EVALUATION OF MULTI-TEMPORAL/SENSOR DATA FUSION FOR URBAN CHANGE ANALYSIS

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ABSTRACT: Natural Resource Management, Planning and Monitoring programs depend on accurate information about the land cover/use for varying sized regions. Satellite sensor images with moderate to various resolutions have facilitated scientific research activities at landscape and regional scales. In this study, a part of Istanbul metropolitan area that faced a great land cover/use change was investigated. For that purpose, 1992 dated SPOT 4 panchromatic image was fused with 2017 dated Landsat 8 OLI multispectral data. As an inverse approach 2017 dated Landsat 8 OLI Panchromatic image was fused with 1984 dated Landsat 5 TM multispectral data. Image fusion processes was performed using Gram Schmidt spectral sharpening algorithm which integrates all bands of the multispectral image into fusion. After fusion operations, two image datasets were classified in order to determine land cover/use changes. Results of the study showed that proposed methodology provided efficient and rapid determination of the changes due to their distinct spectral characteristics from their surroundings in fused images. These methods add significant advantages for land use/cover classification.

1. INTRODUCTION

Turkey faces rapid population increase as similar with other developing countries of the world. In addition to increase in population, migration from rural areas to metropolitan cities also increased due to socioeconomic reasons. This phenomenon also triggered the demand for urban areas in metropolitan cities day by day. The population of Turkey increases averagely 2.2% per year. While the city population was holding %24 of total population in 1945, it increased to %58 in 1985 and reached to % 68 in 2010. According to the statistical studies performed between 1990 and 2010, the population increase rate was 2.9 % in urban areas and –0.75 % in rural areas. It is not possible explain this unbalanced situation just with birth and death rate. In addition to this, rural area populations consisted of older people. One of the most important problems of Turkey is the rural exodus to big metropolitan cities. This migration causes to rapid changes in the land use/cover and unplanned development urbanization at surroundings of metropolitan cities.

Istanbul is not just a metropolitan city of Turkey but also is one of the very important major cities of World. Urban growth and migration results with new urban areas in surrounding of city center and also increase the population density in current urban lands. Developments in service industry and employment opportunities increase the attraction of the city.

This situation accelerates the land use/ cover (LULC) change rate and results with a dynamic LULC characteristics. Especially, agricultural lands and semi vegetated areas are the most negatively affected classes from intensive urbanization. Satellite images have been widely used for decades for monitoring the changes of LULC. The satellite sensor images with high resolution and accuracy is an important source for analysis of such kind of problems (Kaya, 2007). Urban land use change detections have been analyzed using remotely sensed data by many researchers (Ridd and Liu 1998, Tapiador and Casanova 2003, Kaya and Curran 2006, Southworth, 2004, Weng 2012, Taubenböck et al. 2012). Monitoring the trend of changes in urban land use classes with time were the objectives of many remote sensing studies (Ridd 1995).

The main aim of this study is to demonstrate a new perspective to multitemporal/sensor image data fusion to produce effective data source for LULC change analysis. For that purpose, two different datasets were produced. As a first data set 1992 dated SPOT panchromatic data was fused with 2011 dated Landsat 5 TM multispectral data. For the second data set, 2017 dated Landsat 8 OLI panchromatic image was fused with 1984 dated Landsat 5 TM multispectral image. Fused images were inspected visually in different band combinations for detecting the expected enhancements of proposed method. Additionally, data sets were classified to determine the LULC changes. Results of the study demonstrates important findings about LULC changes in surroundings of the city center of Istanbul metropolitan area.

2. DATA SET AND METHODOLOGY USED

Study area was selected as the middle part of the Istanbul metropolitan area where the dramatic changes in LULC occurred (Figure 1). For the preparation of the datasets firstly 6 September 1992 dated 10m spatial resolution SPOT Panchromatic image was fused with 06 July 2011 dated 30m resolution multispectral Landsat 5 TM image using Gramm – Schmidt algorithm. Secondly, 23 June 20017 dated 15m resolution Landsat 8 OLI Panchromatic image was fused with 12 June 1984 dated Landsat 5 TM multispectral image using the same algorithm. Both data set were registered and recorded in UTM coordinate system with Root Mean Square Error ± 0.5 pixel.

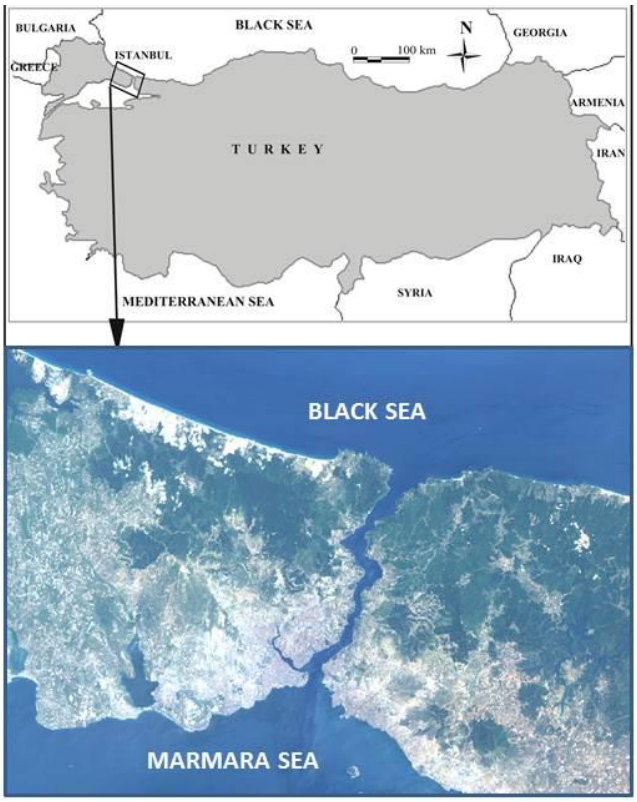

Figure 1. Study Area

The selected fuse algorithm - Gramm-Schmidt - is normalizing the all channels of multispectral imagery according to panchromatic data. Fuse operation is performed to include all bands of multispectral image (Kaya and Seker, 2012). Figure 2 illustrates the first fused data set in 6,6,1 band combination in which urbanized lands are clearly observed.

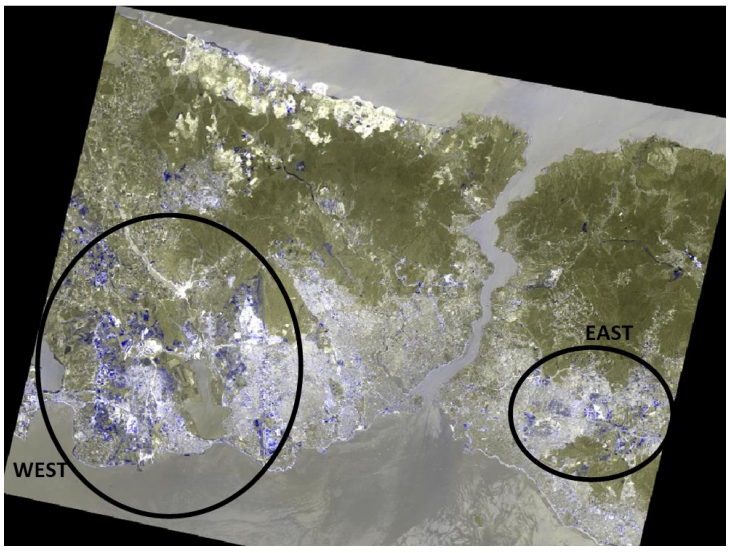

Figure 2. Merged data set (band combination of 6, 6, 1)

According to Figure 2, urban areas increased in west – east direction of the city between 1992 and 2011. Forest areas in North direction were destroyed due to open mining areas. Visual inspection results showed that European side of Istanbul faced more urbanization than Asian side. Results also verified by ISODATA unsupervised classification of the image.

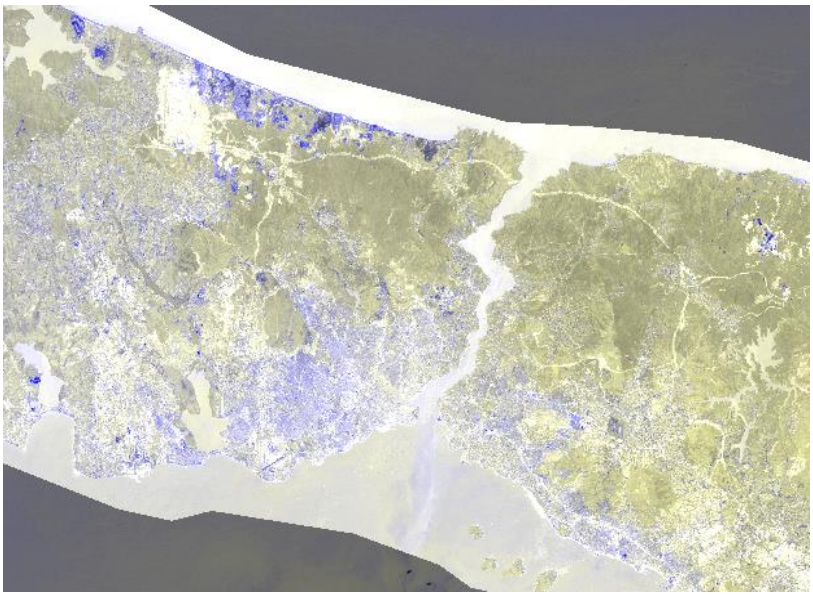

Figure 3. Second Data set - Image of Merged data set (band combination of 6, 6, 1)

In Figure 3, new settlements and impervious surfaces are identified by white color, while blue colored lands correspond to urban areas that are present in 1984 and becoming greater or dense within time.

3. RESULTS

In this study, the Gram-Schmitt method which is a new data fusion method, was used to merge old data has higher geometric resolution with Landsat 5 TM data. In general, land use/cover changes were calculated for whole area using 3 band combinations of 6^{th} bands obtained from this merged image (e.g. 6,3,6- 1,6,6-6,6,2). Obtained results for the combination of 6, 6, 1 is given in Figure 2. The changing areas were represented with different colors according to band combinations and the unchanging areas have remained in different tones of black color. Second data set which contain a recently dated dataset which has higher resolution (Landsat 8 OLI P) and 1984 dated Landsat 5 TM data which has higher radiometric properties were merged using same method. Obtained changes from this dataset were presented in Figure 3.

The changes in the industrial zone of Ikitelli, which started to be constructed in 1988 as a development alternative for Istanbul, has now transformed into major change areas with new housing areas as seen in Figure 4. Land use/cover changes in this area were calculated using mentioned method in a very short time. This was classified and the amount of the changes were calculated. Obtained results were presented in Figure 5.

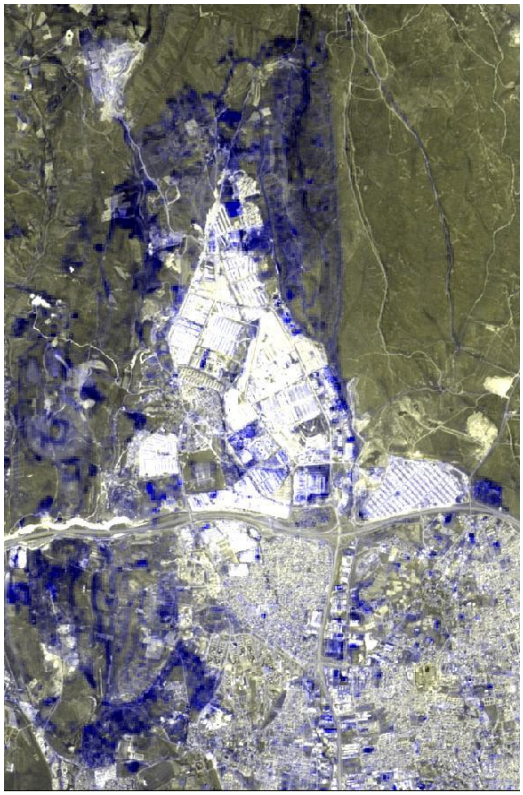

Figure 4. Fist data set: Merged data bands 6, 6, 1

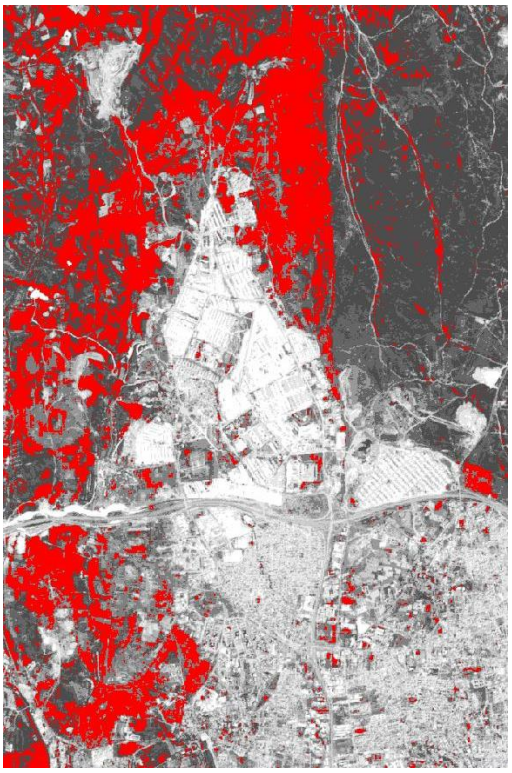

Figure 5. Classified merged data (Red indicates the changed areas in urban)

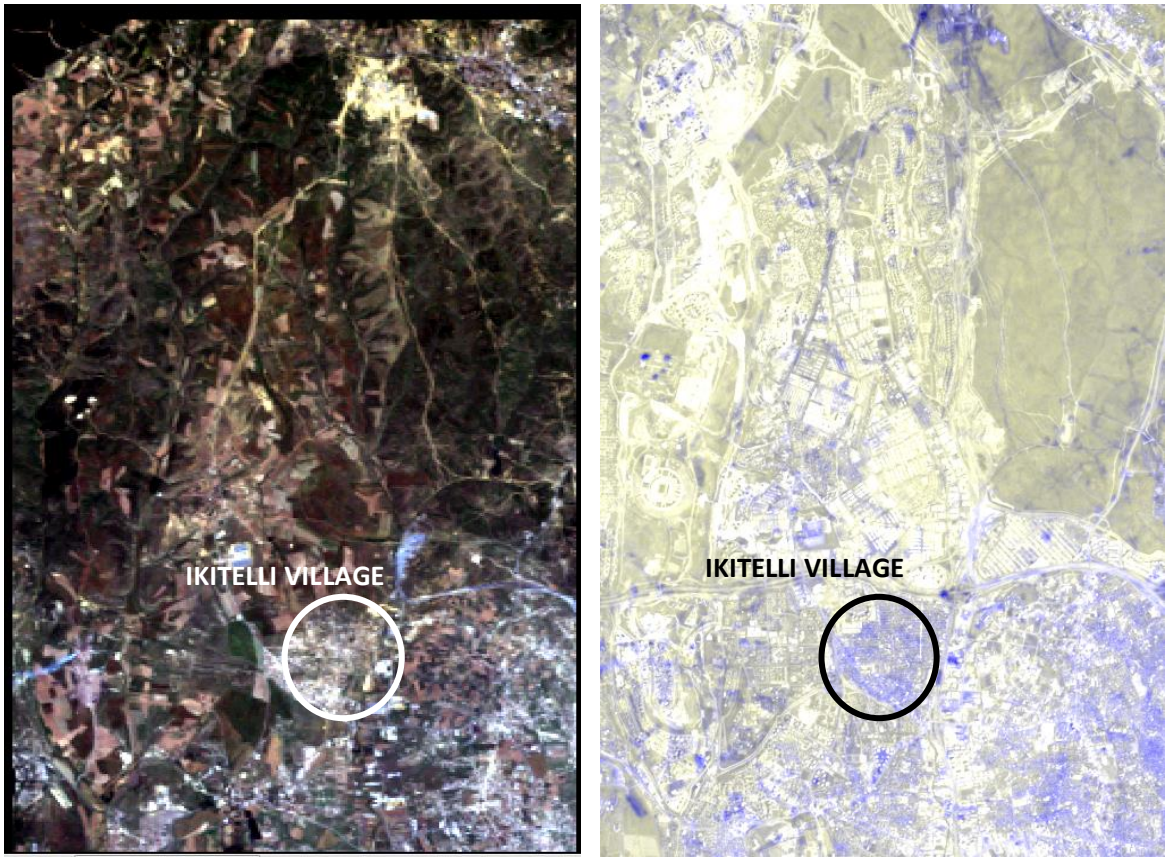

Figure 6. Second Data set: a) Landsat 5 TM image (3, 2, 1) 1984, b) Merged data bands 6,6,1

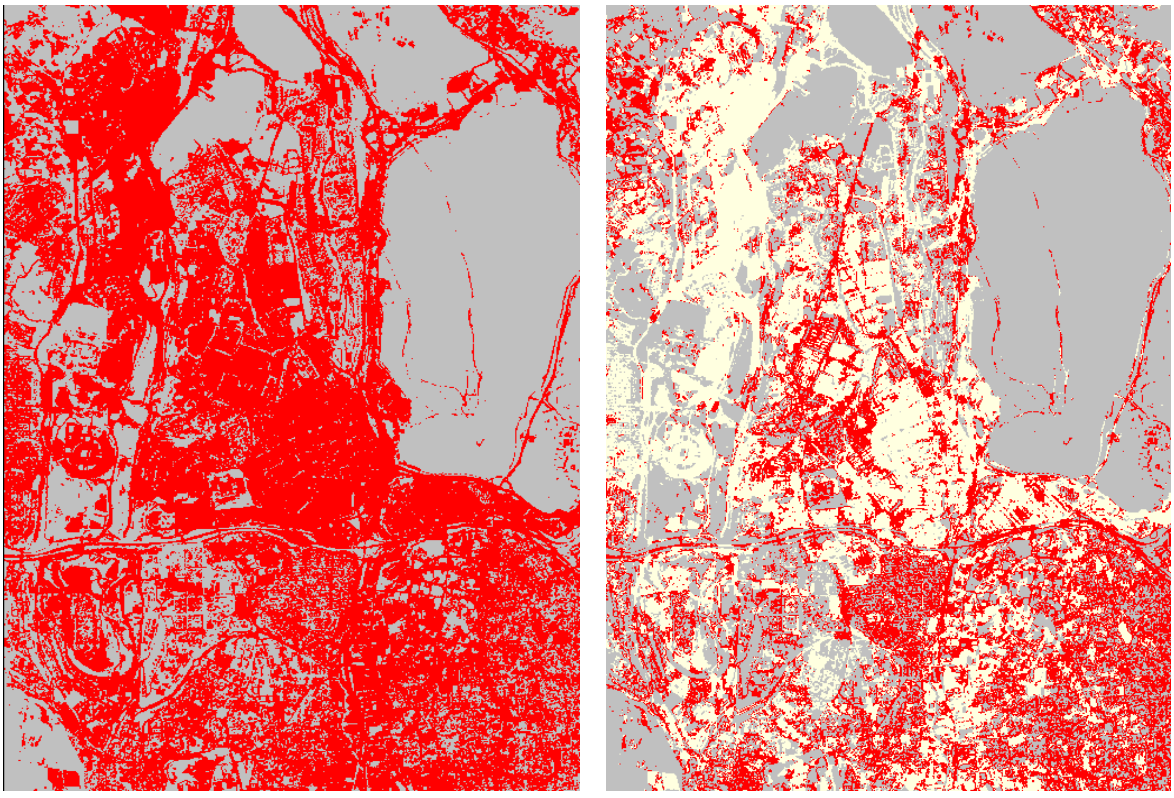

Figure 7. Classified merged data; a) Red indicates the changed area in impervious surfaces b) Red indicates the area were impervious surface in the year of 1984 which were condensed later and white represent the new impervious surface areas made after the year of 1984.

Panchromatic band of 2017 Landsat 8 OLI and all multi-spectral bands of the 1984 Landsat 5 TM were merged using Gram-Schmidt method and changed areas between these years were obtained (Figure 3). These areas were classified in areas where land use/cover was intensively changed and the amount of change was determined (Figure 6 and Figure7). In Figure 7 (a), areas were not changed in land use/cover represented with grey tones while changed areas with red. Most of the unchanged areas are in the military zone, thus were preserved and protected. On Figure 7 (b), the area of impervious surface in the year of 1984 which were condensed later is represented with red and white represent the new growing impervious surface area after the year of 1984.

4. DISCUSSION AND CONCLUSIONS

Determination of land use/cover changes using satellite sensor data is the most important advantage of remote sensing science. Land use/cover changes in the larger areas are determined easily in a short time. Obtained results are reliable and can be analyzed. This study has shown that combining old dated data which has higher resolution with recently obtained data which has higher radiometric resolution including thermal band has given a new dimension to the determination of land use/cover changes. Ikitelli study area selected for this study covers 7509.0 hectares. According to classification results carried out by using ISODATA method changed areas were calculated as 1459.0 hectares. When the area of land use/cover changed was compared to the total area, 19.4% of the study area was determined as changed area.

In the second phase of the study, the reverse process of the first phase was realized, namely the 1987 multi-spectral data merged with the panchromatic data of 2017. The changed areas have been determined rapidly. According to obtained results, 6337 hectares of 7509 hectare area were identified as impervious surface area. 2298 hectares of this area was identified as the condensed of the existing impervious surface after the year of 1984 and 4039 hectares was defined as the newly constructed impervious surface area in the study region. The geometric predominance of high-resolution data has been clearly observed on the merged images. However, the changing areas of land use/cover have been defined through multi-spectral data, which has better radiometric properties. As a conclusion it is suggested that the proposed method could be used as a rapid method for determining changes in land use/cover. Aldo, the results can be used for control of the classification accuracy.

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