Determination of Urban Growth by the Night-Time Images

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INTRODUCTION

Urbanization in Turkey and the world has continued to increase especially in the last 30 years. For developing countries, urbanization is a necessary phenomenon, especially in terms of the sustainability of urban growth. However, this growth must be controlled and in a planned manner, otherwise it could lead to many environmental problems. Therefore, urban areas, having a dynamic structure, should be monitored regularly and identified. Adequately accurate current data, which changes temporally and enables to monitor urban development and land use at regular intervals, are needed. Remote sensing technology is one of the most preferred methods in recent years to determine the urban areas developing fast and dynamically.

Within the scope of this study, using night-time images integrated with GIS, the spatial extent of urban areas in Turkey was identified and the methods used in the identification of the urban areas were compared. To determine the urban size of the cities in Turkey, DMSP- OLS (US Air Force Meteorological Satellite Program (Defense Meteorological Satellite Program) - Operational Line Scan System (Operational Linescan System) night-time images belonging to 2010 were used. While determining the urban size from night-time images, two different image analysis methods, object-based and pixel-based, were used. Object-based image analysis method involves image segmentation and pixel-based classification method involves natural breaks and Otsu method. By comparing the results obtained through these three methods, the method that gives the most accurate urban area size has been determined. Through the comparison of these methods' features used in the determination of the urban areas, the differences, advantages, and disadvantages of these methods have been revealed.

BACKGROUND

Urbanization is quickly increasing in the world and according to data of the United Nations Population Fund it is estimated that the world's population will be 12 billion by 2050, 80% of this population will be living in cities. In our country where an intensely urban migration from villages has been observed, there has been a clear increase in the urban areas. The effects of this increase occurring in urban areas on the social, economic and cultural characteristics of a city and population are inevitable.

Observation and evaluation of these changes occurring in urban areas are crucial for making balanced and sustainable urban development. Today, through the use of remote sensing and information technologies, the assessment process of data is accelerating and the productivity is increasing. In recent years, night-time images have been often used in the studies that determine the urban areas. The fact that these images can be accessed quickly and their assessment process is fast increases the interest in the night images.

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The method was used to detect a threshold value for Chicago, Miami and Sacramento states in the USA. Maps of urban areas were created from night-time images in accord with this threshold value (Imhoff et al., 1997).

It has been showed that a single threshold value in night-time images has been more appropriate to determine the urban areas for different metropolitan regions. Therefore, Henderson et al. have indicated that the threshold value of the data in night-time images should be determined separately for each year for which a temporal analysis needs to be carried out for urban growth detection (Henderson et al., 2003).

As there is very little fluctuation in light intensity in Italy's Sicilian city at night, Elvidg et al. have implemented a quadratic regression model to inter-calibrate among years by using the data of the city as the reference data. The purpose of using a single city for calibration in night-time images is to correct the changes according to the years in the satellite and detector sensors (Elvidg et al., 2009).

By examining the global economic and demographic differences of night-time images, Levin and Duke conducted a study that could be used as an indication of the demographic and socio-economic characteristics of the residential area at a local scale. In the study, the population data of the settlements Israel and West Bank (Arab and Jewish) were compared. It has been stated that the economic and geopolitical differences between Israel and the West Bank lead to pattern differences in night-time images (Levin & Duke, 2012).

Liu et al. carried out a study to uncover the relationship between making timely and right decisions about the dynamics of urban expansion in China between 1998-2002, urban growth, and the ecosystems and to optimize the ways of land use (Liu et al., 2012).

The study aiming to identify the variations of urban areas in major metropolitan areas in China between the years 2000-2010 consists of three steps; an average threshold for the reference year is determined in the first step, invariant features (Pseudo Invariant Features) on the urbanization process are determined and then are normalized with respect to DMSP-OLS data PIF value. Linear regression model was applied in the normalization process. Furthermore an optimal threshold for urban area detection for each year has been designated with respect to reference threshold value and urban areas have been identified based on this (Wei et al., 2014).

MAIN FOCUS OF THE ARTICLE

The aim of this study is to obtain the urban sizes of 81 cities in Turkey by utilizing satellite imagery for 2010. Another object of the study is to apply different image analysis methods in order to determine the method which gives the optimal result in obtaining urban size and to compare these methods with each other. In this study, it is planned to compare two different methods, including object-based and pixel-based.

Used Data: What Are Night-Time Images

Night-time images for 2010 have been used to determine urban areas in Turkey. The NGDC started to develop algorithm in 1994 for global cloudless yearly night lights products collected by U.S. Air Force Meteorological Satellite Program (Defense Meteorological Satellite Program, DMSP) Operational Linescan System (Operational Linescan System, OLS). Temporal series of products are available at http://ngdc.noaa.gov/eog/dmsp/downloadv4composites.html and night-time images for the study area have been retrieved free of charge from this address.

By analyzing the location information, frequency and light image in temporal series of images, four kinds of main light sources in the world: settlements, fires, gas flares and fishing boats can be distinguished. Each pixel has 30x30 arc-second (or 0.86 km2 at the equator) resolution and the images cover the area between +180 and