Comparing Local Climate Zone mapping results of Tirana through different approaches

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Abstract:

According to the statistics of January 2021, over 32% of the population of Albania live in Tirana, making it the most populous municipality in the country. The most serious accompanying consequence brought by the migration of the population towards the capital is, in fact, the chaotic urbanization. Due to this phenomenon, many neighborhoods of the city have become alienated, with many green spaces destroyed to make way for mass construction. While climate change is the focus of global studies, the urbanization of Tirana does not yet seem to include a plan to address these serious environmental issues. Cities with a hot summer Mediterranean climate like Tirana are particularly vulnerable to the urban heat island effect. As this phenomenon is expected to worsen in the future, mapping of the local climate zones was carried out to evaluate the present state of the city. In the present study we compared three different approaches based on the theoretical principles of the method published by Stewart & Oke (2012):

- Using GIS spatial queries on detailed vector and raster data (Unger et al. 2014). To produce a large-scale LCZ map, detailed vector data were required, such as: the building's database; road network; impervious and pervious surface; canopy height. Given that we did not have detailed data for the entire territory of Tirana, we chose a pilot area, where we used available data (high-resolution DSM and building database) and our analysis to compile the necessary raw data for the pilot area and a large scale map of urban climate zones using QGIS.
- Using LCZ Generator, an online platform that uses satellite imagery to map LCZs of a given city and expects a valid training area file and some metadata as input (Demuzere et al. 2021). The map is compiled using an open-source web application running on Google Earth Engine. It provided supervised classification at 100 x 100 m ground resolution for the whole municipality of Tirana in 100 by 100 m ground resolution. This satellite data based analysis was carried out using 5-15 training areas for each LCZ type.
- Using LCZC, an ArcGIS-based toolbox that provides LCZ classification based on open access Copernicus data (Oliveira et al., 2020). The method works with mandatory inputs (except 'Building Height') freely accessible from the Copernicus Land Monitoring Service (CLMS). As a result, it creates a raster-type map with a ground resolution of 50 by 50 m.

The three LCZ map representations of Tirana all have advantages and disadvantages. The large scale mapping, based on the highly detailed vector data, more effectively identifies the varying urban climate zones on the level of city planning (Figure 1B). The disadvantage of this mapping in a dynamically changing city is the stationarity of the information and the difficulty in obtaining building pattern data. The overall results of the vector-based method showed that 88% of the pilot area was classified as urban (rather than nature) climate zones, confirming the current predominance of buildings over green spaces, which should not be increased further if sustainable urbanization is to be achieved.

The medium-scale map produced by the LCZ Generator was created from freely available and up-to-date data using an open-source online tool. The analysis covered a larger area than the pilot zone compiled through QGIS spatial queries. The map serves rather an overview purpose, as its resolution does not allow us to understand the fine structure of the urban area (Figure 1A). Using the LCZ Generator method, a total area of 107.3 km^2 was analyzed and categorized into LCZ classes, where the urban-type climate zones were classified as compact midrise (5.78 km^2 - 5.38%), compact low-rise (5.2 km^2 - 4.48%) and compact high-rise (3.21 km^2 - 2.3%). Further analyses focusing only on the pilot area cannot be done, as the output is a simple image and the statistics provided are summarized for the total area.

The advantage of using the LCZC Toolbox also lies in the use of free data from Copernicus Open Access Hub. It produces a map with better resolution than the LCZ Generator (Figure 1C), but it must be run on a local computer in an ArcGIS environment, which is a commercial program. Classification based on LCZC resulted in a different pattern of classes in

the pilot area examined using the vector-based method (Figure 1D), with some of the categories only matching in terms of LCZ class name, and it is important to highlight the fact that none of the calculated values match (Figure 1 graphs).
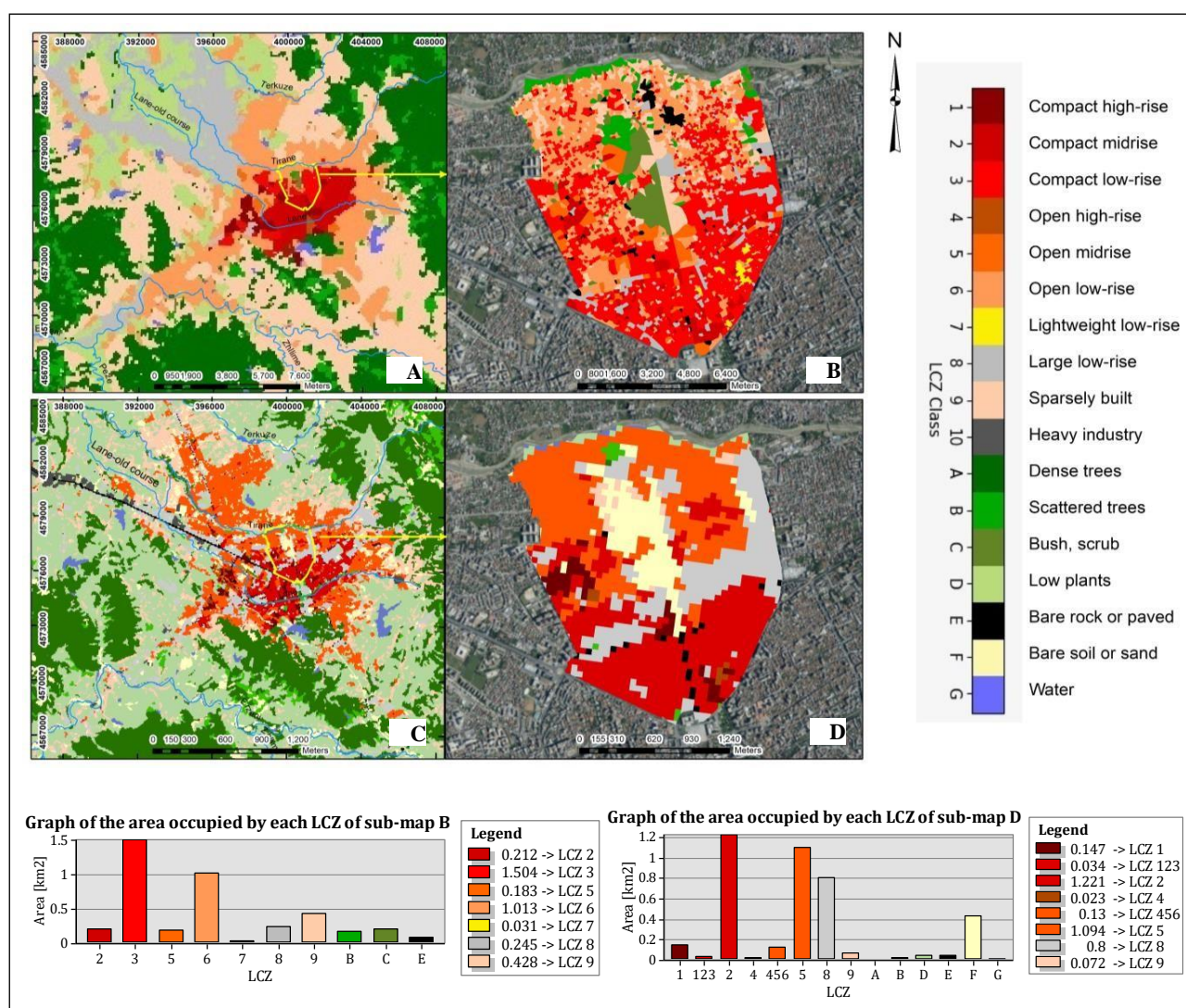

Figure 1. Local Climate Zone maps of Tirana municipality through different approaches. The large-scale map (B) on the top right corner shows the pilot area compiled through QGIS spatial queries, while the medium-scale map on the top left corner (A) was compiled using the LCZ Generator. The Local Climate Zone map of Tirana and its surroundings, compiled using the ArcGIS Toolbox "Local Climate Zones from Copernicus" is shown in the bottom left corner (C), while the bottom right corner (D) presents the same results but focused on the pilot area. The graphs for sub-maps B and D provide information on the area covered by each LCZ class according to each method. As base map, orthophotos from 2018 were used, which cover the area of Tirana-Durres. The coordinate system is UTM Zone 34N (WGS84).

LCZ maps are important media for increasing people's awareness. These maps show the state of the urban environment and the dynamics of its change. They can help people understand the values we expect decision-makers to uphold in Albania and beyond.

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