Geospatial Analysis of Urbanization and its Impact on Land Use Changes in Sargodha, Pakistan

Omar Riaz[1], Huma Munawar[1], Muhammad Nasar u Minallah[2,*], Kashif Hameed[1] and Maryam Khalid[3]

[1]*Department of Earth Sciences, University of Sargodha, Pakistan*

[2]*Department of Geography, Govt. Postgraduate College, Gojra, Pakistan*

[3]*Department of Geography, GC University, Faisalabad, Pakistan*

Abstract: The focus of this study is on the application of GIS and remote sensing on urbanization and its impact on land use changes in Sargodha from 1992-2015. Sargodha has witnessed rapid urbanization and due to urban expansion many changes have been detected in the land use of Sargodha. For this study, census data, multi-temporal city maps and multi spectral satellite images are used. Landsat TM 1992 and ETM+ 2000, 2005, 2010 and 2015 Landsat 8 are classified using supervised classified method (MLC) to produce land use maps. The classification accuracy has been assessed by calculating kappa index of agreement and ground control points were also collected to verify the results. The results indicate that, over the past 24 years there is a growing trend in urban land use while the agricultural land and all other categories are showing a declining trend since 1992. The total increase in urban land use is 25380.8 hectares and it has increased in 2000, 2005, 2010, and 2015 at the rate of 2.2%, 4.1%, 9.2% and 17.4% respectively. This rapid urbanization resulted into loss of agricultural land. While the overall change observed in agricultural land, water area and bare land is -11008.5, -38926.5 and 9492.7 hectares respectively.

Keywords: Urbanization, Land use, Change Detection, RS, GIS.

1. INTRODUCTION

Urbanization is a global process and an important social and economic phenomenon. It is the most powerful anthropogenic force that brought changes in land use patterns all over the world. In developing countries, rapid urbanization is a crucial issue that is a major contributor to global change [1]. Urbanization causes deep changes in the spatial structure of landscape and produces new landscape patterns [2]. It is closely related to the introduction of modes of transportation like road links and rail routes [3]. According to World Bank projections, the number of people residing in cities is increasing with the passage of time [4]. When settlements grow human needs and activities also grow [5]. Rural to urban migration has increased urban population of Pakistan from 17.8% in 1951 to 39.2% in 2015 [6]. According to the report of United Nations Population Fund Pakistan ranks 163 on a list of over 200 countries. Urban population of Pakistan grew from 25% to 35% during 1975-1995. According to UN forecast, the share of urban population will increase from 35% in 1995 to 60% in 2025 [7]. Rapid urbanization is responsible for numerous problems such as problems of drinking water, waste disposal, noise pollution, air pollution, traffic congestion and substandard living environment [8]. Uncontrolled urban sprawl is swallowing rural landscape which in turn is altering the land use patterns of urban periphery [9]. Remote sensing is a chief source to provide data for urban land use mapping and monitoring [10]. The integration of remote sensing with GIS is helpful in data processing and presentation of analysis. GIS also interprets spatial data with socio economic data and makes the analysis meaningful and effective. GIS maps provide visualization of spatial patterns and relationships [11]. In present study census data and satellite images have been used to evaluate urbanization and its impacts on land use changes in study area from 1992-2015. For this purpose Landsat TM, ETM+ and OLI_TIRS imageries are used and the main objectives of this study are, to analyze the main factors governing urbanization and pattern of urban growth in Sargodha. The applications of GIS and RS techniques to monitor urbanization and associated land use changes in the study area have been utilized.

2. DISCRIPTION OF THE STUDY AREA

Sargodha is 11th most populous metropolitan city of Pakistan known as “City of Eagles”. It is also known as “California of Pakistan” because it is famous for citrus fruit “Kinu”. Sargodha is one of the fastest growing cities. Sargodha is situated between 31.34′ N to 32.36′ N latitudes and 72.10′ E to 73.18′ E Longitudes. It covers an area of 5854 square km. On the northwest the River Jehlum and on the east the Chenab River

*Address correspondence to this author at the Department of Geography, Govt. Postgraduate College, Gojra, Pakistan; Tel: +923336564413;
E-mail: Nasarbhalli@gmail.com

ISSN: 1814-8085 / E-ISSN: 1927-5129/17

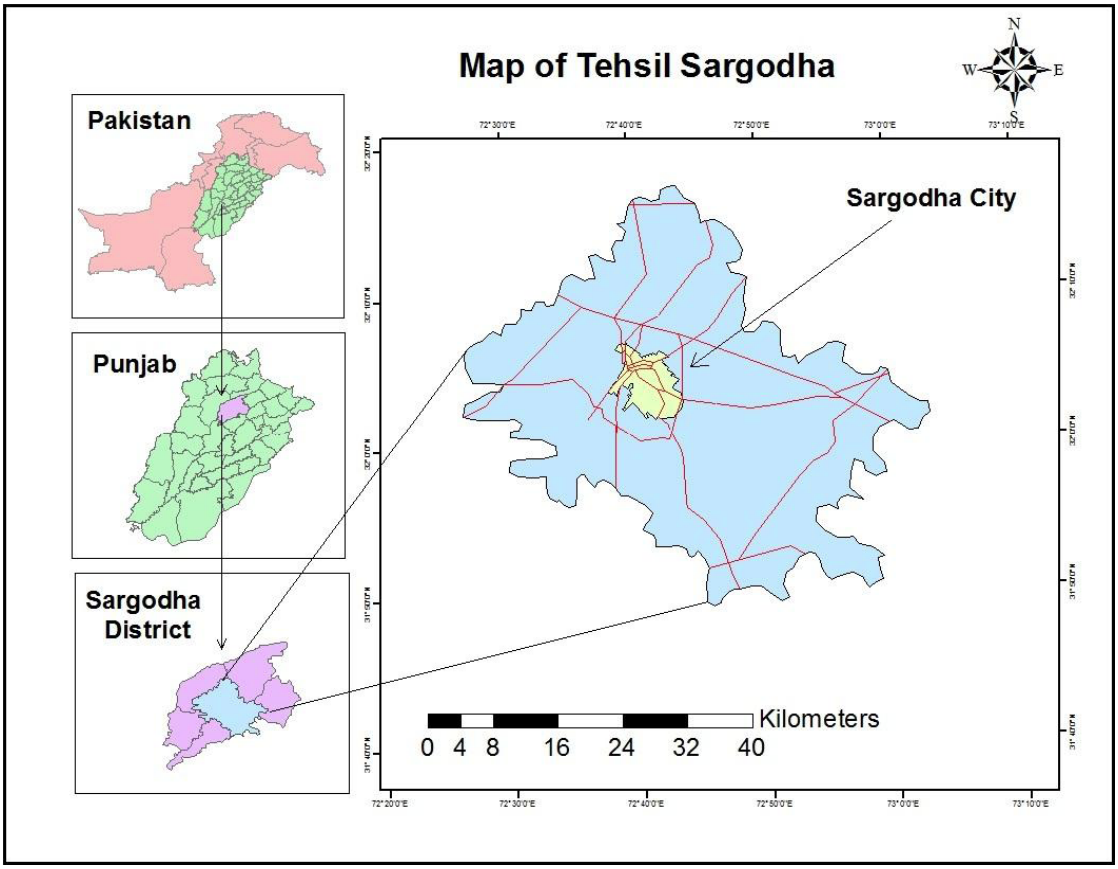

Figure 1: Map of the study area Tehsil Sargodha.

bounded Sargodha. According to the Punjab Development Statistics in 2015 the total population of Tehsil Sargodha was 1,422,000 and 584,000 persons were living in urban area; while 838,000 persons were living in rural area [12]. It has continental type of climate. The mean maximum and minimum temperatures of summers remains 39 25 respectively and this means temperature drops to 21 to 6 in winter. The average annual rainfall of District Sargodha is 413.0 mm.

3. MATERIAL AND METHODS

3.1. Data Collection and Sources

The census data of 1951 to 2015 was acquired by the District Census Reports of Sargodha. Economic Survey of Pakistan was also consulted for this study. The satellite images of 1992, 2000, 2005, 2010 and 2015 were collected from USGS website to evaluate Spatio-temporal characteristics of urbanization and associated land use changes in Tehsil Sargodha. The characteristics of these satellite images are presented in (Table **1**). Extensive field work was conducted to collect Ground Control Points (GCPs) and pre-processed images and maps were verified.

3.2. Image Processing

Layer stacking, radiometric and geometric correction methods are considered as the pre-processing operations for remotely sensed data. They are performed before information extraction from image. Landsat TM of 1992 and Landsat ETM+ images of 2000, 2005, 2010 and Landsat 8 for 2015 were in different format. The different bands of tiff image were converted into image format through layer stacking method in ERDAS IMAGINE to produce False Color Composite (FCC) Image. After that all images were geometrically projected in Arc GIS to Universal Transverse Mercator (UTM) system. The boundary of Tehsil was extracted by masking function in Arc GIS. In supervised classification method images of different years were classified independently. A Maximum Likelihood Classification (MLC) algorithm was applied. A spectral signature for each land use class is created through analysis of the pixels of image. After the creation of signature files for all land use classes the image was classified. Images were classified into 4 classes of land use such as urban/built-up area, agriculture land, bare soil, and water bodies. The classified images demonstrate the characteristics of

Table 1: Description of Landsat Image Data

Year	Date of Acquisition	Satellite Sensor	Spatial Resolution	Path/Row	Spectral Resolution (Bands)
1992	20-09-1992	Landsat TM	30m	150/37	7
2000	16-10-2000	Landsat ETM+	15m	149/39	9
2005	02-04-2005	Landsat ETM+	15m	149/39	9
2010	01-01-2010	Landsat ETM+	30m	150/38	9
2015	31-05-2015	Landsat OLI_TIR	15m	150/38	11

Source: USGS.

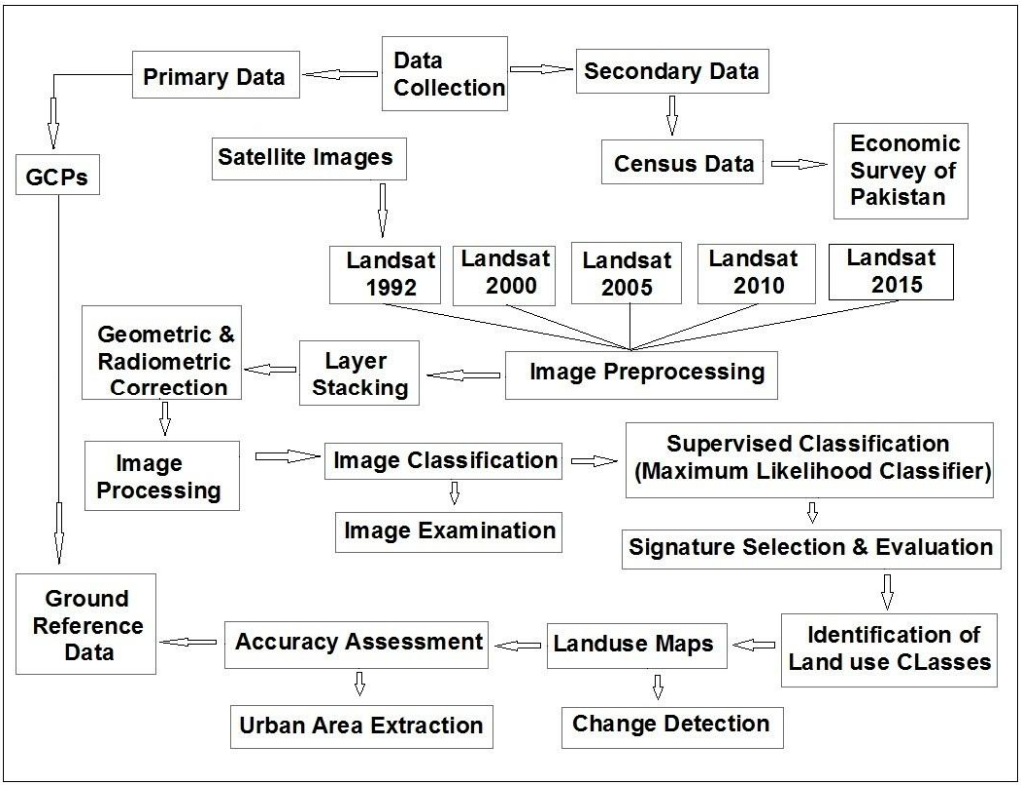

Figure 2: Flow Diagram of Methodology.

area and give the necessary information to comprehend the land use changes in the area. After image processing built-up areas were extracted. Then built-up areas were considered as one of the indicator to evaluate change [13].

3.3. Accuracy Assessment

After image classification accuracy assessment was done. The random points which were taken as ground referenced test points were utilized to assess the accuracy of each category in a classified map because it is not possible to visit each and every pixel of remote sensing derived classification map for accuracy assessment. Therefore, the total sample size and the number of samples required per class are calculated. The geographic location (x, y) of these pixels were determined to visit and obtain ground reference test information. The relationship between pixels of classification map and ground reference test information is usually summed up in contingency table or confusion matrix [13]. At the end final maps were prepared with the help of GIS. The results of five images produced by MLC classifier are presented in (Table **5**).

4. RESULTS AND DISSCSSION

4.1. Increases in Urban Population in Tehsil Sargodha

The results of satellite image analysis and discussion on findings showed that rapid urban

Table 2: Population Growth of Sargodha from 1951-2015

year	Total Population of District	Urban Population of District	%	Total Population of Tehsil	Urban Population of Tehsil	%
1951	893,269	164,400	18.40%	318,035	78,447	24.60%
1961	1,107,226	216,772	19.50%	406,939	129,291	31.70%
1972	1,557,641	368,552	23.60%	578,849	200,460	34.60%
1981	1,911,849	503,254	26.30%	722,570	291,362	40.30%
1998	2,665,979	750,032	28.10%	1,081,459	458,440	42.40%
2015	3,397,000	956,000	28.10%	1,422,000	584,000	41.10%

Source: [12].

Table 3: Land use of Tehsil Sargodha

year	Urban/Built-up		Agriculture		Bare Soil		Water		Total	
	Area Hectare	Area %	Area Hectare	Area %	Area Hectare	Area %	Area Hectare	Area %	Area Hectare	Area %
1992	2361.9	1.6	47585.8	32.6	55152.3	37.8	40600	27.8	145700	100%
2000	5553.6	3.8	65729	45.1	73008.2	50.1	1409.2	0.9	145700	100%
2005	8394.4	5.7	64348.9	44.1	71424.1	49	1532.6	1	145700	100%
2010	15856	10.8	52966.5	36.3	74525	51.1	2352.5	1.6	145700	100%
2015	27742.7	19	36577.3	25.1	64645	44.3	16735	11.4	145700	100%

Source: Calculated from satellite images.

population growth is a major factor of land use changes in Tehsil Sargodha. According to the 1998 census of Pakistan the population of Tehsil Sargodha was 1,081,459 and out of which 458,000 were living in urban area and 623,000 were living in rural area [14]. The recent estimate shows that the urban population of Tehsil Sargodha was 1,422,000 and 584,000 persons were living in urban area, and 838,000 persons were living in rural area.

4.3. Change in Land Use

Table **4** depicts the relative changes in land use trend from 1992 to 2015 in Tehsil Sargodha. During 1992-2015 the overall change in water area is -38926.5 hectares and -16.4 percent. The urban/built-up area of Tehsil Sargodha has expanded. It was 2361.9 hectares in 1992 and was 27742.7 hectares in 2015. Over the past 24 years, the Tehsil Sargodha has experienced some low and high speed stages of urban growth. During this time period, the urban growth rate varies significantly. A growing trend is observed in urban land use. The overall urban/built-up land use change is 25380.8 hectares and 17.4 percent (Figure **6**). During the study period all other categories are showing declining trends.

The overall change in category of bare soil is 9492.7 hectares and 6.5 percent. The agricultural land showed constant decreasing trend during this time period. The overall change in agricultural land use is -11008.5 hectares and -7.5 percent. The agriculture land is being converted into urban land. The urban/built-up land is increasing in 2000, 2005, 2010, and 2015 at the rate of 2.2%, 4.1%, 9.2% and 17.4% respectively. These land use changes are showing a noticeable change in the study area in the form of residential colonies around the city. The detailed information, relevant statistics, classification results, their graphical representation and visual interpretation revealed the relative land use changes in each category of land use of Tehsil Sargodha. After that all maps were reclassified into two classes of urban/built-up and non-built-up land use. Figure **6** depicts the change in urban land use of study area during different time periods.

4.4. Kappa Index and Overall Accuracy

The classification accuracies are assessed by evaluating the overall classification accuracy and Kappa statistics. Kappa index is calculated for all classified maps to find out the accuracy result of each

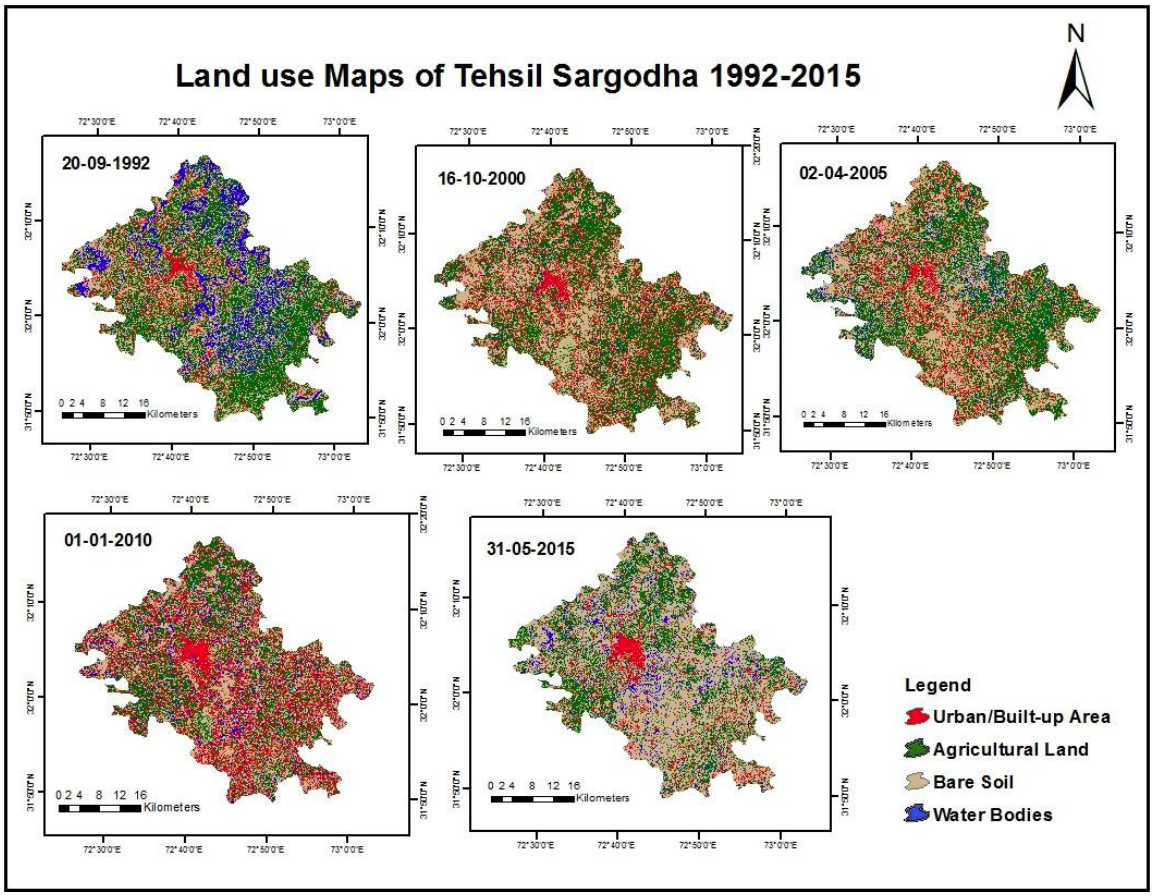

Figure 3: Land use Map of Tehsil Sargodha from 1992-2015.

Table 4: Change in Land use from 1992-2015

Year	Urban/built-up		Agricultural land		Bare Soil		Water Bodies	
	(Area Hectare)	Area %	(Area Hectare)	Area %	(Area Hectare)	Area %	(Area Hectare)	Area %
1992-2000	3191.7	2.2	18143.2	12.5	17855.9	12.3	-39190.8	-26.9
2000-2005	2840.8	1.9	-1380.1	-1	-1584.1	-1.1	123.4	0.1
2005-2010	7461.6	5.1	-11382.4	-7.8	3100.9	2.1	819.9	0.6
2010-2015	11886.7	8.2	-16389.4	-11.2	-9880	-6.8	-679	9.8
1992-2015	25380.8	17.4	-11008.5	-7.5	9492.7	6.5	-38926.5	-16.4

Source: As in Table **3**.

Table 5: Built-up and Non Built-up Area in between 1992-2015

Land use Type	Urban/Built-up Area		Non Built-up Area		Total Area	
	Area Hectare	%	Area Hectare	%	Area Hectare	%
1992	2361.9	1.6	143338.1	98.3	145700	100
2000	5553.6	3.8	140146.4	96.1	145700	100
2005	8394.4	5.7	137305.6	94.2	145700	100
2010	15856	10.8	129844	89.1	145700	100
2015	27742.7	19	117957.3	80.9	145700	100

Source: As in Table **3**.

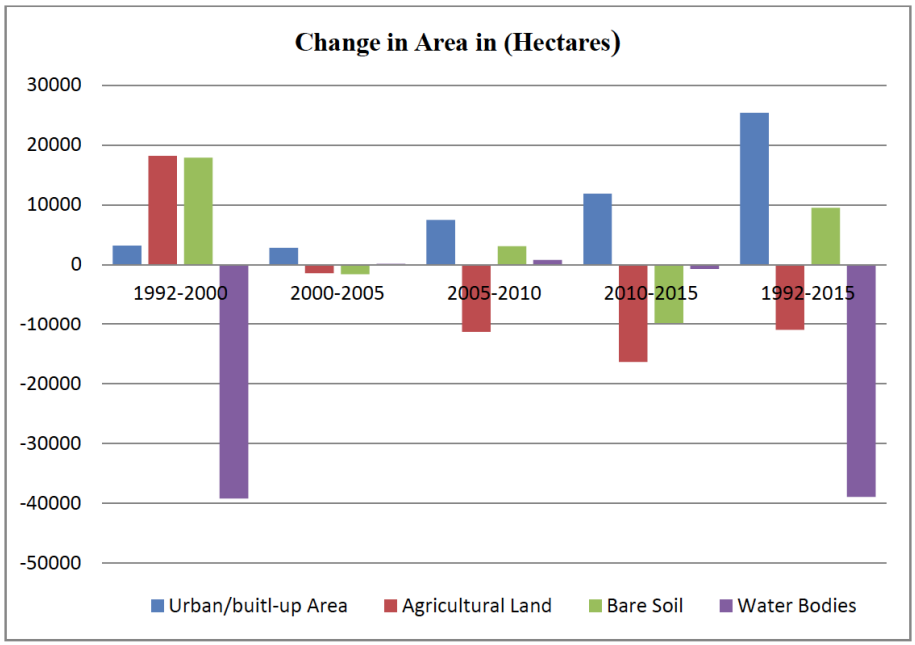

Figure 4: Land use Change Depictions in Tehsil Sargodha from 1992-2015.

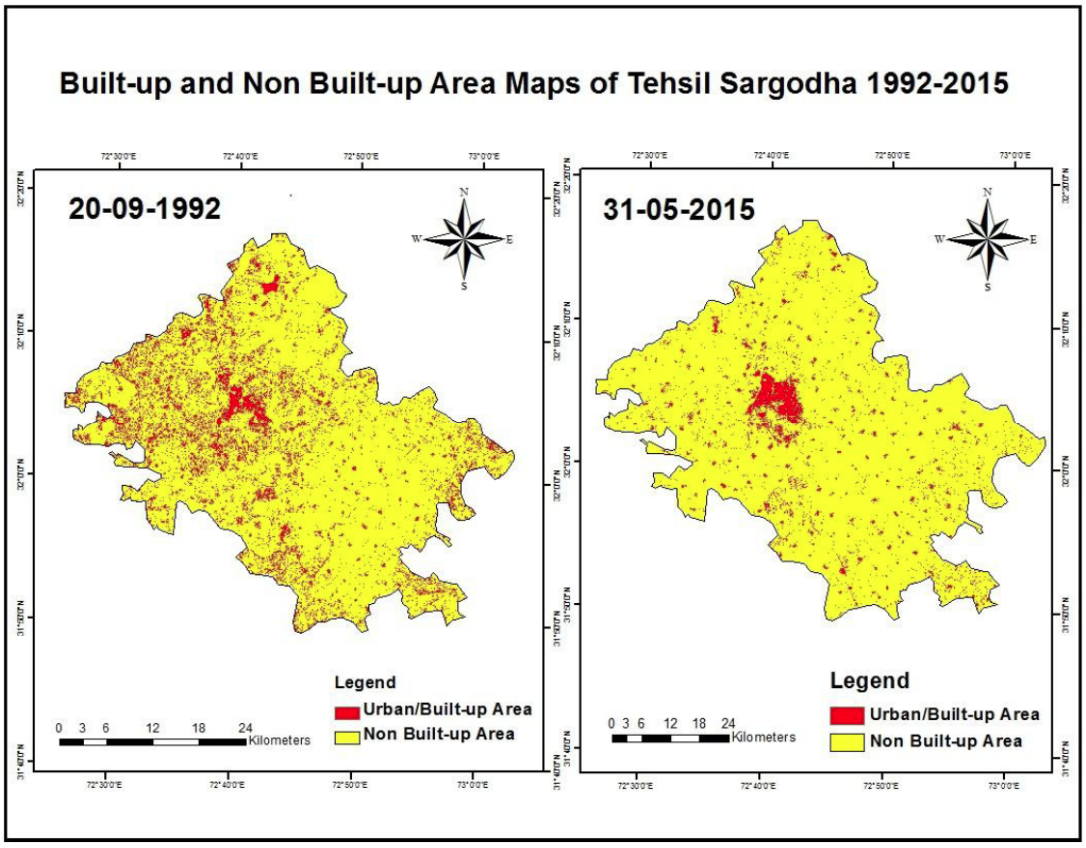

Figure 5: Built-up and Non Built-up Area in between 1992-2015.

image. The overall classification accuracies of 1992, 2000, 2005, 2010 and 2015 are 88.6%, 86.6%, 91.56%, 85.62%, 94% respectively, whereas overall kappa statistics of each image are 84.6%, 81.9%, 88.75, 80.83% and 92.2%.

5. CONCLUSION

This study acknowledged that urbanization can change the land use patterns and alter the landscape. GIS and remote sensing techniques are found very

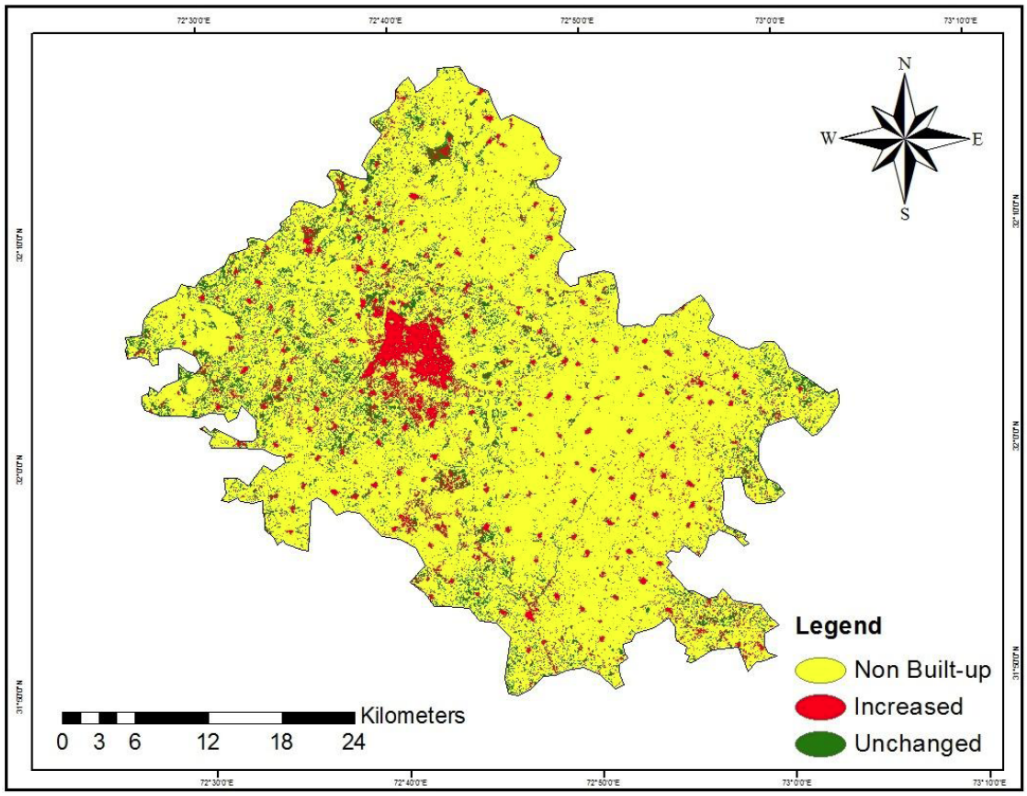

Figure 6: Land use Change Map of Tehsil Sargodha from 1992-2015.

effective to evaluate the urban growth patterns and the impacts of urbanization on land use changes. With increasing population and development pressure land use change will continue. The changes in land use of Tehsil Sargodha during the last 24 years indicate that there is 17.4% increase in urban area and 6.5% in bare land. Overall change in category of water is -16.4% and -7.5% in agricultural land. Urban land development was uneven in all parts of the study area. The major growth was observed along the major link roads such as Lahore road, Faisalabad road and Jhang road that connect the city with rest of the province. Several problems arise due to urban sprawl such as traffic conjunction, urban slums, environmental degradations, climate change, poor water and air quality and land use/and cover changes. Therefore, it is suggested that separate detailed studies should be taken up regarding these problems.

REFERENCES

[1] Deng JS, Wang K, Hong Y, Qi JG. Spatio-temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization. Landscape and Urban Planning 2009; 92(3): 187-198. https://doi.org/10.1016/j.landurbplan.2009.05.001

[2] Antrop M, Eetvelde VV. Holistic aspects of suburban landscapes: visual image interpretation and landscape metrics. Landscape and Urban Planning 2000; 50: 43-58. https://doi.org/10.1016/S0169-2046(00)00079-7

[3] Antrop M. Landscape change and the urbanization process in Europe. Landscape and Urban Planning 2004; 67(1): 9-26. https://doi.org/10.1016/S0169-2046(03)00026-4

[4] Siciliano G. Urbanization strategies, rural development and land use changes in China: A multiple-level integrated assessment. Land Use Policy 2012; 29(1): 165-178. https://doi.org/10.1016/j.landusepol.2011.06.003

[5] Adeel M. Methodology for identifying urban growth potential using land use and population data: A case study of Islamabad Zone IV. Procedia Environmental Sciences 2010; 2: 32-41. https://doi.org/10.1016/j.proenv.2010.10.006

[6] GOP. Pakistan economic survey 2014-2015. Islamabad: Finance Division Islamabad, Govt. of Pakistan 2015.

[7] Haider M, Badami MG. Urbanization and local governance challenges in Pakistan. Environment and urbanization ASIA 2010; 1(1): 81-96. https://doi.org/10.1177/097542530900100107

[8] Rai PK, Kumra V. Role of Geoinformatics in Urban Planning. Journal of Scientific Research 2011; 55: 11-24.

[9] Riaz O, Ghaffar A, Butt I. Modelling Land Use Patterns of Lahore (Pakistan) using remote Sensing and GIS. Global Journal of Science Frontier Research. Environment & Earth Science 2014; 14(1): 24-30.

[10] Rawat J, Kumar M. Monitoring land use/cover change using remote sensing and GIS techniques: A case study of Hawalbagh block, district Almora, Uttarakhand, India. The Egyptian Journal of Remote Sensing and Space Science 2015; 18: 77-84. https://doi.org/10.1016/j.ejrs.2015.02.002

[11] Verma RK, Kumari KS, Tiwary R. Application of Remote Sensing and GIS technique for efficient urban planning in India. Paper presented at the Geometrics Conference Proceedings. Mumbai, India 2009. Retrieved: http://www.csre.iitb.ac.in/~csre/conf/wp-content/uploads/fullpapers/OS4/OS4_13.pdf.

[12] Government of the Punjab. Punjab Development Statistic 2015. Bureau of Statistics, Government of Punjab, Lahore, 312, 2015.

[13] Jensen RJ. Introductory Digital Image Processing: A Remote Sensing Perspective. United States of America: Pearson Prentice Hall 2005.

[14] Government of Pakistan. District Census Report of Sargodha 1998. Population census organization statistics division Islamabad, Government of Pakistan 1999.

Received on 27-03-2017 Accepted on 14-04-2017 Published on 10-05-2017

https://doi.org/10.6000/1927-5129.2017.13.39