring the palm grove to its rare value. This requires a systematic mapping of land skills and the creation of an urban forest. It also seems essential to restore the palm grove to its rare value, to make cartography. The development of green spaces in the city of Boussaada requires the identification and knowledge of tree species. The diversity of use or functions of trees is ensured thanks to the adaptation of planted species to ecological, climatic and landscape conditions. The study thus highlights the importance of urban forestry. In the case of

the city of Boussaada, taller trees with a closed canopy can provide a cooling benefit like acacia tree with a big ability to thrive under hard conditions. The consideration of the quality and quantity of green spaces in urban planning instruments must be strengthened and based on a much more qualitative approach and on a real urban forestry (care, treatment, silviculture); that seeks to maintain a healthy environment and an aesthetic and clean image of the city. As we have shown in the course of this research, the land use plans of Boussaada city should control the Algerian urban space, protect the existing natural heritage, in this case the oasis, and create and promote green spaces in the future.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interest.

REFERENCES

Baghiani B (2006). Cours de télédétection applique à la désertification m1zones arides. Département de biologie, université Batna. Available at: http://staff.univ-batna2.dz/sites/default/files/beghiani-belgacem/files/cours-teledetection.pdf

Bonhomme M (2012). Création d'un outil d'aide à la décision pour un aménagement durable des espaces verts dans les municipalités (Doctoral dissertation, Université de Sherbrooke).

Boudjellal L (2009). Rôle de l'oasis dans la création de l'ilôt de fraicheur dans les zones chaudes et arides–cas de l'oasis de Chetma, Biskra. Université Mentouri P 133.

Bougé F (2009). Caractérisation des espaces verts publics en fonction de leur place dans le gradient urbain rural (Doctoral dissertation, Polytech'Tours, Aménagement).

Cocean P (2020). Repulsive cultural landscapes. La Revue Roumaine de Géographie 147:14-54.

Dehimi S, Hadjab M (2019). Evaluating the quality of life in urban area by using the Delphi Method. A case study of M'Sila City/Algeria. Romanian Journal of Geography 2(63):193-202.

Donadieu P (1996). Paysage de campagne: du rural à l'urbain. Ligeia. P 121.

Encyclopedie (2015). 1830-1962 de L'Afrique du nord 2015. consulted 22/12/2015.

Fadel D, Dellal A, Badouna BE (2016). Enjeux et concept des espaces verts dans le développement durable urbain: proposition d'aménagement d'un espace vert forestier d'une ville du nord-est algérien. Revue Ecologie and Environnement 12:6-13.

Faure G, Shmakov SA, Yan WX, Cheng DR, Scott DA, Peters JE, Makarova KS, Koonin EV (2019). CRISPR–Cas in mobile genetic elements: counter-defence and beyond. Nature Reviews Microbiology 17(8):513-525.

Feyisa GL, Dons K, Meilby H (2014). Efficiency of parks in mitigating urban heat island effect: An example from Addis Ababa. Landscape and Urban Planning 123:87-95.

Flouri E, Midouhas E, Joshi H (2014). The role of urban neighbourhood green space in children's emotional and behavioural resilience. Journal of Environmental Psychology 40:179-186.

François D (2010). Les îlots de chaleur urbains. Répertoire de fiches connaissance. Available at: https://www.iau-idf.fr/fileadmin/NewEtudes/Etude_774/Les_ilots_de_chaleur_urbains_REPERTOIRE.pdf

Gherraz H, Alkama D (2020). L'estimation de l'impact des espaces verts et des surfaces d'eau sur le climat urbain et la temperature de surface du sol (Mila, Algérie). Available at: http://www.rjgeo.ro/atasuri/revue%20roumaine%2064_2/Gherraz,%20Alkama.pdf

Iverson LR, Peters MP, Prasad AM, Matthews SN (2019). Analysis of climate change impacts on tree species of the eastern US: Results of DISTRIB-II modeling. Forests 10(4):302.

Manusset S (2012). Impacts psycho-sociaux des espaces verts dans les espaces urbains. Développement durable et territoires. Économie, Géographie, Politique, Droit, Sociologie 3(3):1-12.

Meerow S, Natarajan M, Krantz D (2021). Green infrastructure performance in arid and semi-arid urban environments. Urban Water Journal 18(4):275-285.

Minzhanova G, Pavlichenko L, Karbayeva S, Bimagambetova L, Razdobudko O (2021). The green space and social impact in Almaty City: A cross-sectional data analysis. GeoJournal of Tourism and Geosites 34(1):251-255.

Nacib Y (1986). Cultures oasiennes: essai d'histoire sociale de l'oasis de Bou-Saâda. Publisud.

Philippe C (2007). Une écologie du paysage urbain. Rennes, Éditions Apogée.

Porcherie M, Linn N, Le Gall AR, Thomas MF, Faure E, Rican S, Simos J, Cantoreggi N, Vaillant Z, Cambon L, Regnaux JP. (2021). Relationship between Urban Green Spaces and Cancer: A Scoping Review. International Journal of Environmental Research and Public Health 18(4):1751.

Richardson EA, Pearce J, Mitchell R, Kingham S (2013). Role of physical activity in the relationship between urban green space and health. Public Health 127(4):318-324.

Roy CA (2008). Cartographie végétale du col le la vallée de Sverdrup, île d'Ellesmere, avec le NDVI MODIS et analyses des changements d'échelles (Doctoral dissertation, Université du Québec à Trois-Rivières).

Shahabi H, Ahmad BB, Mokhtari MH, Zadeh MA (2012). Detection of urban irregular development and green space destruction using normalized difference vegetation index (NDVI), principal component analysis (PCA) and post classification methods: A case study of Saqqez city. International Journal of Physical Sciences 7(17):2587-2595.

Shiflett SA, Liang LL, Crum SM, Feyisa GL, Wang J, Jenerette GD (2017). Variation in the urban vegetation, surface temperature, air temperature nexus. Science of the Total Environment 579:495-505.

Sjöman H, Hirons AD, Bassuk NL (2018). Improving confidence in tree species selection for challenging urban sites: a role for leaf turgor loss. Urban Ecosystems 21(6):1171-1188.

Vergriete Y, Labrecque M (2007). Rôles des arbres et des plantes grimpantes en milieu urbain. Revue de la littérature et tentative d'extrapolation au contexte montréalais. Available at: https://cremtl.org/sites/default/files/upload/documents/publications/roledesarbresetdesplantesgrimpantes.pdf

Wolfe SA, Nickling WG (1993). The protective role of sparse vegetation in wind erosion. Progress in Physical Geography 17(1):50-68.