THE REMAINING GREEN SPACES IN THE BEIRUT METROPOLITAN AREA

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ABSTRACT

Urban expansion is one of the major environmental problems affecting Lebanon: 73.5% of the Lebanese population resides in urban areas (Worldmeters, 2017), and the Lebanese urban front continues to extend over the coastline and even on the mountain ridges (Faour et al., 2005). Thus, urbanization and its extension are shown to be crucial problems threatening green spaces. Inhabited areas extend over green areas, covering a radius between 5 to 15 km around the city of Beirut (Davie and Drouaot, 2000). Since the war, The Lebanese population has migrated from urban areas to green spaces. People have migrated to areas on the outskirts of villages, in mid-level mountains, coastal areas and even steep slopes (Davie and Drouaot, 2000). Construction spanned the peripheral area of the littoral, medium slopes (30%) and even the steeper slopes (greater than 60%) (Arnaud, 1997; Bou Kheir, 2001). Thus, urban extension is considered a significant factor of the Lebanese landscape. For this reason it is important to preserve forests, that occupy a fairly important part of the Lebanese cover. Hence, it seems necessary to understand the phenomenon of urban extension (especially towards green spaces) and to analyze its mechanisms. To fully understand this highly important topic, a study area representing the city/forest interface forms the subject of a meticulous investigative work. Since the suburbs surrounding the capital Beirut are the areas most affected by the extension of buildings, we have chosen the following study area: The Metropolitan Area of Beirut, known as the "Greater Beirut Area", comprising the city of Beirut (Beirut Governorate) and the adjacent municipalities in Mount Lebanon Governorate. The adopted approach employ a territorial dynamics component (the spatial component of the territory). This technique depends on a diachronic analysis of satellite images, seeking a better qualification of the built-up areas evolution to the detriment of green spaces. This approach will focus on promoting and valuing the forests located at the edge of urban areas.

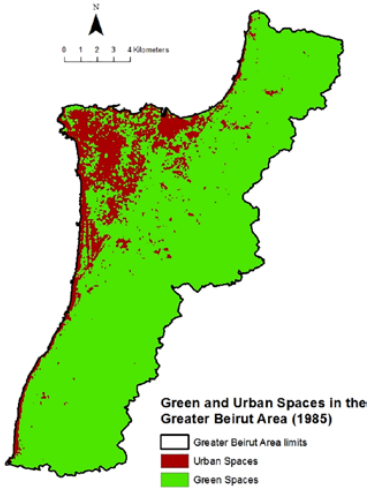

Figure 1

First, we proceeded to download the required images: Landsat images of 30 m resolution. The chosen images clearly show the Greater Beirut Area. We chose images from 1985, 2000, and 2016. The image dating from 1985 was processed, since, based on an image dating back to this almost ancient period, we were able to visualize the presence of a large percentage of green areas (forests and agriculture areas). We decided to process the image dating back to the year 2000 as a representative of the post-reconstruction period following the civil war (1975-1990). This image represents an intermediate period between our base image dating from 1985 and the recent one dating from the year 2016. This latest one represents the current situation of urban extension in Lebanon. These images and their databases were analyzed in the Aeronautical Reconnaissance Coverage Geographic Information System (ARC GIS). In this system, we began by importing the Lebanese Map, the Greater Beirut Area's Map, the registration land division map of the municipalities belonging to the two governorates constituting the Greater Beirut Area (Beirut and Mount Lebanon), and finally the different downloaded images. These images were taken by different Landsat satellites (Landsat 5, 8). In order to observe the affected areas and determine the areas most affected by this phenomenon, we analyzed the Normalized Difference Vegetation Index (NDVI) of each satellite image. This index is a data processing method, allowing us to describe the stage of plant growth, identify and monitor the vegetation dynamic. The image processing using this index, displays pixels with different values ranging from 0 to 255 (or -1 as 0 to +1 as 255)

It should be noted that the Landsat 8-images are of a better resolution than those taken by the Landsat 7 and 5, probably due to some improvements in the Landsat-instruments. These improvements constitute significant progress in the ability to detect changes on the earth's surface, which are captured better than with the previous Landsat satellites. Therefore, it becomes imperatively important to calculate a relationship equation between the Landsat 7 image (the image used to estimate the value of the minimal green pixel) and the Landsat 8 image (the image for which we wanted to obtain a minimal green pixel value equal to the minimal green pixel value in Landsat 7). Hence, we imported two satellite images (Landsat 7 and Landsat 8) into ARC GIS, taken at close dates during the same year (May 2016). Subsequently, we sampled random values of the pixels on these two images processed by the analysis of the vegetation index. Based on the collected data, a graph was developed that shows the variation of the Landsat 8 image's pixels value compared to the Landsat 7 image's pixels value, in order to seek an equation. The developed equation "y=0.812x + 36.33"is a linear function that we have used to calculate the theoretical values. The variation between the observed values and the calculated ones provided us with a residue. Afterwards, the calculated residues were analyzed, by developing a graph showing the variation of the residues according to the sampled Landsat 7 values. The average value of all the residues is 2.890571429. The standard deviation of these values is 3.899170946. The majority of the calculated values are within ± 3.899170946. Thus, the standard deviation made us accept the calculated values, and therefore our findings were accepted and applicable. Hence, this equation allowed us to determine the value of the minimal greenery pixel in the Landsat Image 8, corresponding to the value "103" estimated on the Landsat 7 image.

While estimating the value of the minimal threshold of pixels representing the green spaces in Landsat images 4 and 5, and calculating the minimum value of the green pixels in the satellite image taken by the Landsat satellite 8, we used the "tabulate area" tool, which calculates the surface area of the pixels of each value. In Excel, data resulting from this tool can be processed. We calculated the sum (of the surface) of green pixels, starting from the minimal pixel value for each Landsat image, and the total surface area of each municipality (the sum of all the surface-area of the pixels), in order to be able to calculate the percentage of green spaces present in the Greater Beirut Area. We continued by calculating the variation of the percentages of green spaces in each municipality between the years 1985 and 2016. In this way, the software allowed us to deduce the decrease in green spaces in these regions. This same procedure was used to calculate the percentage of urban spaces within the same study area, but in a reverse way. We have calculated the sum of the surface of non-green pixels ranging from the maximal threshold pixel value for each Landsat image (considered 103 in Landsat 7) and the total surface area of each municipality (the sum of all the surface area of the pixels), in order to be able to calculate the percentage of the urban spaces invading our study area.

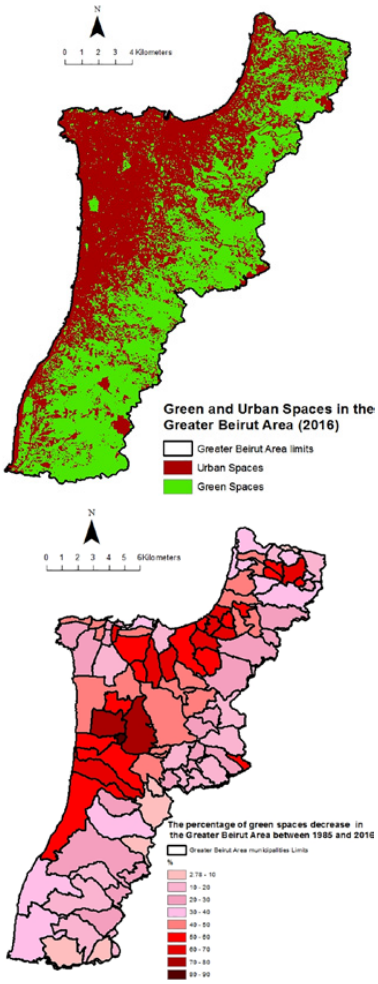

Figure 2 and 3

As for the results, we have seen a remarkable decrease in the green-area surface in the majority of the 92 municipalities, constituting the Great Beirut Area (Figures1 and 2). The average value of the loss of woodlands is about 36.07%. The variations inthis loss fluctuate around this average value (Figure 3). The minimum value is around 2.78% for the municipality of Kliliye, and the maximum value is about 89.82% for the municipality of Lailake. In addition, we proceeded by calculating the decrease in the green spaces area in each municipality. This method showed us that in some large municipalities, the decrease in the area of green space reached 5,214,600 m2 (Quobbe Choueifat). All of the above leads us to suggest various causes that induce the urban extension of the Lebanese population. These reasons combine in order to provoke the urban areas' extension. Moreover, land and apartment costs are higher in the city than in the countryside, which encourages the development of Beirut's peripheries. Furthermore, peri-urban areas are generally less controlled, with fewer regulations (Harvey and Clark, 1965). Also, green and agricultural spaces are depreciated, which makes construction on the periphery less expensive (Sainteny, 2008). Additionally, road networks are some of the most important reasons for this huge extension. These networks, especially the highways, facilitate the commute between the city and the countrysides, causing a rapid growth of the city (Harvey and Clark, 1965). All of these reasons instigate two main phenomena that stand in direct relation to the extension: i) First, the emergence of new work opportunities provided by several companies or industries located in the peripheral zones. ii) Second, the educational system tries to evolve in order to meet the needs of peri-urban areas' residents, which has intensified the sprawl. Thus, this analysis discusses our findings, addressing the problem of the urban dynamics at the city/forest interface in Lebanon.

FIGURES

Figure 1. Map showing the distribution of green and urban spaces in the Greater Beirut Area in 1985. Illustration source: United States Geological Survey (image dated from 20 may 1985), LM51740371985140AAA03_MTL. Name of copyright holder: Christy Chaoul

Figure 2. Map showing the distribution of green and urban spaces in the Greater Beirut Area in 2016. Illustration source: United States Geological Survey (image dated from 25 may 2016), LT05_L1TP_174037_20000529_20161215_01_T1_MTL. Name of copyright holder: Christy Chaoul

Figure 3. Map showing the percentage of green spaces decrease in the Greater Beirut Area between 1985 and 2016. Illustration source: United States Geological Survey (image dated from 20 may 1985), LM51740371985140AAA03_MTL; United States Geological Survey (image dated from 25 may 2016), LT05_L1TP_174037_20000529_20161215_01_T1_MTL. Name of copyright holder: Christy Chaoul

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