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Research article

Change detection using Landsat images and an analysis of the linkages between the change and property tax values in the Istanbul Province of Turkey

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ABSTRACT

In this study, the Istanbul Province was monitored using Landsat 5 TM, MSS, Landsat 7 ETM+, and Landsat 8 OLI imagery from the years 1986, 2000, 2009, 2011, 2013, and 2015 in order to assess land cover changes in the province. The aim of the study was to classify manmade structures, land, green, and water areas, and to observe the changes in the province using satellite images. After classification, the images were compared in selected years to observe land cover. Moreover, these changes were correlated with the property tax values of Istanbul by years. The findings of the study showed that manmade structure areas increased while vegetation areas decreased due to rapid population growth, urbanization, and industrial and commercial development in Istanbul. These changes also explain the transformation of land from rural and natural areas to residential use, and serve as a tool with which to assess land value increments. Land value capturing is critical for the analysis of the linkages between the changes in land cover, and for assessing land transformation and urban growth. Due to inadequate market data, real estate tax values were used to analyze the linkages between detection changes, land cover, and taxation. In fact, the declared tax values of land owners are generally lower than the actual market values and therefore it is not possible to transfer the value increasing of land in urban areas by using property taxation from the owner to local and central governments. The research results also show that the integration of remote sensing results with real estate market data give us to determine the tax base values of real estate more realistically.

1. Introduction

The remotely sensed data enable researchers and decision-makers to monitor changes in an area of interest in the long term without in situ observation in the field. For this reason, it is less costly and less labor to collect data and analyze the change detections, and it also serves to explain the reasons for these changes and linkages with the socioeconomic data. Remote sensing has wide range of application area in the change detection analysis. One of the most important applications of the remote sensing studies in change detection application is the analysis of land cover and land use studies (Rawat and Kumar, 2015; Hegazy and Kaloop, 2015; Butt et al., 2015). Some of the studies were conducted by only observing land cover changes of an area while others correlated this changes in land with social data as secondary data. For instance, Kwarteng and Chavez (1998) studied change detection of Kuwait City and environs using multi-temporal Landsat Thematic Mapper data to observe change in the land cover. Jensen and Toll (1982) also detected residential land-use development at the urban fringe. Another study was conducted by Sexton et al. (2013) for detecting land change in urban. The authors observed continuously the urban growth of the Washington, DC, and Baltimore, MD metropolitan areas over a long period. Many other studies about urban change detection and land cover changes can be found in the literature (Yin et al., 2005; Lu et al., 2009; Griffiths et al., 2010; Wakode et al., 2014; Mihai et al., 2015; Zhang, 2001; Zhang et al., 2013). Relation between change in the land cover and social and environmental data are also studied in the literature. For instance, remote sensing maps and socio-economic data are related in land use

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change (Long et al., 2007; Irwin and Geoghegan, 2001). Multi-temporal Landsat data are related with land cover and land management decisions making (Yuan et al., 2005). Tian et al. (2005) studied relation of economic growth environments, land cover changes, and macro-urban development policies. Red River Delta's (Vietnam) land cover change and relation to aquaculture is studied by Béland et al. (2006). Change in land cover and its relation with environmental variables in Hesse, Germany is another example of correlation studies between change detection and a secondary data. (Hietel et al., 2004). Many other studies that relates land cover observation from remotely sensed data and any other secondary data can be found in the literature. However, relation between real estate data and land cover studies in the literature is not observed. The aim of this study is to discover correlation between land cover change and increase/decrease of property values.

In this study, to relate land cover change and real estate tax value as a secondary data, Landsat images of Istanbul that are freely available on the US Geological Survey website were used. Istanbul is one of the fastest expanding cities in Turkey, and the expansion of the province is very explicit in statistical terms. In the present study, determining the change of Istanbul area was proposed using remote sensing data for the last three decades (1986–2015). Urban area change detection with remote sensing data has already been studied by Sunar (1998), Geymen and Baz (2008), Maktav and Sunar Erbek (2005), and Akın et al. (2015). Unlike the other change detection studies on Istanbul, the present study analyzed relations between changes in manmade structures, land value increments, and the possibilities for transferring these kinds of value gains to the local and central governments through property taxation instruments were analyzed. In fact, land use affects land cover and changes in land cover affect land use in general (Ayuyo and Sweta, 2014). The meaning of increasing manmade structure in urban sprawl is directly affected the use of land and land market values. The analysis results of change detection may integrate with the data related to sale prices, assessed values, and inspection dates by using remote sensing displays.

The change detection analysis results are assessed from the viewpoint of increasing the manmade structure and nature of real estate based urban development in Istanbul. By this aim, the 1986, 2000, 2009, 2011, 2013, and 2015 Landsat data were used to monitor Istanbul. These years were chosen since the image data from these years contained almost no cloud coverage, which could have adversely impacted the results. Therefore, the time interval of the data sets used in this study vary. Quality control of the classification results were conducted both quantitatively and qualitatively. According to quantitative quality control overall classification accuracy found between % 79-% 88 and overall kappa statistics calculated between 0.6830 and 0.8451. After classification the results are compared with tax values. For the comparative analysis of the Landsat data tax values of the urban and rural lands were defined in the closer years. The real estate tax values for the 1986, 2002, 2006, 2010, and 2014 years were assessed by the real term and the increases in land values in urban and rural areas were compared with change detection in the province of Istanbul.

2. Description of the study area

The province of Istanbul connects the continents of Asia and Europe. The Istanbul province is located between 41.0082° N and 28.9784° E Latitude and Longitude. Fig. 1 illustrates the official borders of Istanbul, which was chosen as the study area. Istanbul is the most crowded province in Turkey. According to official census results, 18.62% of the country's total population live in Istanbul (Fig. 2, Table 1).

With the adoption of market economy and development policies focused on industrialization, along with the effect of increased use of machinery in agriculture in the period after 1950 in Turkey, intense migration to large cities with better living conditions and job opportunities started and large cities, particularly Istanbul, grew rapidly. The total population in the Istanbul province was 806,863 in 1927, 1,166,477 in 1950, 5,842,985 in 1985, 10,018,735 in 2000, and 14,657,434 people in 2015 (Fig. 2, Table 1). While the province's population increased by 1.44 times in 1927–1950, it increased by 5.01 times in the 1950–1985 period, and 2.05 times from 1985 to 2015. The total number of households increased by 10.35 times, while the average household size decreased by 24.84% in the 1960–2015 period. The increase in the total population and the increase in the number of households are not at the same level and the average household size is decreasing rapidly (Table 1). Physical population density in the province was 147 persons/km^2 in 1927, 216 persons/km^2 in 1950, 1022 persons/km^2 in 1985, 1835 persons/km^2 in 2000, and 2821 persons/km^2 in 2015. The settlement with the highest density of population in Turkey is the Istanbul Province and the increase in the physical population density has resulted in narrowed open and green spaces as well as agricultural, pasture and forest land assets, and has led to a rapid increase in residential and commercial areas.

There are currently 728 neighborhood settlements distributed over the 39 sub-provinces established within the province. In 2012, 1.05% of the total population lived in rural areas and 98.95% lived in sub-provincial centers and within the boundaries of zoning development districts. Almost all of the people in the province are employed in the industrial and service sectors, and the number of households that are actively engaged in and provide their income from agricultural activities has remained quite limited. The share of the residential areas in the total area of the province has increased rapidly and reached 31.29% of the provincial area. The total number of housing units in the province is 2,291,228, which is proportional to the number of families and the average household size, and it is clear that a small number of households have two houses and that there is a limited number of vacant housing units (TurkStat, 2016); see Table 2.

The distribution of farmland based on utilization types may be classified as farmlands (arid and irrigated), orchards and vineyards, vegetable and flower fields. Farmland have decreased rapidly in the last three decades in the province, to the extent that even the lands allocated to meet the needs of the resident population of the province for perishable foods such as vegetables in the development plans of the 1950s have increasingly been made available for development. According to data from 2015, the total agricultural area in the province is 71,542.20 ha and the share of agricultural lands within the provincial area has dropped to 13.10 percent. In the 1970–2015 period, which saw intense population growth due to internal migration and births, very high decrease rates were observed – for example, 40.5% in farmland and 45.62% in pasture lands and a period of destruction of natural assets was experienced (Table 2). There has been a decrease in areas such as bare rocks, rubble, dry river beds, and scrub forests owned by the Treasury, as well as agricultural, meadow, pasture, and forest land assets, and land in these areas was converted to residential and commercial purposes in this period. The reasons for the rapid development in the increased industry and commercial activities in the province clearly include residential structures towards meeting the needs of the growing population, commercial real estate investments and the rapidly increasing constructions of buildings with educational, cultural, administrative, and social purposes. The total land assets in the province will rapidly be converted into settlements over time, which will cause the destruction of the natural flora and land assets that should be protected.