



USING GOOGLE EARTH™ AND GEOGRAPHICAL INFORMATION SYSTEM DATA AS METHOD TO DETECT URBAN SPRAWL AND GREEN SPACES FOR BETTER WELL BEING CASE OF A COASTAL LANDSCAPE

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ABSTRACT

Coastal landscapes are facing a huge challenge to manage the spatial extension of their built-up area at the expense of the reduction of natural and cultivated areas. This is the case of Hergla city, located in the southern part of Hammamet Gulf, Tunisia. This paper firstly highlights changes of LULC in Hergla city, between 2007 and 2017 using a supervised classification of Landsat images. The evolution of built-up area between 2002 and 2020 is examined expending Google Earth images. Lastly, the geolocalization of green spaces are provided. Then, the superposition of all these analyzes will be used to propose a landscaping for a better human well-being. Finally, this research indicates the importance of analyzing LULC change at multiple scales; it revealed that built-up area has been increased and olive fields reduced from 64 % in 2007 to 30.2 %in 2017. It shows, too, an important urban expansion from 39.9 Ha in 2002 to 48.3 Ha in 2020. However, the green spaces are concentrated in the North and middle part of the city and a proposal for the development of an urban park on the south side will help to balance the spatial distribution of green spaces in this area and ensure better human well-being.

1. INTRODUCTION

Urban sprawl represents the extent of urbanization, which is a global phenomenon mainly driven by population growth and large-scale migration [1]. It is, an increase of the population living in cities, the level of non-agricultural employment or production, the pace of resource use, or the presence of traffic saturation [2]. The [3] admitted that by 2050, 66% of the world's population will be living in urban areas, because it has been expanded rapidly from 746 million in 1950 to 3.9 billion in 2014 [4]. However, in developing countries the speed and scale of urbanization can result in unsustainable settlements which generate ecosystem pression [5], [6]. In this situation, [7] predicted that cities become unable to compete in a globalized environment. Recently, [8] proposed that to guide this phenomenon and support growth of cities, it is essential to know what the natures of urban land cover are and how the extinction was done. And for that reason, the appropriate information can be extracted from remote sensed data and Google Earth Observation. According to [9] and during the past ten years, remotely sensed data is used in most cases when studying the changes of LULC, and included also case studies of particular settlements. In fact, the availability of satellite imagery and remotely sensed data, help to convert these data into significant information about the nature and pace of urban landscape changes and human settlements [10], [11], [12], [13], [14], [15], [16], [17], [8], [18] explained that the spontaneous urbanization and irregular occupation of public and private land have created urban and landscape dynamics in the Tunisian territory. In contrast, [19] involved that urban mutations led to the fragmentation of landscapes and the degradation of living environment in Hergla city, which is one of the coastal cities marked by its significant urban extension [20], [21] has underlined profound transformations in the city, in 2018. To more asses and update this evolution in Hergla city different objectives were assigned in this paper: a) to understand LULC changes between 2007 to 2017 using Landsat images, b) to assess the extent of built-up land cover in the Hergla city, over the period 2002 to 2020 using a Google Earth Time Series Images, c) to geolocate the green spaces of the city and d) to propose the management of an urban park.

2. MATERIALS AND METHODS

2.1. STUDY AREA

Hergla, appears as one of the rare coastal cities of the southern part of Hammamet Gulf (Figure 1), with a small coastal port (3.2 ha) constructed in 1984 and an offshore tuna farm installed in 2003, characterized by its landscape and cultural qualities (the historical sites). The climate is part of the lower semi-arid bioclimatic stage characterized with mild winters and a yearly mean precipitation of 200 mm. The coldest month is January with an average temperature of 11.5 °C, and the hottest one is August with an average temperature of 28 °C.

In 2007, the municipality of Hergla has 5622 inhabitants and 1049 households. The population growth is about 2.58%, whereas the estimated national average is of 2.3%. The city is marked by the preponderance of the industrial sector and it knows certain dynamism in the tourism sector who makes Hergla a privileged destination but also increases significantly the anthropogenic pressure that threatens the natural environment balance [22].

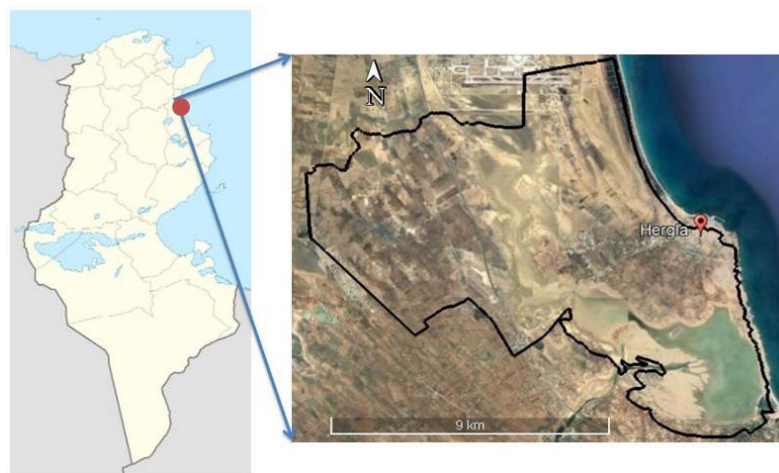


Figure 1: Geographic localization of the study area (www.wikiwand.com/fr/Sousse, @Google earth)

2.2. METHODOLOGY

2.2.1. SATELLITE DATA

Two Landsat images were used in this study: the Landsat 5 TM and the Landsat 8 OLI, respectively from Avril 2007 and 2017 with a spatial resolution of 30 (<https://earthexplorer.usgs.gov/>). The images were georectified to a Universal Transverse Mercator (UTM) coordinate system, using World Geodetic System (WGS) 1984 datum, assigned to north UTM zone 32 and Path 191 Row 035.

2.2.2. PREPROCESSING

Atmospheric and radiometric corrections were done using the ENVI® 5.3. The reflectance calibration consists on deriving the reflectance value from the Digital Number (DN) and calculating the top of atmosphere reflectance (TOA) [23]. Hence, the GPS points were collected via the Garmin Map 64 S.

2.2.3. IMAGE CLASSIFICATION

The supervised classification was applied using the ENVI® 4.8 to both images and the Maximum Likelihood (MKL) method, which is one of the most implemented land use classification techniques [24], [25] was processed. The technique consists in collecting Area of Interest (AOI) represented by GPS points validated in the field for the 2017 Landsat image and using Google earth visual validation for the 2007 Landsat image. This will be used to derive spectral signatures of pixels in the satellite image. After that, DN of each pixel is converted to radiance values. So this technique requires prior knowledge in the study area of different land use types [26], [27], [28].

2.2.4. GOOGLE EARTH TIME SERIES IMAGES

Five Google Earth images were used to map historic changes in built-up area between 2002 and 2020. Thus, the urban spatial features extraction was investigated in urban area using Google Earth time series images for the years: 2002, 2011, 2014, 2017 and 2020.

2.2.5. LANDSCAPE DESIGN

The conception of the urban park is based on the results of changes obtained then to the geolocalization of the existing green spaces using the GPS. Then, two softwares were used: AutoCAD (2016) for the realization of the master plan and Sketch UP (2018) for 3D modeling.

3. RESULTS AND DISCUSSIONS

3.1. LULC HERGLA- REGIONAL SCALE

For mapping LULC, seven land use classes were extracted: urban, wetlands, olive fields, forest, cultivated soil, uncultivated and grassland. Figure 2 shows, that in 2007, the urban is almost located near to the costal side, which represented the urban core of the city; it occupied only 3.4 %, whereas in 2017 some patches are detected in the middle-east occupying 6.6 % of the total built-up area. The wetland in this city indicated by “Halq El Mingel” sebkha, takes over 20.1 % in 2007 and 15.4 % in 2017. The olive fields are situated in the middle-east and the middle-west, with 64% in 2007 and 30.2 % in 2017. Nevertheless, the area occupied by “El Madfoun” forest was marked by its stability during the two study dates (0.7 %). Then, in 2007, the cultivated soils are sited mainly in the middle-west with 22.2 %, and in 2017 new fields are detected in the middle-east (26.3 %). The occupations of uncultivated land evolved from 1.4 % to 9.9 % and this especially around the sebkha and from 5.4 % to 11.1% or grasslands scattered throughout the region.

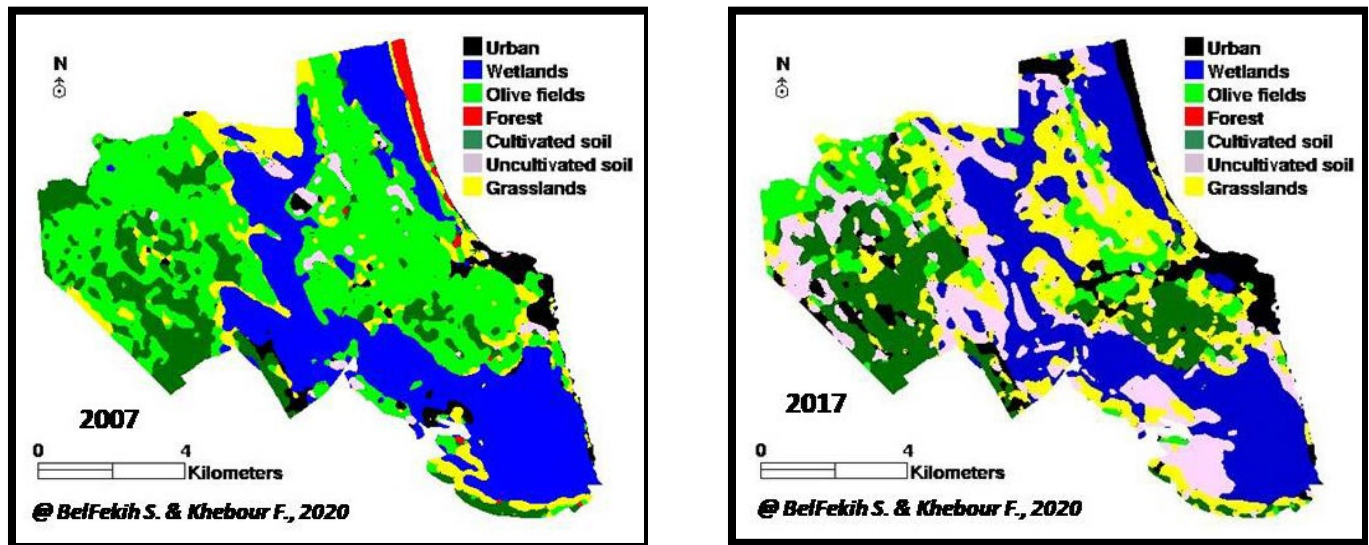


Figure 2: LULC classification maps of Hergla city (left in 2007, right in 2017)

Figure 3 shows that built-up area detected between 2007 and 2017 has been increased while the olive fields have been reduced. The strong growth of urban areas can be easily explained by a current population progression in the region. It is clear that it has lost a considerable proportion of its olives field's surface to the benefit of the built-up areas. At the same time, the areas of uncultivated soil and grasslands have increased in 2017. However, the total wetland "Halq El Mingel" area has shrunk from. So, more than 4 %of the natural wetland has been lost over the last 10 years and this variation is probably linked to climatic effects. Yet, the area of forest remained substantially stable from.

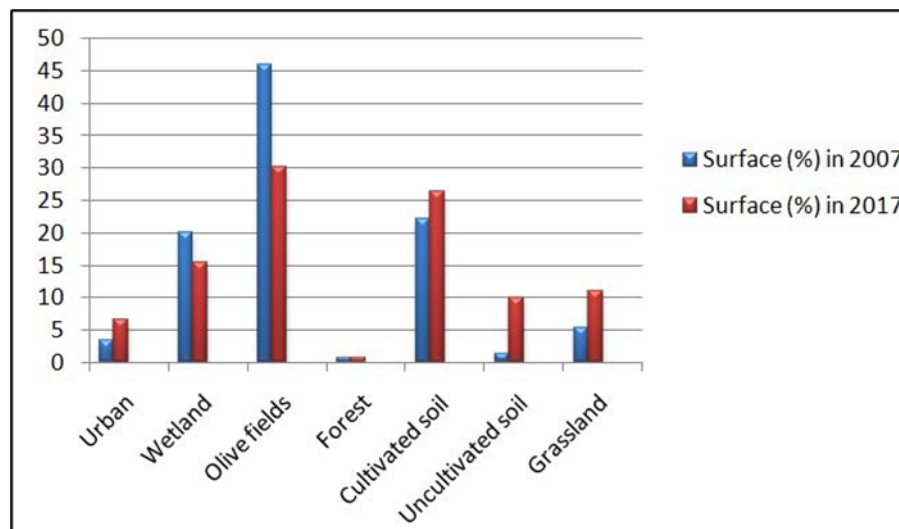


Figure 3: Variation of LULC classes (in %) in Hergla city between 2007-2017

3.2. HERGLA CITY-LOCAL SCALE

The figure 4 explains that in 2002 the spatial distribution of the urban built-up in Hergla was concentrated in the center city with a greater density on the west side. In 2011, the urban sprawl was especially digitized in the South side with appearance of some scattered patches on the North-west side. However, from 2014 to 2020, the appearance of constructions is less important with a more increasing gradient oriented towards the South-east side.



Figure 4: Urban sprawl in Hergla city from 2002 to 2020 (@Google Erath)

Then, the urban sprawl detected along 18 years shows that the Hergla city has known an increase in built areas in 2011, the year of the revolution, this area is of the order of 45.2 ha. While in the years that followed, urban sprawl has slowed down, passing to slight increases of 46.8 ha, 47.8 ha and 48.3 ha in the respective years: 2014, 2017 and 2020 (Table 1).

So recently, a new urban area is created in the Southside of Hergla; it became patchier and disconnected from the urban core. This expansion corresponds to the population growth in all the delegation of Hergla that is equal to 7419 inhabitants, according to the 2014 Census of the population [29]. And according to the Hergla Coastal Technical Report the rural population represented more than three quarters of the total population in 2017 [30]. These recent spatial extensions of built areas in this coastal landscape are due to the significant development in Hergla city's periphery in the second decade of 2000. Witch adequate with the estimation elaborated from the National Institutes of Statistics that population growth will about 9924 inhabitants in Hergla for the year 2020 [31].

Table 1: Evolution of Built-up areas (ha) between 2002 and 2020 in the city center of Hergla

Year	2002	2011	2014	2017	2020
Built-up areas	39.9	45.2	46.8	47.8	48.3

3.3. SPATIAL DISTRIBUTION OF GREEN SPACES IN HERGLA

Figure 5 shows that green spaces are designed mainly at the level of the roads, west side and south side with some spaces on the littoral side. Whereas, they include some public gardens, fitted out traffic roundabouts, public institutions gardens (Educational institutions, hospital, youth clubs, public administrations ...), as well as plantations (roadside trees which border avenues, road beltways and touristic routes). Then, the city is devoid from an urban park that is an open space developed in residential environments; and managed as part of the zoned open space of cities, or as part of new private residential development and it may include playgrounds and sport facilities [32], [33], [34]. Although, given the study carried out on the urban extension of this area, the lack of green spaces face of this urban sprawl is very important.



Figure 5: Spatial distribution of green spaces in Hergla region (@Google Earth, 2018)

3.4. LEISURE AND WELL BEING AT HERGLA REGION

A new district was created from the Land Housing Agency in the South entrance of the city. This urban space contains residences and is almost devoid of green spaces, which contributes more to enhance the North-South imbalance. As a solution to resolve this problem, a management of a recreational park is proposed, near to the wetland, in order to conserve this ecosystem and to develop recreational functions in this landscape to the residents. The park is located in the South of Hergla city; it is 500 meters from the sebkha and 200 from the beach. The park is rectangular in shape and has an area about 9965 Meters² (Figure 6).

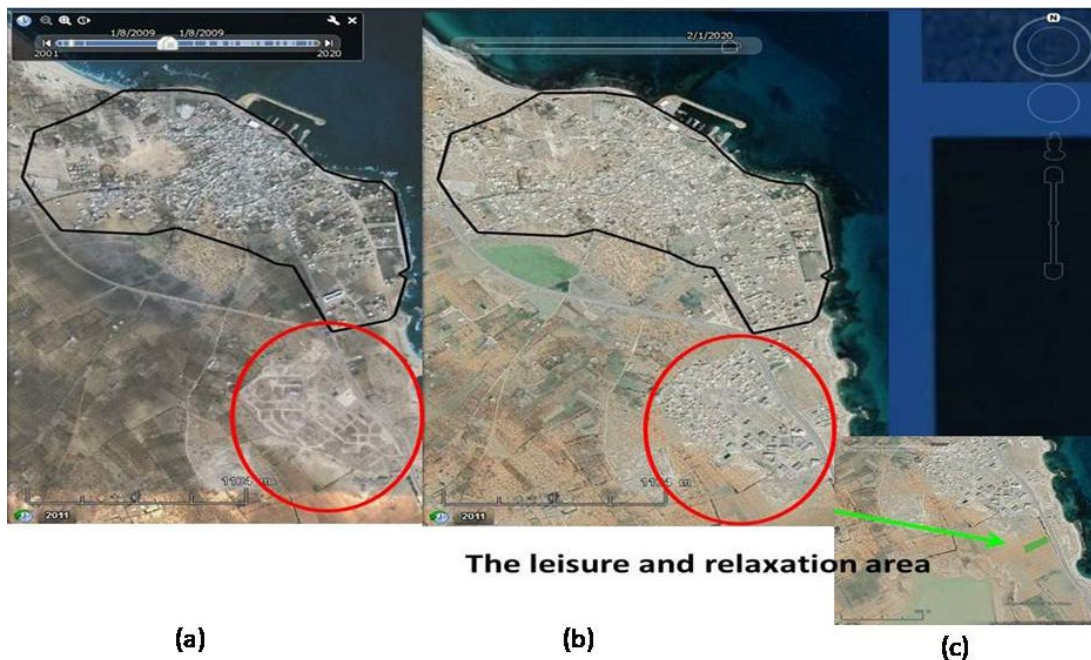


Figure 6: Urban sprawl detected in the south of Hergla from 2009 (a) to 2020 (b) and the geographic localization of the urban park (c) (@Google Earth)

Concept

The concept is based on « natural-urbanization » [35]. The main objective of this management is to improve human wellbeing and save natural resources by using ecological and social scenarios. For example, the environmental aspect is reflected in the use of the wood in the majority of materials. Although, the densification and the diversification of plants are advisable to create a green lung and to improve the wellbeing of the local population and visitors by promoting meeting of people, leisure, relaxation, discovery and reduction of the stress. The development of the social-economic aspect will be encouraged by the insertion of a refreshment bar and games in the design of landscape units.

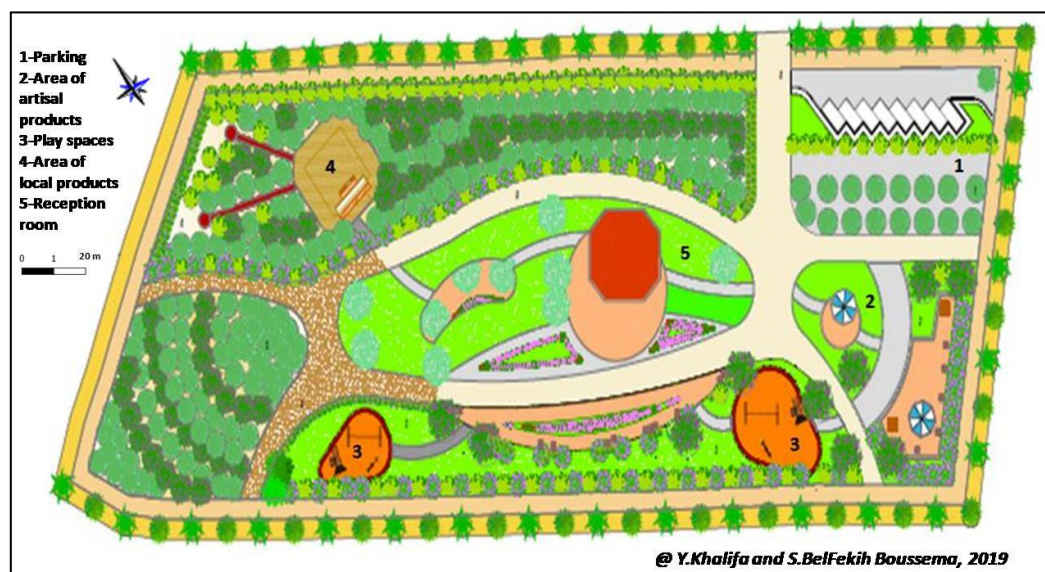


Figure 7: Master Plan of Halq El Mingel urban park, Hergla

Landscape units

Five landscape units are designed in the park such as: a parking, an area of local product, an area of artisan product, a reception room and a play spaces. The parking, is managed to receive the most number of visitor's cars. The olive trees are planted around to mark the identity of the city, playing a shady role and to minimize the effect of sea spray. While the inhabitants of Hergla can participate in handicrafts using the Alfa products, an exhibition center to sale artisan products has been set up to revive this traditional activity. And wooden rest benches lined with shade trees such as the *Cursus ilex* are introduced. The play spaces are dedicated for children from 6 to 12 years and were occupied by wood materials. The coating used is sand to remind the coastline as well for child safety. The route is marked by a brick border. The area of local product is a space with a flexible shape in which local products will be exhibited. To avoid monochrome, deciduous and evergreen trees are alternated to master the opening and closing of the space. At the entrance to the park, the reception area evokes a particular theme through the choice of its plant composition, its decor, and its atmosphere. The palette of plant is varied in the surroundings with flowered beds. The reception room is to get brochures and other information about the park. And there is a refreshment bar that offer a variety of drinks to sale.



(a)



(b)



(c)



(d)



(e)



Figure 8: Sketches of landscape units a) Parking, b) Area of artisan Product, c) Play spaces, d) Area of local Product and e) Reception room

4. DISCUSSION

The LULC results of Hergla city between 2007 and 2017, shows that built up areas has been increased and olive fields has been decreased. Also, more than 4 % of the natural wetland has been lost in one decade. As a result of GE images that during the second decade of 2000, Hergla city was heavily built-up, after the revolution. The spatial distribution of green spaces in the city revealed that a strong disparity is detected between districts. Landsat images were helpful in detecting the LULC change that has taken place in this period. The expansion of built up areas maybe explained by the rapid population growth, especially in its peri-urban areas. In this context, many studies suggest a close relationship between the distribution of built-upland cover and the distribution of the population in a city [1], [36], [37]. Witch adequate with the result of [8], which showed that a high and significant correlation between the distribution of the built-up land cover in Ho ChiMinh City and the distribution of its population. For the disparity created between district [38], affirmed that the bad territorial distribution of the green spaces intensifies more and more the segregation North-South in the city and compromises the balance and the social coherence between districts. So, it is recommended to create new spaces and maintain the others, like the management of the urban park near to the sebkha. Due to advancements in remote sensing and Geographic Information Systems (GIS), the use of satellite data has replaced the traditional field survey methods in preparing urban landuse maps in recent decades [39]. It is considered as an essential data required by planners and policy makers for performing different tools used in urban planning and management. As [9] explained that proper information on LULC is necessary for implementing various developments, planning and land use schemes to meet up the increasing demands of basic human needs. Google Earth Engine has been used in previous studies for various applications, including population [40], [41] and forest cover mapping [42]. Similarly, according to [43] with the availability of Google Earth images is so feasible to monitor urbanization in multi-spatial and temporal resolutions and to understand urban dynamics globally. The use of Google earth has many advantages such as it provides the latest satellite imagery having spatial resolution less than one meter. Also, it provides images taken at different time periods which will be very useful for urban planners to complete land use map preparation [44], [45].

5. CONCLUSION

In This study different spatiotemporal change patterns, composition and rates were highlighted using Landsat images, for the period extended from 2007 to 2017. Also, the spatial distribution analysis of built-up areas using GE images allows the important expansion in Hergla city especially after the revolution. In fact, the distribution of green spaces in the district is unequal. So, analysis of LULC changes is an essential step, not only for quantitative evaluation of the changes already implemented, but for future modeling and prognosis of urban development. It promotes human wellbeing and provides recreational activities for Hergla inhabitants. That is why raising awareness of this situation at all sectors of society is essential for their life; to achieve this goal, the management of an urban park is proposed. Also, it is recommended to enhance wetland accessibility and attractiveness by improving traffic conditions, facilities, creative activities and services, as well as to improve social opinions through new media and volunteer action. In this context, interactive tools such as the ones proposed can contribute to educational programs aimed to protect these and other natural habitats. GIS and remote sensing data help to analyze the growth, pattern

and extent of urban sprawl. However, understanding the sprawl dynamics advance appropriate management strategies that could contribute to the region's sustainable development and assists in planning for efficient natural resource utilization and infrastructure facilities.

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CONFLICT OF INTEREST

The author have declared that no competing interests exist.

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