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Land Use Change Detection of Maragheh City and Its Implication for Agricultural Area and the Orchards by Using the Multi-Temporal Satellite Imagery

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ORIGINAL ARTICLE

ABSTRACT: Urban growth is one of the complex behaviors which the cities show over passing time and in order to meet the needs of living spaces, working spaces, shopping areas, etc. of its residents. Sometimes this behavior is in contrast with agricultural areas and it causes destruction of this areas. Maragheh is one of the cities whose urban growth process has been in contrast to agricultural areas and this contrast has caused the destruction of agricultural areas and orchards at the price of urban built-up areas. At this paper, the changes of agricultural areas and especially the orchards of Maragheh to built-up areas have been shown between 1984-2011 by using the Landsat TM & ETM+ imagery and GIS. Thus, the images have been classified using Fuzzy ARTMAP method and consequently the process of land use changes have been extracted by utilization of Cross correlation. The results of paper show that about 591 hectares of agricultural areas has been changed to built-up areas in the period of 1984-2011 (hence 45 percent of entire land use changes); 207 hectares of agricultural areas and 16 percent of entire changes to built-up areas consists of orchards. In addition to having ecological effects, Maragheh orchards are one of the indicators of the urban landscape and identity.

Keywords: Land use change, city of Maragheh, agricultural areas, RS & GIS.

INTRODUCTION

Sustainability appears to be the for a guiding principle global society entering the new millennium, superseding almost all others within the environment and development communities (IIASA, 1993; Kidd, 1992). The sustainability principle obscures the distinction between environment and development and encourages the fusion of global change research and sustainable development (Turner, 1997). Sustainable development seeks to balance the conflicts among economic development, ecological preservation, and intergen-erational equity (Berke, 2002) While this balance is beguiling in theory, efforts to manage the conflicts arising from the separate thrusts of environment, economy, and equity have often met with limited success, as noted by Owens and Cowell (2002): In practice, land-use planning proved to be one of the most important arenas in which conceptions of sustainable development are contested. Here, more than anywhere else, it has become clear that trying to turn the broad consensual principles into policies, procedures, and decisions tends not to resolve conflicts, but to expose tensions inherent in the idea of sustainable development itself (Berke, 2002). One of the topics in this case is land use/cover change. Land use/cover change plays a pivotal role in regional social and economic development and environmental changes (Xiuwan, 2002). These human enterprises lead to local land-use and land-cover changes that when aggregated have a global-scale impact on climate, hydrology, biogeochemistry, biodiversity and the ability of biological systems to support human needs (Foley et al. 2005; Sala et al. 2000). Applying new methods in studying land use changes will make investigating of sustainable development easier for authorities. One of these methods is using Remote sensing data and GIS. Remotely sensed data is very useful for mapping vegetation and land use/cover changes in urban areas by overcoming many limitations of traditional surveying techniques to obtain a continuous and extensive inventory of ecosystems (Ridd and Liu 1998; Ward et al. 2003; Rogan and Chen 2004; Gillanders etal.2008;Torres-Veraetal.2009).With the use of remote sensing, it is possible to map and monitor the spatial extent of various factors influencing and contributing to environmental degradation, such as changes in vegetation cover, impervious surface, land use type, and human activities. Remotely sensed data can

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also provide the necessary area-based land use/cover parameters to run different urban change models as well as plausible scenarios used to simulate future response to different planning/management scenarios (Clarke and Gaydos1998; Veldkamp and Lambin 2001; Lo and Yang 2002; Sohl et al. 2007;Tangetal.2007;Yuan2009). The study area is Maragheh city as one of the oldest cities of Iran. It is located in 37°24'51.38"N to 37°20'23.41"N and 46° 9'29.06"E to 46°17'22.49"E. The area of this city is about 1866 hectares and is medium city. This city had a population of 100679 in 1984 that grew to 149929 in 2006 (Census center of Iran 2006). The reason of selecting this city for case study is Increasing the destruction of orchards of Maragheh city is the result of urban growth in the recent years; in addition to being an ecological feature, the orchards of Maragheh city are one of the symbols of urban personality and in this case historians and travelers have referred to the orchards of Maragheh as the main landscape of the city from long past times (Morvarrid, 1981). Figure 1 shows the destruction of Maragheh orchards resulted by urban growth compared the year 1984.

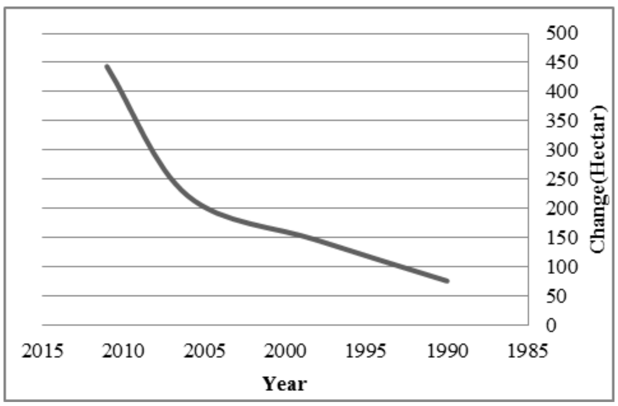

Figure 1. Destruction rate of Maragheh orchards resulted by urban growth compare to 1984 year

MATERIAL AND METHODS

Land use Change Detection

Monitoring of land cover and land use is one of the main applications of remote sensing based change detection. Change detection is the process of identifying differences in the state of an object or phenomenon by observing it at different times (Lu et al, 2004; Singh, 1989). Remote sensing based change detection applies comparison of a set of multi-temporal images covering time period of interest using specific change detection algorithms (Rymasheuskaya, 2007). Various methods have been employed using remotely sensed data for land use/cover change detection for many decades in urban environments (Singh, 1989; Lu et al, 2004; Rogan, 2004). Those methods may be broadly classified into two categories: pre-classification change detection and post-classification comparison (Singh, 1989; Yuan et al, 1998). A variety of change detection techniques has been developed for pre-classification change detection, or simultaneous analysis of multi-temporal data (Singh, 1989; Rogan and Chen, 2004; Yuan et al, 1998). These techniques generally generate "change" vs. "no-change" maps, but do not specify the type of change (Singh, 1989; Lu et al, 2004). Post-classification comparison methods detect land use/cover change by comparing independently produced classifications of images from different dates. Although the post-classification comparison method requires the classifications of images acquired from different times, it can not only locate the changes, but also provide "from-to" change information (Jensen, 2004; Mas, 1999; Yuan, 2005). Among the main advantages of which method are:

- no need in radiometric co-registration of images involved into the analysis (Jensen, 2005);
- lower than of spectral change detection methods sensitivity to the spectral variations due to difference in the soil moisture, vegetation phenology (Mas, 1999);
- Quite high change detection accuracy.

Post-classification comparison change detection was selected to perform land cover change detection in this study. Post-classification comparison change detection is the most commonly used quantitative method of change detection. It requires rectification and classification of each remotely sensed image. These two maps are then compared on a pixel-by-pixel basis using a change detection matrix.

DISCUSSION

In this paper, Landsat TM images are employed for digital images processing that were captured in 1984 and 2011 .The most important characteristics of these images are, 30 meters spatial resolution and 8-bit radio metric resolution capability. The 30 meters spatial resolution of the Landsat Thematic Mapper data is appropriate for many applications of land use/cover classification, because this resolution causes an average effect and reduces most of the land heterogeneities and lead to accurate description of land segments (farms, built-up areas and so on) and linear views like rivers (Mahmoud Zadeh, 2004).

Figure 2. RGB image, 1984 year

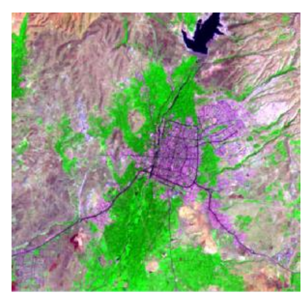

Figure 3. RGB image, 2011 year

After combining desired images, classification of images has been done. Various methods have been employed for classification of satellite imagery. Recently, artificial fuzzy methods have been used widely because

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they indicate very high accuracy in comparison with the conventional ones like Maximum Likelihood Classification (MLC), Minimum Distance Classification, and Parallelepiped Classification (Tong Hou and Pern 2000; Muchoney and Williamson 2001; Reveshty 2011). One of the fuzzy-based (artificial fuzzy) methods is using Adaptive Resonance Theory (ART). Adaptive Resonance Theory (ART) based on the neural network developed by Grossberg and Carpenter (Carpenter et al., 1991) has evolved from the biological theory of cognitive information processing. ART networks are designed in particular to resolve the stability-plasticity dilemma and exhibit a high degree of stability in order to preserve significant past learning, but remain adaptable enough to incorporate new information whenever it might appear (Carpenter, 1989). A comprehensive description of ART models is found in several key citations (Carpenter et al., 1991, 1992; Mannan et al., 1998). Fuzzy ART is a clustering algorithm that operates on vectors with fuzzy analog input patterns (real numbers between 0.0 and 1.0) and incorporates an incremental learning approach which allows it to learn continuously without forgetting previous learned states (Eastman, 2011). In the present work, the fuzzy adaptive resonance theory (Fuzzy ARTMAP) is employed for image classification. First, 741 RGB color composites of Landsat images were prepared. Then training areas were selected for 7 land use and Land cover classes which are built-up area, orchards, water, dry farming, regolith and waste land, grassland, irrigated agriculture land. These training areas were determined referring to aerial photographs and GIS thematic maps. To assess the accuracy of classification, topographic maps and aerial photos were employed. Overall accuracy was estimated to be around 93%. Figures 4 and 5 show the results of land use classification.

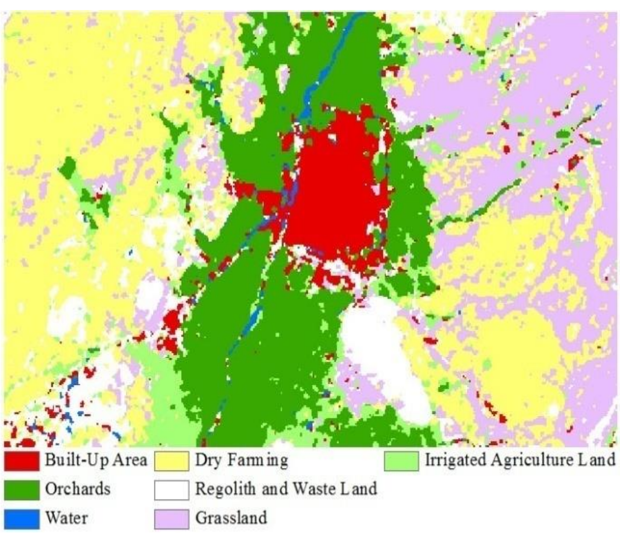

Figure 4. Result of land use classification for Maragheh, Iran using Landsat TM image captured in 1984

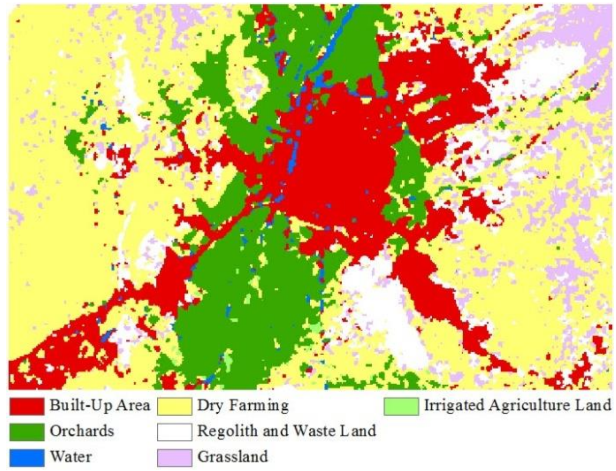

Figure 5. Result of land use classification for Maraghe, Iran using Landsat TM image

In the next step detection of changes between the two periods has been considered. In order to detect rate of changes, post-classification comparisons or cross tab module has been used. With qualitative data, Cross Tab should be used for change analysis between image pairs (Eastman, 2011). Table 1 shows the total rate of land use changes in two periods of 1984 and 2011.

Table of land use changes shows that 47% of land uses have been changed and moreover most changes consist of built-up areas. But the purpose of this paper is to show the changes resulted by the urban growth of Maraghe; in other words, it wants to determine that which types of land use have been changed to built-up areas in urban growth between 1984-2011 and the amount of changes that have caused destruction as well as changes of agricultural lands especially orchards. Figure 6 shows the areas that have changed to built up areas between1984-2011.

As observed, the most changed lands to built-up areas are Grass lands which their rate is about 413.82 hectares. These Grass lands are mostly placed to the north east side of city and they include built-up areas, extended in the years after the war between Iran-Iraq (1991). Three types of agricultural lands included Irrigated Agricultural lands, Orchards and Dry farming lands have also had an important contribution in the extension of built-up areas, so that the 591 hectares of entire built-up areas (1306 hectares) include these three types of lands. It means that about half the built-up areas in the period of 1984-2011 consist of agricultural lands. Also destruction of orchards is considerable at this period of urban growth, so the orchards of Maragheh city have changed about 207 hectares to built-up areas in this period. This change includes 16 percent of entire changes of land use to built-up areas.

CONCLUSION

Urban growth is an aspect of urban complex dynamics that it is done because of urban resident's requirements. In some cases this type of urban behavior is in contrast with agricultural area and because of personal interests this environment is destructed. The destruction of urban agricultural area causes many problems for human in the future and because of this, the experts of sustainable development field identify it as a kind of unsustainability of development; it means a type of development which disregards needs of future generations.

Maragheh city is one of the cities whose urban growth is done with intensity growth and in addition to the waste land; this growth has been at odds with the urban agricultural area. In other words, it has caused destruction and changes of agricultural land especially; it's orchards to urban built-up areas. In addition to their ecological aspects, the orchards of Maragheh city are the main urban landscape and urban identity. Such a problem has led to the formation of some kinds of unsustainability in the urban growth. Land supply for urban built-up area with regard to population growth, direction to the urban growth of cities and in some cases shifting urban growth over the city limits, necessity of urban orchards protection and so on are enumerated as primary requirements of urban growth of this city and it is possible thorough urban sustainable management and by using decision-making tools of urban planning (e.g. geographic information system and remote sensing).

Table 1. Estimated land use transitions in Maragheh city, Iran between 1984-2011 (hectare)

	Built up Area	Orchards	Water	Dry Farming	Waste Land	Grass Land	Irrigated Agriculture	Total	Change %
Built up Area	559.53	207.63	36	225.09	270.27	413.82	153.81	1866.15	14.14
Orchards	11.43	1349.82	17.28	46.53	13.68	9.45	137.97	1586.16	2.56
Water	12.15	44.73	16.83	7.74	9.54	2.25	8.82	102.06	0.92
Dry Farming	34.56	247.05	10.98	2258.91	353.97	718.02	330.39	3953.88	18.35
Waste Land	11.16	10.71	0.45	215.82	253.8	429.39	37.98	959.31	7.64
Grass Land	1.89	7.02	0.54	222.66	42.03	443.97	26.01	744.12	3.25
Irrigated Agriculture	0.09	19.98	0.72	0.09	0	0.72	5.76	27.36	0.23
Total	**630.81**	**1886.94**	**82.8**	**2976.84**	**943.29**	**2017.62**	**700.74**	**9239.04**	**47.09**

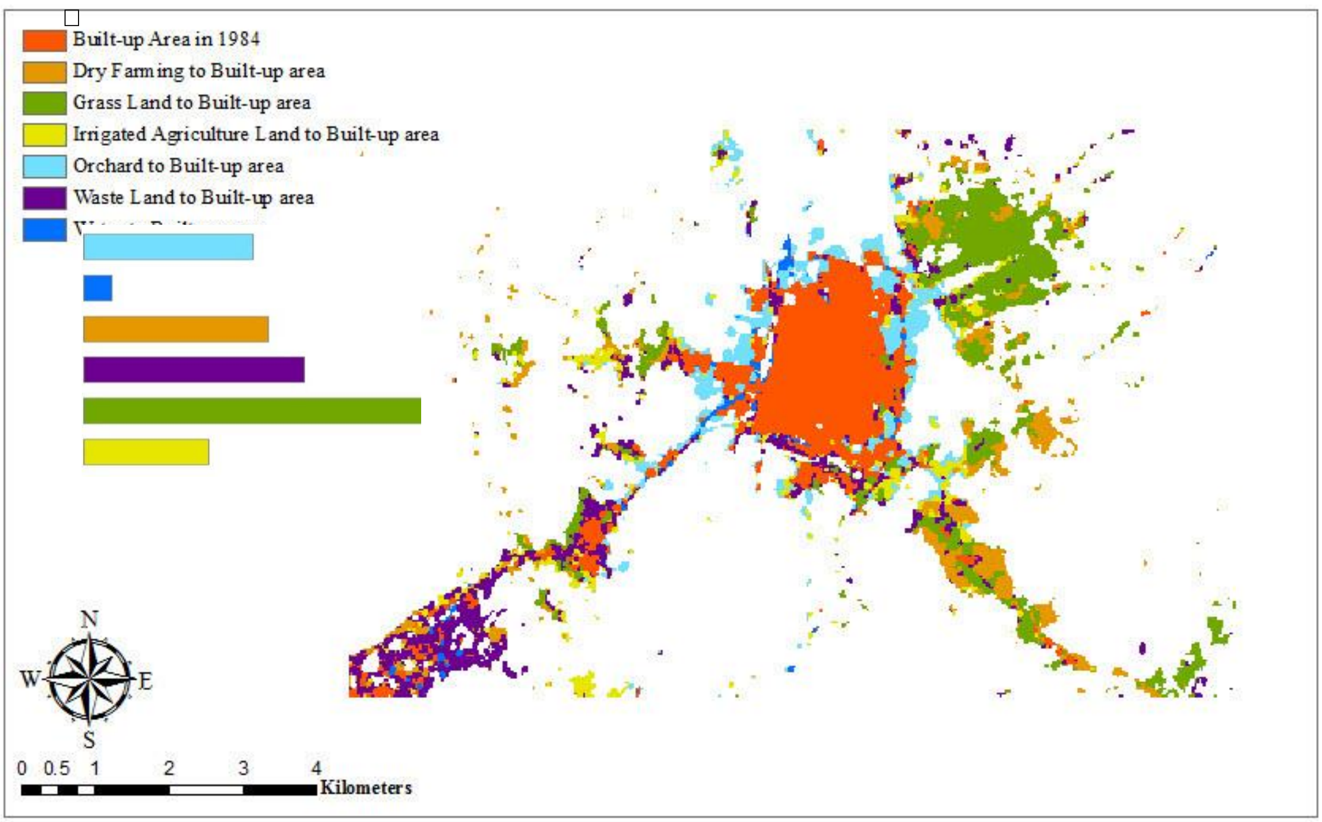

Figure 6. The areas that have changed to built-up ones in the period of 1984-2011

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