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Research Article

LANDSCAPE ANALYSIS BY FRAG STATS TO EXAMINE LAND USE CHANGE CASE STUDY: New HASHTGERD CITY

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ABSTRACT
Landscape analysis has improved in the recent decades and turned into an applicable approach for land use planners and landscapers. New Hashtgerd City (Shahr-e Jadid-e Hashtgerd) has undergone drastic change in terms of socioeconomic structure because of adjacency to the cities of Tehran and Karaj. Considering both increasing construction rate and population growth in this city, in the near future, it is expected that environmental issues and pollutant spread would arise. Thus, this study aims at landscape analysis of the past and the present development as well as anticipating the future development. Accordingly, the city's landscape was identified through satellite date in order to determine status quo to foresee future change. Finally Frag State was employed to carry out landscape analysis – altogether, various applications were used to conduct the study: IDRISI Andes and ERDAS IMAGINE 9.1 for primary image processing, including atmospheric and geometric corrections in preprocessing of satellite data; IDRISI Andes, ERDAS IMAGINE 9.1, and ArcGIS 9.3 and 15.0 for categorizing and processing images. For a comparative study of satellite images from 1990 to 2013 were taken into account, i.e. a twenty-three-year span. The results suggest heterogeneous patches and uses across the area. Development trend shows that a large portion of groves and green spaces will fade away by 1400, and a population of 500,000 individuals will settle the area.

Keywords: *Landscape, Hashtgerd New City, Landscape Analysis, Frag Stats*

INTRODUCTION

The world around us is undergoing numerous alterations. There is nearly no habitat or natural ecosystem across the planet not experiencing change. This is due to human activities and, although adverting long time ago, it has never been a cause of major concern to human until recent decades.

Landscape ecology has improved in recent decades and turned into an applicable approach for land use planners and landscapers. The fundamentals of landscaping have existed in European culture for centuries. However, it was not until 1980, when it thrived in the North America, that these started to catch on worldwide. In the 1990s, scientific discussion about landscape ecology spread rapidly. Afterwards, ecology of vast heterogeneous areas of land, in simpler words land configuration, was adopted widely (NPMO, 2005).

A landscape is a heterogeneous land area with kilometers of expansion composed of clusters of ecosystems and uses repeated throughout. Focus on heterogeneous configuration, such as various neighboring land uses and considering overall landscape form a spatial point of view is increasing. Furthermore, wildlife, plants, water, material, and energy distributed within this settings shows motion, flow, and change predictable within this configuration. Integration of structure and function of landscaped can be perceived and measured by patterns and scales (AzariDehkordi *et al.*, 2010).

Discussion on landscape is applicable to spatial scale, and its focus of interest lies in integrating the human and the nature. Using landscape is applicable to any settings from urban to forest, rangelands, or tundra. Its definition of space is simple, setting a common understanding among decision-makers, professionals, and researchers concerned with land use planning. For example, if there is a need for new road construction, designating a natural reserve, or housing, employing these concepts and providing more ecologic integration will minimize land degradation, and proper technical planning and decision making will shift the community to a successful future. In addition, the simplicity can result in integrated designing and planning, less fragmentation, and less landscape degradation. Also, landscape ecology approaches will help environmental and social issues concerning designing and planning thorough intersect oral solutions (AzariDehkordi *et al.,* 2010).

Remote Sensing (RS) technology using extensive up-to-date multispectral data along with qualitative features can be used in developing maps and defining landscape to fully inform us. However, complex soil type, atmospheric phenomena, and thick vegetation in dry and sub-dry areas undermines collection of reliable data, hindering determining major geographical features like vegetation with less than 30% density. Thus, modern techniques are employed to overcome such problem. Such problem applies to other features as well, including dirt roads, agricultural fields where the crop is harvested, degraded forest areas, orchards combined with agriculture at understory level, etc. Nevertheless, availability of spectral and spatial images of high resolution can tackle such problem (O'Neill, 2001).

Nowadays, considering increasing population growth and scarcity of resources to meet various needs, data and information from satellite images and their processing by information processing applications play a vital role in effective, sustainable management of (scarce) natural resources. RS has proved helpful worldwide because of its unique qualities such as providing an extensive, consistent perspective of an area, employing electromagnetic range to register phenomena, recurrent spatial and temporal patterns, pace of transmission, diversity of images, and applicability of professional application software. It is a tool for assessment, monitoring, control, and sustainable management of the environment and resources like soil, air, water, forest, crops, rangelands, and is gaining a broader range of application.

Literature

Khazaiee and AzariDehkordi (2009) investigated landscape destruction across the SefidRud watershed by using landscape ecology metrics. They considered spatial distribution metrics of patches at landscape level to quantify the status quo (Khazaei and AzariDehkordi, 2010). AzariDehkordi and Fathi (2009) investigated qualitative relationship between road development and landscape destruction around Anzali Wetland across Rasht-Kapourchal Road and the Caspian Sea, where they distinguished two agricultural and urban zones (AzariDehkordi and FathiSaghezchi, 2010). Dehdar (2007) addressed the applicability of landscape ecology to No-hunting Zone of Miankaleh (Khazaei and AzariDehkordi, 2010). Mahini (2007) used landscape metrics and erodibility factors as two quantitative criteria for rapid impact assessment of development projects (Salman, 2008). Herzag and Lausch (2002) employed landscape metrics to monitor landscape change across an area of 700km in eastern Germany. The authors calculated these metrics for the whole area at patch, class, and landscape levels scales. Their results suggested that the patches had less diversity and showed tendency to fragmentation. Furthermore, to evaluate landscape change in Shijiazhuang, China, Shi *et al.,* (2008) combined landscape metrics at class and landscape levels and concluded that doing so contributed to quantifying land use conversion – the study area was undergoing a shift toward unsustainable, human dominated use. Also, Yu and Young (2009) analyzed the change in spatial and temporal patterns because of urban development in Taipei, Taiwan, between 1971 and 2005. This study showed that natural clusters suffered a decrease, while human dominated ones showed an increase regarding both number and diversity. In another study, Tang *et al.,* (2008) compared the temporal and spatial alteration of landscape in Houston, Texas and Daking, China. They examined urban development impact on landscape patterns and concluded that natural landscape had been destroyed in the past 20 years; however, urban landscape experienced a rise.

Study Area

New Hashtgerd City (Shahr-e Jadid-e Hashtgerd) is located on the southern hillside of the Alborz and northern outskirts of Central Kavir, Iran, with a climate ranging between mountainous to dry and sub-dry (nationwide); and Mediterranean (globally). The city's elevation varies between 1,310m and 1.610m.

The temperature usually alters between -10C in winter and 40C in summer. The maximum relative humidity amounts to 80% and annual average humidity is about 45%. The area enjoys abundant precipitation since it is mountainous. The 35-year-old consecutive data on annual precipitation confirms an average annual precipitation of 300mm (Figure 1).

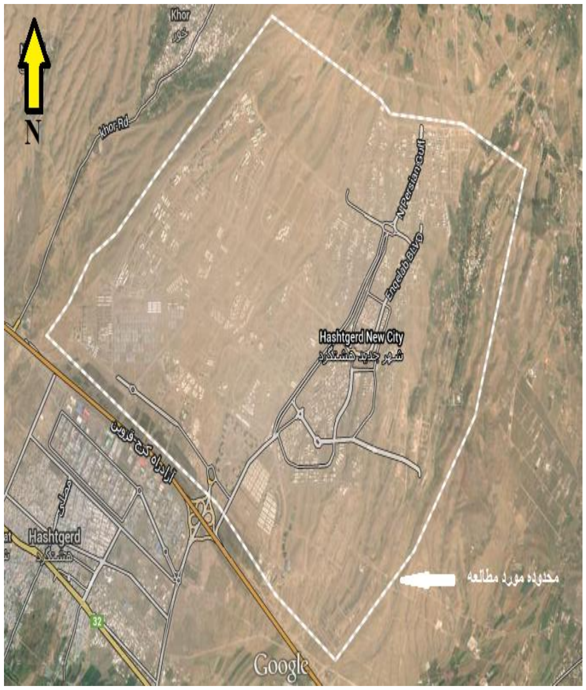

Figure 1: A satellite image of Hashtgerd (Google Earth)

MATERIALS AND METHODS

In this study, TM, ETM+ and landsat images were utilized to examine and plot human land uses and natural spots within the study area. The scope of the study area was delineated in Google Earth, and then plotting human uses and natural spots was carried out. The layers prepared in Google Earth were transferred to GIS environment. Next, all the layers were geo-referenced and ultimately fieldwork verified precision and reliability of the maps. Finally, Fag Stats was employed to conduct landscape analysis.

Table 1: Specification of satellite images

Image	Satellite	Date	Number of Bands	Magnification (m)	Producer
TM	Landsat 4	1990	7	28.5	the U.S.
ETM+	Landsat 8	2013	7	28.5	the U.S.

Landscape Analysis by Frag Stats

Making use of Frag Stat in landscape analysis requires that retrieved maps be of Grid format. Settings pertaining to parameters were modified in Set Run Parameter dialogue box for land use map – based on a study purpose. Since landscape analysis in this study aimed at determining number, size, distance, and shape of patches by using Frag Stat, the following metrics were utilized: NP (patches per land use), CA (average circumference of each patch in a class in hectare), MNN (mean nearest neighboring patch in landscape in meter), and SHAPE (circumference-area ratio of a patch from a class).

RESULTS AND DISCUSSION

Results

Polygonal Uses (Spots)

Hashtgerd area includes four polygonal uses as follows:

Constructed Area

This use makes up for the biggest one involving 202 patches. It has an area of 766.3h. Table 2 shows the related data.

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Table 2: Information regarding the area of constructed land use

Number of patches	Minimum area (m^2)	Maximum area (m^2)	Total Area (m^2)	Average area of pathes (m^2)
202	256.22	771,614.88	27,889,425.88	3,793.51

This spot used to have poor, abandoned pastoral vegetation undergoing intensive development, and because of future development plans will expand in area.

Agricultural Land (Dry Farming)

This land use consists of four patches whose area totals 206h. Table 3 shows the data on this use. It is gradually fading away because of Hashtgerd's new development plan as well as land use conversion. This spot is mainly observed on the eastern side of the study area.

Table 3: Agricultural land

Number of agricultural/dry farming spots	Minimum area (m^2)	Maximum area (m^2)	Total Area (m^2)	Average area of pathces (m^2)
4	30,899.63	1,318,236.18	2,062,082.17	515,520.54

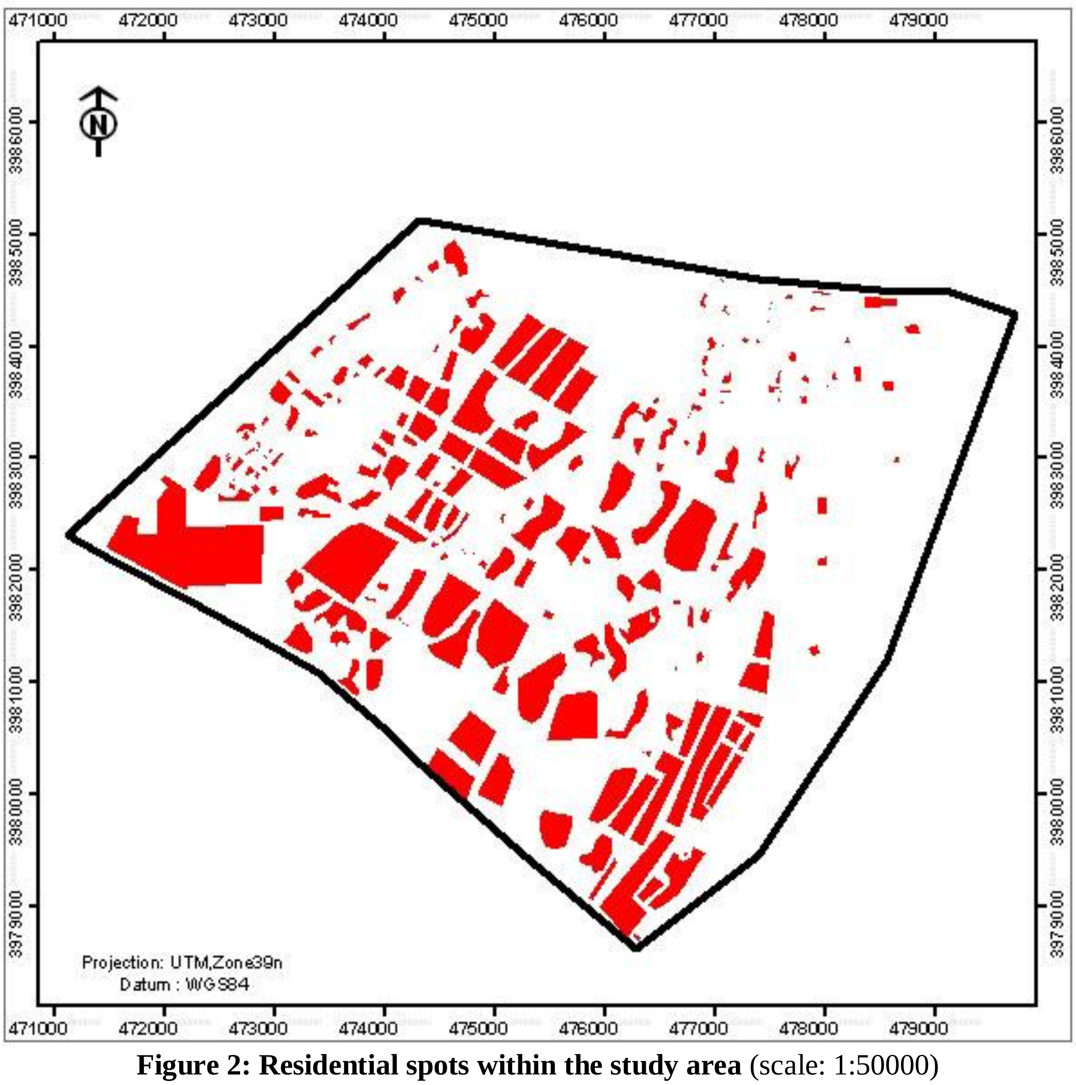

Figure 2: Residential spots within the study area (scale: 1:50000)

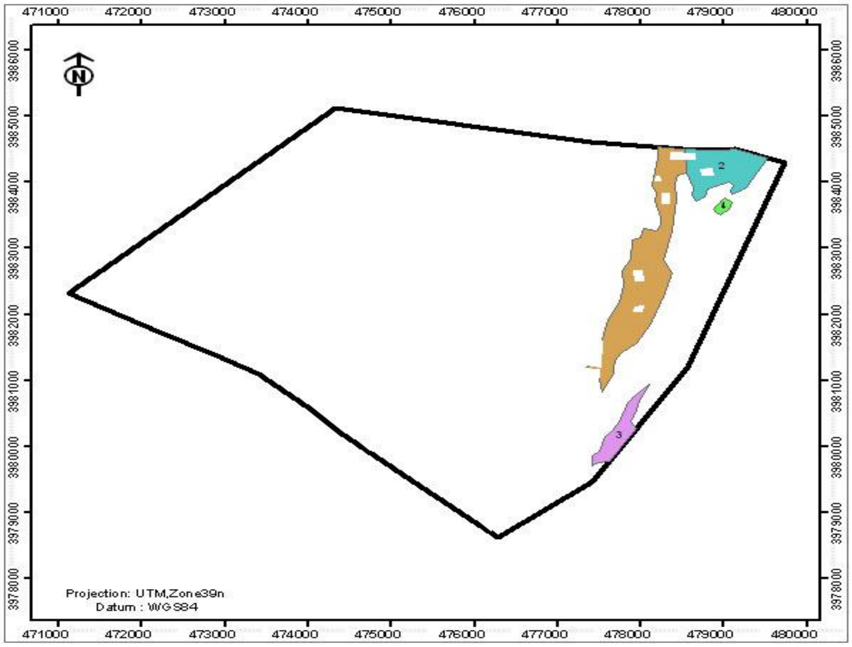

Figure 3: Location of agricultural spots within the study area (scale: 1:50000)

Groves and Miscellaneous Uses

This use encompasses 13 patches with total area of 12.7h. The general information on this use is demonstrated in table 4.

This land use stretches north southward. As groves involve fruit trees which are more resilient, their future is considered more hopeful. However, because of value of estate and based on the analysis by satellite images, reduction in such land use and its conversion to residential purposes is quite likely.

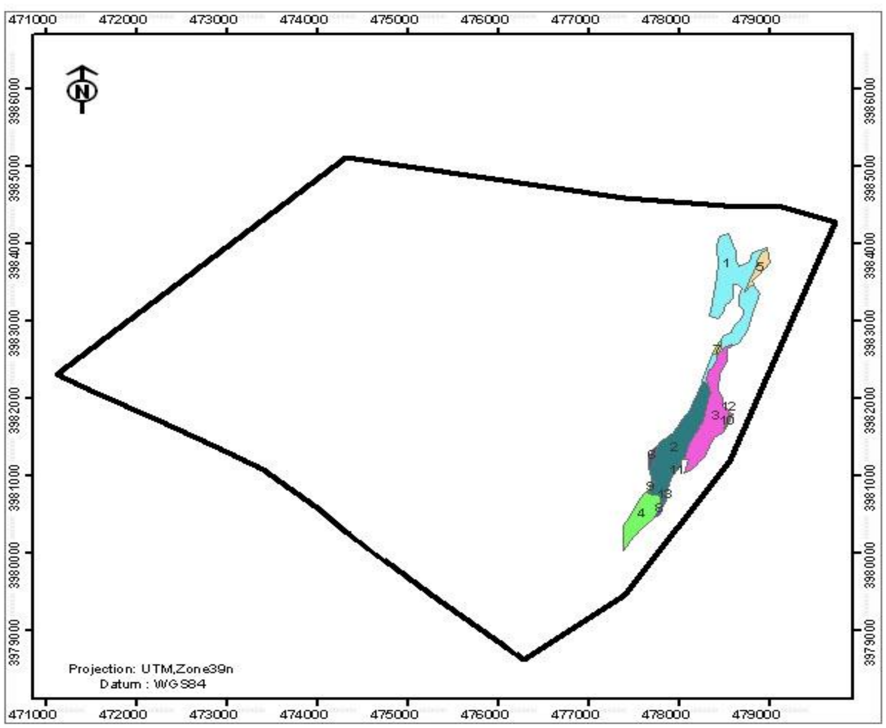

Figure 4: Location of groves (scale: 1:50000)

Table 4: Grove land use

Number of patches	Minimum area (m^2)	Maximum area (m^2)	Total Area (m^2)	Average area of patches (m^2)
13	129.47	420,756.83	1,270,084.73	97,698.82

Land with Poor Vegetation or Abandoned

This use involves 214 patches with an area of 204.1h (table 5). It used to make up around 80% of the area. However, implementation of development plans and urban development has shrunk this land use, and development projects will reduce its size in the future.

Table 5: Information on land with poor vegetation or abandoned

Number of abandoned patches	Minimum area (m^2)	Maximum area (m^2)	Total area (m^2)	Average area of patches (m^2)
214	422.22	350,653.36	2,041,103.66	17,545.18

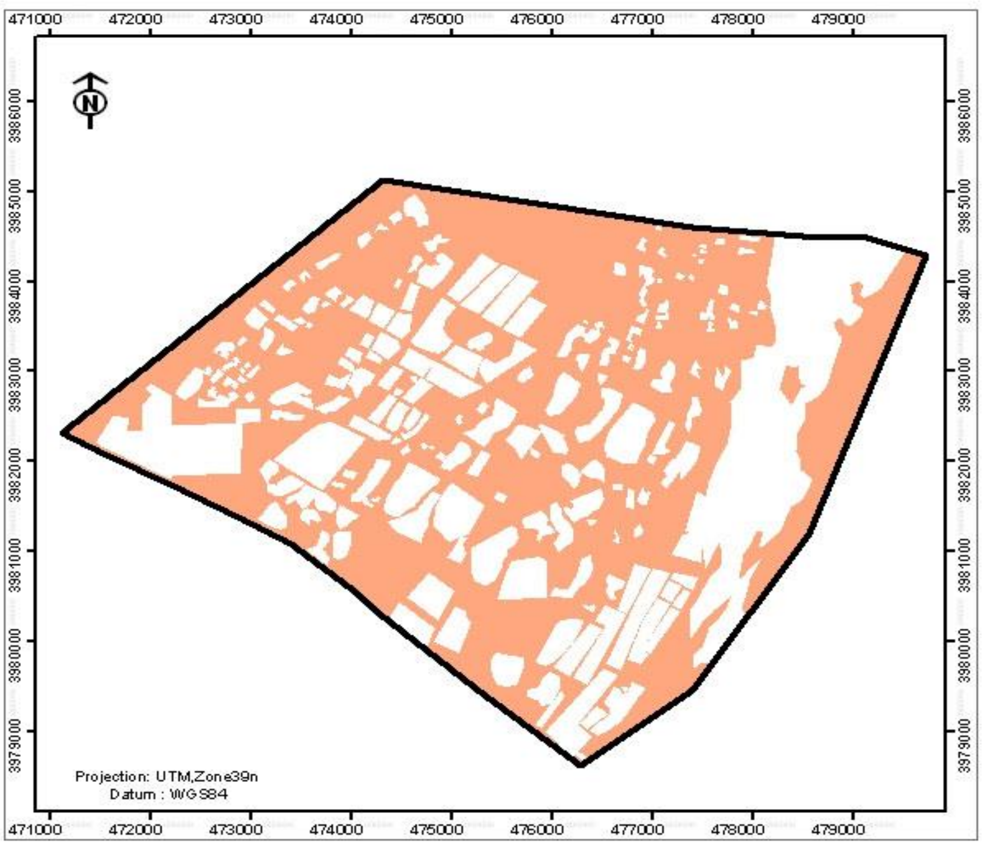

Figure 5: Location of spots characterized by poor vegetation and abandoned within the study area (scale: 1:50000)

Linear Use (Corridors)

Streams and Rivers

Because of the area's climate and precipitation regime, there is only one major stream located on the western side of the area, which is dry most of the year.

Tarmac Roads

The length of main access roads is calculated by considering paths along blocks.

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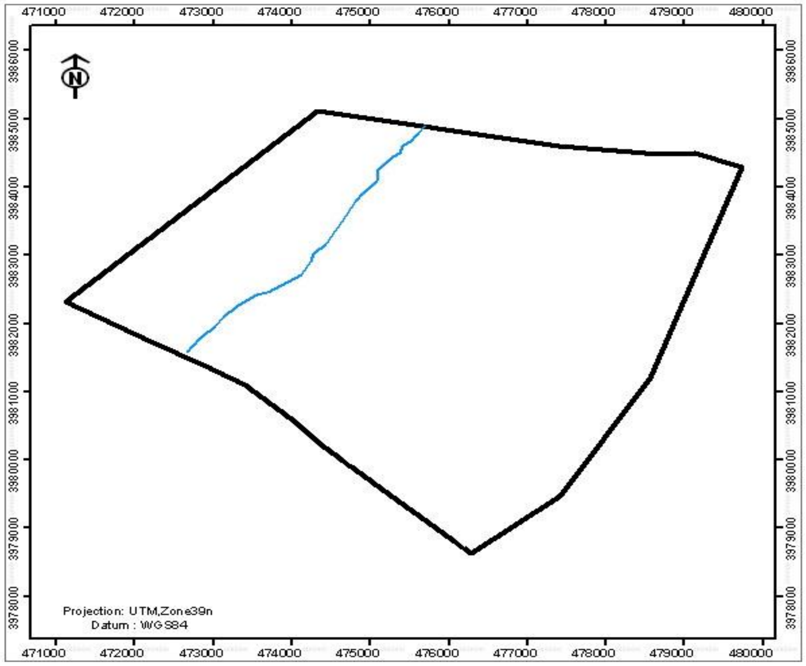

Figure 6: Location of the main stream within the study area (scale: 1:50000)

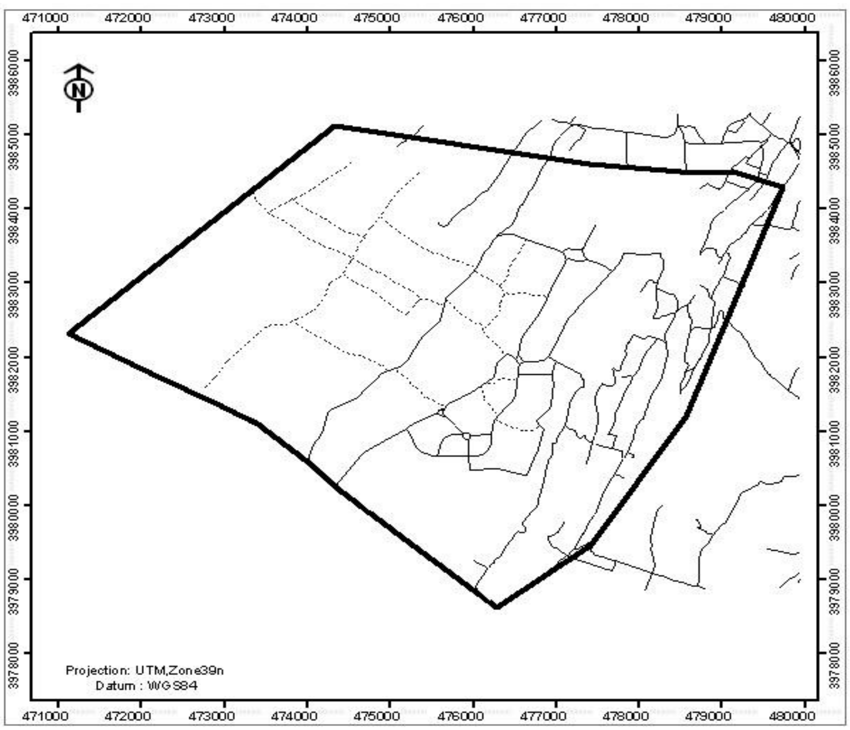

Figure 7: Location of major access roads within the study area (scale: 1:50000)

Detecting Land Use Conversion

After finalizing the land use map, the prepared land use layers were compared through post-categorization comparison, the most frequent detection technique for independent comparison of images. This technique proves to be the most applicable of all because of use of two separate images and less normalization issue, concerning difference between sensors as well as atmospheric condition during two periods.

Table 6: Land area in 1990 and 2013 in hectare

	Human-made land	Groves and miscellaneous land use	Agriculture/dry farming	Land with poor vegetation or abandoned
1990	12.2	135	28.7	2,964.74
2013	2,788.94	127	206	204.1

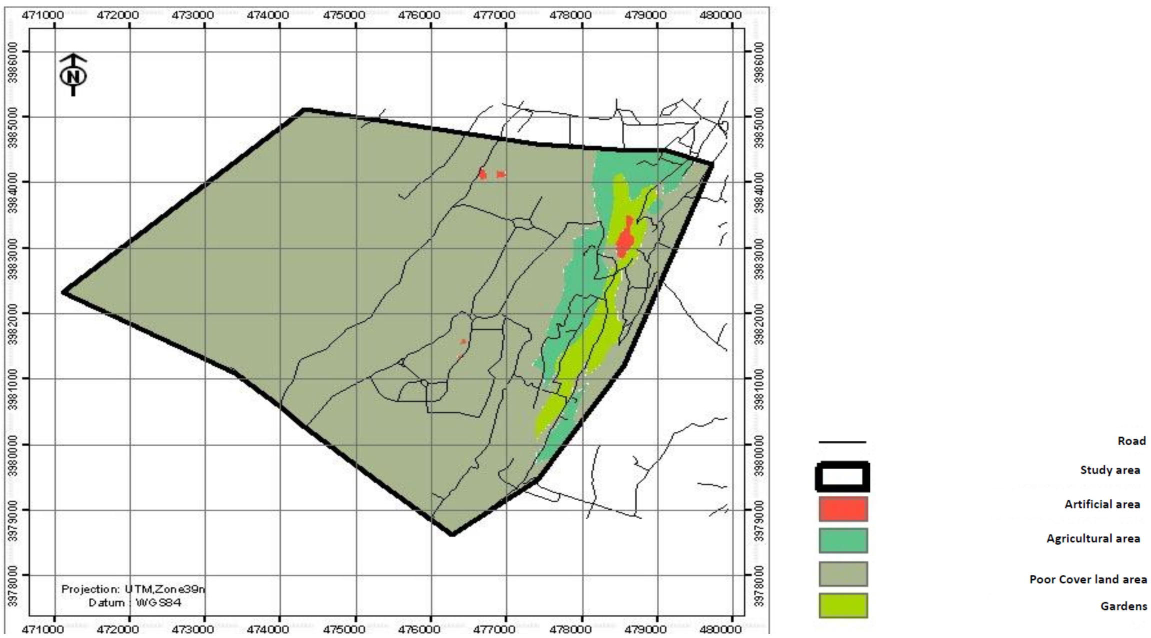

Figure 8: Land use map of the study area in 1990(scale: 1:50000)

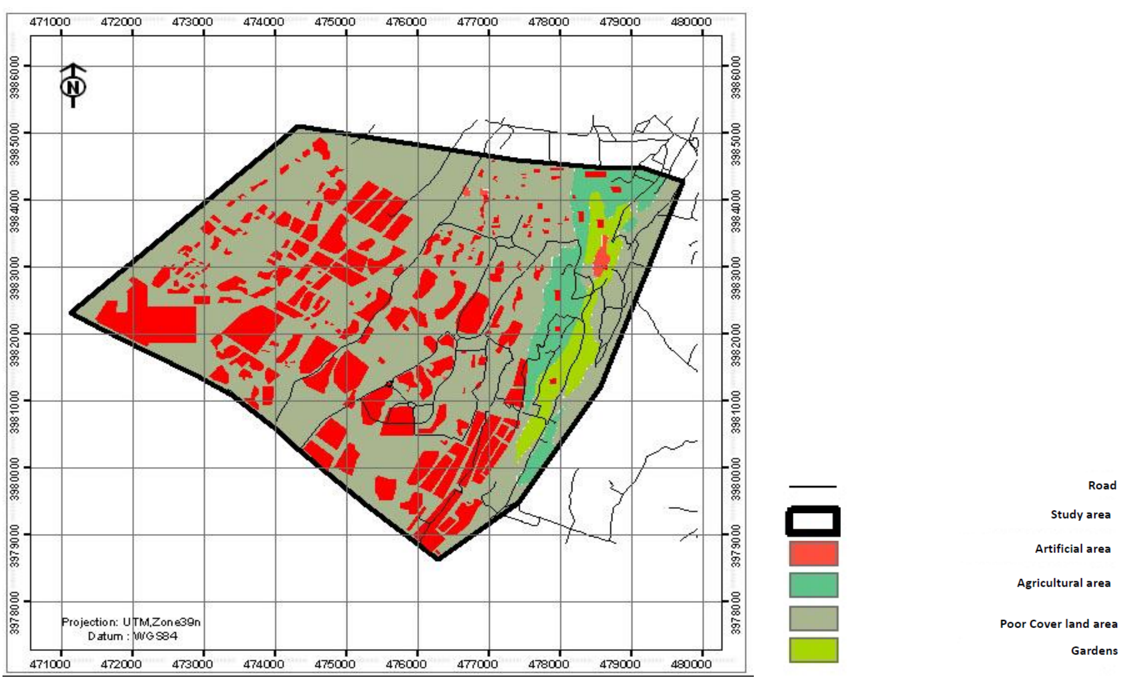

Figure 9: Land use map of the study area in 2013(scale: 1:50000)

Discussion and Conclusion

The results suggest that during two last decades increasing urban development caused main land uses to change and human dominated use now accounts for the most expanding one.

In general, to perceive the trend of change in landscape, the transformation of natural settings should be considered over homogenous time spans. Hence, it is necessary landscape analysis be carried out in due time to allow change appear in pilots. In our study, first of all land uses were identified. This revealed that different spots or land uses emerged in recent years. These uses followed an abnormal development pattern across the area (former rangelands), leading to destruction of the area's natural ecosystems. Expansion of human dominated uses such as roads, buildings, and facilities resulted in destruction and fragmentation – a factor that can wreak havoc on the natural resources in the area. The focus needs to be placed on removing some patches and replacing others. Growth of some uses threatens the existing diversity and the nature. Human dominated use, for example, developed extremely heterogeneously in the center and western parts of the area, whose irregular patches extend to the eastern side where rangelands, green space, and groves exist. To prevent further destruction by human made spots, e.g. agriculture, they should be contained within a certain part of the area to hinder their expansion. However, the existing groves can be advantageous in the sense that they can allow for alternative livelihood accompanied by natural resources conservation.

In addition, previous studies found that the population growth (migration, birth rate) did not conform to the population projection. If average population growth is adopted, the current planning's foresees 500,000 individuals in 2021. The current population amounts to 60,000 individuals, implying that infrastructures required by an eight-time increase in population do not happen to exist.

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