LANDSCAPES CLASSIFICATION AND ITS IMPACT ON AGRICULTURE USING GEO-SPATIAL TECHNIQUES OF DISTRICT SIALKOT

SANIA MERAJ DIN [1] • SAIF ULLAH KHAN [1, 2] • ISMA YONES[1] • ZAHID MAQBOOL[2] • MUHAMMAD ADNAN SHAHID[2, 3] • AHMED MUBASHIR[3]

[1] Department of Geography, University of Punjab, Lahore, Pakistan
[2] Agricultural Remote Sensing Lab, University of Agriculture Faisalabad, Pakistan
[3] Department of Irrigation and Drainage, UAF, Faisalabad, Pakistan

Corresponding author: saifullahsaifi29@gmail.com

ABSTRACT

Rapid urbanization is among the dominant causes of land use changes all over the world. Therefore, detection of land use changes of a particular area is a matter of great concern. In this scenario, geo-spatial techniques offer promising tool for land use classification of an area over variable time. In this regard, present study was carried out for land use classification of district Sialkot. For this purpose, Landsat satellite images (Landsat 5 TM, Landsat 8 OLI) for the year 1990, 2000 and 2016 of district Sialkot were obtained through United State Geological Survey (USGS). Pre-processing of the obtained satellite imagery i.e., layer stacking, image enhancement etc. was performed using Erdas imagine 9.0 and Arc Map 10.1 software. Supervised classification of satellite images was carried out and the total area of district Sialkot was classified in to four different land use classes i.e., agriculture land, bare soil, build up area and water bodies. According to the results, the total agriculture area in 1990 was 2109.60 km^2 which was decreased in 2000 (2027.07 km^2) and increased in 2016 (2354.65 km^2). Bare soil area (809.70 km^2) in 1990 was found decreased and reached up to 391.45 km^2 in 2016. Build up area was also increased in district Sialkot and reached at 176.59 km^2 in 2016. So based on results, it can be concluded that land use classes such as agriculture and built-up area were increased while the area covered by bare soil exhibited decline and water bodies exhibited a positive trend in all the years. Moreover, results of present study also suggested that geo-spatial techniques have considerable potential for land use classification of a particular area. Additionally, the results of present study might be useful for developing and implementing valuable management strategies for resource utilization on sustainable basis.

KEY WORDS: Land use changes, classification, Landsat imagery, Image Classification, Change detection.

1. INTRODUCTION

Land use mainly refers to the ways human beings use the land with emphasis on economic, cultural, political and historical activities (Arsanjani, 2011; Rozenstein and Karnieli, 2011; McConnell, 2015). Land use provides complete understanding of the interactions of anthropogenic activities associated with the environment (Prakasam, 2010). However, Land use classification/change involves change analysis in terms of qualitative (structure and functions of land) and quantitative (extent of area) changes. Land use change is a continuous process which involves alteration of various types of land uses and poses considerable effects on atmospheric composition leading towards climate change at regional and global levels (Pielke et al., 2011; Rawat et al., 2013; Pielke et al., 2013). Moreover, changes in biodiversity and ecosystem services and extent and frequency of disasters are also associated with land use changes (Mas et al., 2004; Zeller et al., 2017; Gomes et al., 2021; Su et al., 2021). Land use change is mainly triggered by socio-economic development which causes persistent environmental degradation especially in terms of land fragmentation (Grimm et al., 2008). Therefore, land use classification is critically important not only for better understanding of complex interactions and relationships between anthropogenic activities and natural phenomena but also for improved land use planning and resource management for scientists and policy makers (Rozenstein and Karnieli, 2011; Seif and Mokarram, 2012; Butt et al., 2015).

In this regard, remotely sensed satellite data together with GIS techniques offers promising tool for accurate assessment and monitoring of land use through observation of land cover (Karl and Maurer, 2010; Rozenstein and Karnieli, 2011; Liping et al., 2018; Hamud et al., 2019; Sánchez-Espinosa et al., 2019; Schulz et al., 2021; Shegwe et al., 2021). Several previous studies reported the use of Landsat Thematic Mapper (TM) satellite data having 30 m resolution for precise land use classification (Manandhar et al., 2009; Schulz et al., 2010; Cai et al., 2019; Xu et al., 2020; Kumar et al., 2021; Hussain et al., 2022; Sarif and Gupta, 2022). Landsat satellite imagery is commonly used for land use classification on regional scale due to their relatively lower cost, longer history, and acquire measurements in all major portions of the solar electromagnetic spectrum (visible, near-infrared, and shortwave-infrared) (Rozenstein and Karnieli, 2011). Although several techniques e.g., supervised classification, unsupervised classification, principal component analysis (PCA) etc. have been developed and successfully employed for accurate land use classification of a particular area using remotely sensed satellite imagery. However, supervised classification is most widely used method for land use change analysis throughout the world (Rawat et al. 2013; Butt et al., 2015; Boori et al. 2015; Rawat and Kumar, 2015). For instance, Hassan et al. (2016) developed land use classification map of Islamabad city and its surroundings by observing land use change from 1992 to 2012. For this purpose, satellite images (Landsat 5 TM and SPOT 5) were obtained and subjected to supervised classification for change detection. Results showed that agricultural area, build-up area and water bodies were increased from 1992 to 2012. But forests and barren lands were decreased during this time. In another study, Pande et al. (2018) prepared land use classification map (2008-2015) of the northern region of the Akola district of Maharashtra, India through supervised classification of satellite imagery (LISS-III satellite and Landsat TM+). Land use was classified in to agricultural land, developed land, wasteland, water bodies, and forestland. Results revealed significant changes in agricultural and forest land between 2008 and 2015. Recently another study, Hussain et al. (2022) identified LULC changes through supervised classification in district Okara from 2000 to 2020 using Landsat imagery. Results showed that vegetation area in Okara was decreased from 91.6% in 2000 to 89.3% in 2020. Moreover, build up area was increased by 4.5% during 2000-2020.

1.1. Problem Statement and Objectives of Study

Pakistan is a developing country and badly facing the problems associated with land use changes due to haphazard population outburst and unplanned urban development. As a results, valuable agricultural land is being encroached by new houses, industries and roads. Agriculture sector plays important role in economic development of Pakistan as it provides raw materials to industrial sector and contributes significantly in country's export. Therefore, it is a matter of great concern to develop land use classification maps by studying the land use changes for better planning and management of land resources in Pakistan. District Sialkot is located in northern part of Punjab province and observed to face severe land use changes due to rapid industrial development and population outburst. Loss of agricultural land and increase in urban area with construction of roads and buildings are significant land use changes in this area. Therefore, present study was planned to study the land use changes and its impacts on agriculture in district Sialkot through remote sensing and GIS techniques during the years 1990-2016.

1.2. Study Area

District Sialkot is located in northern part of Punjab province of Pakistan. Sialkot city is the administrative headquarter of Sialkot district. It is the 12th biggest city of Pakistan in term of population and considered as one of the best industrial and agriculture zones of Punjab. According to census of 2017, total population of district Sialkot is 3893672 persons including males (1921643 persons), female (1971746 persons) and transgender (283 persons). However, the average annual growth rate is 1.89 from 1998 to 2017 (Pakistan Economic Survey, 2021). Sialkot is also Known as the "World class manufacturing hub" and famous for its surgical, sports and leather products. Sialkot is birth place of Allama Muhammad Iqbal and dominant language of population of Sialkot is Punjabi. Sialkot city lies between 32°30' N latitude and 74°31' E longitudes at an altitude of 256 m above sea level. The complete area of district Sialkot is 3,016 square kilometers and comprises of four Tehsils named Sialkot city, Sambrial, Daska and Pasrur. The Chenab River runs on the northern side of Sialkot. Moreover, three seasonal streams named Bher, Aik and Phalku are also flowing through the Sialkot city. In general, Sialkot district has plain and fertile land and considered best for agricultural crop production especially rice and wheat crops. The map of the study area is shown in Figure 1.

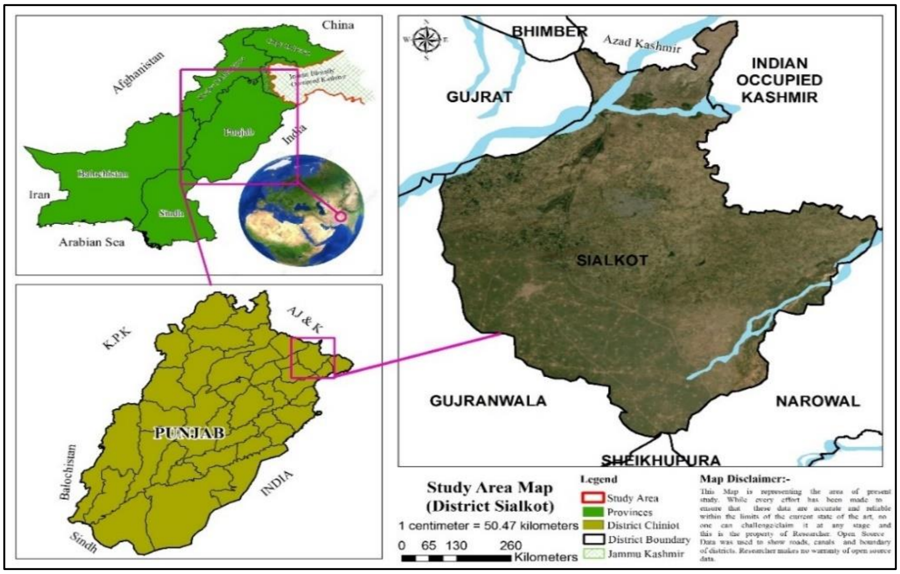

Fig 1. Study Area Map

2. MATERIAL AND MEATHODS

2.1. Data Acquisition and Sources

In this study, satellite data was used for detection of land use change and its impacts on agriculture in Sialkot district during the years 1990-2016. For this purpose, three Landsat satellite images of the study area for the year 1990, 2000 and 2016 were obtained from United State Geological Survey (USGS) an earth observatory website. Two tiles of satellite imagery cover the complete Sialkot district, therefore, two tiles of satellite images for each year were obtained and processed for land use classification. The first and second images were captured on March 16, 1990 and February 24, 2000, respectively, by the Landsat 5 with sensors TM and 30-meter resolution. However, third image was captured on March 9, 2016 by the Landsat 8 with OLI sensor and 30-meter resolution. The necessary information about the satellite data have been presented in Table 1. All the acquired satellite images were used as basic data sources for change detection and developing land use classification map. The basic work flow of the present study has been presented in Figure 2.

Table 1: Information of Satellite data used in this study

Sr. #	Row/Path	Date of Acquisition	Satellite	Sensors	Spatial resolution
1	149/37	16-Mar-1990	Landsat-5	TM	30m
2	149/38	16-Mar-1990	Landsat-5	TM	30m
3	149/37	24-Feb-2000	Landsat-5	TM	30m
4	149/38	24-Feb-2000	Landsat-5	TM	30m
5	149/37	9-Mar-2016	Landsat-8	OLI	30m
6	149/38	9-Mar-2016	Landsat-8	OLI	30m

2.2. Pre-processing of Satellite Images

The acquired satellite images were subjected to pre-processing which involve conversion of raw satellite images in to new image through layer stacking as previously reported by Hassan et al. (2016). Layer stacking is an imperative process of combining multiple separate bands in order to produce a new multi band image. As we know that satellite images are always provided in separate bands and the process of merging these bands is known as Layer stacking. For example, Landsat 8 satellite imagery comprised of 11 different bands with different files. In this study, layer stacking was carried out using a software named ERDAS Imagine 9.2 followed by image sub-setting in which satellites images were clipped to focus on the study area through changing digitized boundaries in to area of interest (AOI format) and then clipping the images into study area.

2.3. Image Enhancement

Image enhancement involves different tools to improve graphic dissimilarities of various feature classes available in satellite images. After pre-processing of satellite images, next step of image enhancement was performed in this study. Based on the features to be extracted from satellite imagery, suitable method for image enhancement was chosen. The most commonly used approach for image enhancement is contrast stretching which comprised of various other techniques. However, after examining numerous methods, the most suitable approach named Brightness/contrast method was adopted in the present study. So, image enhancement of Landsat images 1990, 2000 and 2016 was carried out with the help of brightness/contrast so that improved and better results can be achieved.

2.4. Image Classification and Change Detection

Image classification is the most commonly used method for extraction of the thematic information from the satellite images (Hassan et al., 2016; Khurshid and Shirazi, 2021). In this study, image classification was carried out to study the land use change of the study area during the years 1990, 2000 and 2016. Among the various methods, pixel-based methods are most widely used for image classification. Pixel based method involves various pixel values chosen from image and then classified in different classes through supervised and unsupervised classification. In supervised classification, the whole process is based on the researcher who selects sample pixels in an image that are representative of specific classes. In unsupervised classification all the process is done automatically by the computer based on the image's spectral value. In this study, pixel based supervised classification of satellite images was carried out for land use classification of study area in to four different classes i.e., agriculture, built up, bare soil and water bodies. Change detection is a method in which two satellite images of different time period are used which overlays through cross operation and then compared for detection of change. In this study, the acquired satellite images were compared using Arc Map 10.1 software and used for detection of land use change in district Sialkot.

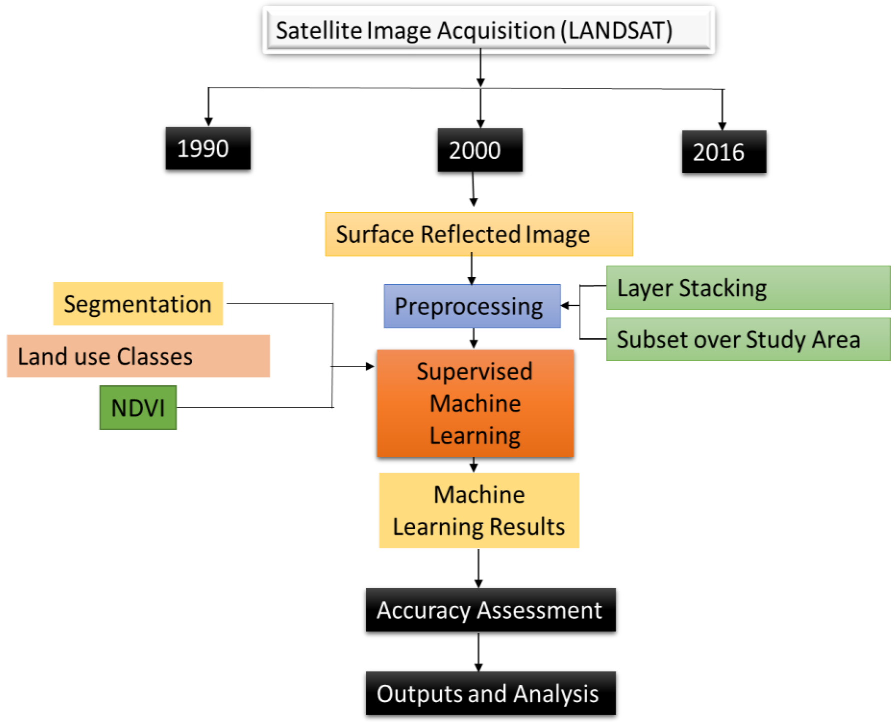

Fig 2: Study Work Flow

3. RESULTS AND DISCUSSION

Results regarding the data analysis of remotely sensed information for land use classification and its impacts on agriculture in Sialkot district during the years 1990-2016 have been presented in this study. According to the results, land use in study area was classified in to four classes i.e., agricultural area, built up area, bare soil and water bodies. It was observed that all the four land use classes experienced change during the study period. These results were in accordance to the findings of Khurshid and Shirazi (2021) who also recorded significant changes in land use in Dera Ghazi Khan during the period 1991-2021. Land use changes have also been reported by several other studies focused on use of Landsat satellite imagery for identification of land use change in different areas (Butt et al., 2015; Hassan et al., 2016; Iqbal and Iqbal, 2018; Hussain and Karuppannan, 2021).

3.1. Land use Distribution

Results revealed that land use of Sialkot district can be classified in to four different land use classes i.e., agricultural land, bare soil, built up area and water bodies. These land use classes have been presented in land use classification maps of each study year. The total area covered by Sialkot district is 3016 km^2, however, in this study, the total area under study was and used for land use classification was 3017.28 km^2 which might be attributed to little distinction in the area calculation. Land use distribution presented in table 2 was performed on the basis of total geographical area determined through digitization of Sialkot district map. According to the results, most of the land in Sialkot district was utilized for agricultural activities from 1990 to 2016. However, the second largest land use class was bare soil area followed by built-up area (Table 2). It was noticed that agricultural area was the largest land use class of Sialkot district in 2016 which covered an area of 2354.65 km^2. Moreover, further classification revealed that agricultural area was reduced from 2109.6 km^2 in 1990 to 2027.07 km^2 in 2000 which was further increased in 2016 (2354.65 km^2). So, results of present study suggested that agricultural land was increased in Sialkot district from 1990 to 2016. However, these results were contradictory to the findings of Khurshid and Shirazi (2021) who reported almost 31% decrease in agricultural land during 30 years (1991 to 2021). Furthermore, negligible effects of land use change in built-up area were noticed in the area under study. Moreover, bare soil area was noticed to be decreased during the years 2000 to 2016. The land use distribution of district Sialkot has been shown in table 2.

Table 2: Land use distribution of district Sialkot for the years 1990, 2000 and 2016

Land use classes	1990		2000		2016	
	Area		Area		Area	
	Km^2	%	Km^2	%	Km^2	%
Agricultural area	2109.60	69.91	2027.07	68.23	2354.65	78.73
Bare Soil	809.70	26.83	851.52	27.31	391.45	12.55
Water bodies	68.63	2.27	85.38	2.73	95.02	3.04
built up	29.34	0.97	53.30	1.70	176.59	5.66
Total	3017.28	100	3017.28	100	3017.28	100

Figure 3 also represents the results of land use classification during the years 1990-2016. It can be clearly seen that agricultural land was increased from 2000 to 2016. However, bare soil was found decreased during the years 1990 to 2016. Water bodies were also found increased during the years 2000 to 2016 in district Sialkot.

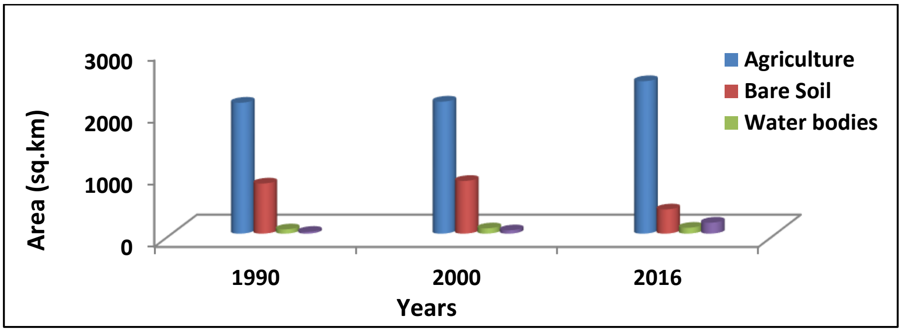

Fig 3. Land use distribution of district Sialkot for the year 1990, 2000 and 2016

3.2. Land Use Classification and Accuracy Assessment

The land use classification maps of district Sialkot for the year 1990, 2000 and 2016 have been presented in Figure 4. However, the results regarding the accuracy assessment of land use classification have been presented in table 3. Accuracy assessment is a technique employed to determine the accuracy of land use classification. It was observed that all the three images exhibited accuracy in the range of 80-90% which showed excellent accuracy for developing land use classification map. The Landsat images obtained in 1990 exhibited 87.18%, 85.17%, 89.15%, and 82.15% accuracy for agricultural area, bare soil, water bodies and built-up area, respectively. In case of images acquired 2000, accuracy of land use distribution in to agricultural area, bare soil, water bodies and built-up area was recoded 89.15%, 75.89%, 83.66% and 80.74% respectively.

However, the accuracy assessment for image acquired in 2016 was recorded 90.45% (agricultural area). 87.26% (bare soil), 86.18% (water body) and 88.78% (built-up area). These differences in accuracies have been reported by many other studies focused on identification LULC changes through geospatial techniques (Hassan et al., 2016; Khurshid and Shirazi, 2021). Our results indicated that the accuracy and reliability of land use classification map of present study was good enough and suggested that land use classification was performed accurately with minimum errors.

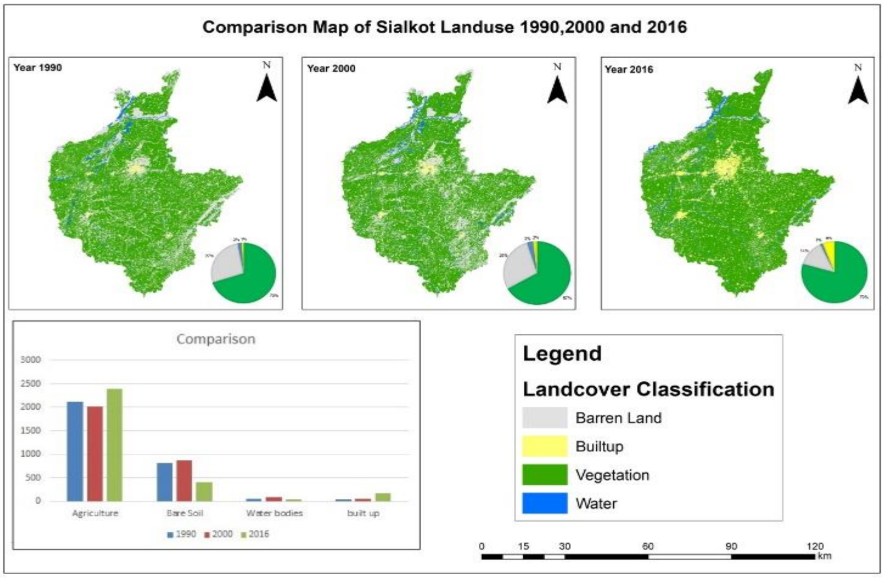

Fig 4. Land use classification maps of district Sialkot for the years 1990, 2000 and 2016

Table 3: Accuracy assessment of land use classification of district Sialkot for the years 1990, 2000 and 2016

Image Acquisition Date	Land use Classes	Accuracy Assessment (%)
March, 16 1990	Agricultural area	87.18
	Bare Soil	85.71
	Water Bodies	89.15
	Built-up area	82.15
Feb, 24 2000	Agricultural area	89.15
	Bare Soil	75.89
	Water Bodies	83.66
	Built-up area	80.74
March, 09 2016	Agricultural area	90.45
	Bare Soil	87.26
	Water Bodies	86.18
	Built-up area	88.78

3.3. Change Detection

Change detection is a tool which is extensively utilized to gather information about the land use changes of a particular area of interest over specific time periods. The basic aim of change detection is associated with assessment of enhanced or reduced land use pattern in the area under study. This tool is helpful in identifying that which land use transformed in to what type of land use. For instance, conversion of agriculture area in to built-up area can be easily identified by change detection tool. Moreover, it provides reliable information about the rate and magnitude of land use changes. The land use changes occurred in district Sialkot during the years 1990-2016 have been presented in land use classification maps (Figure 4). However, rate of land use changes was measured using map of single class which was compared with overlying maps of particular land use class of other two years (Table 4, Figure 5). For this purpose, overlying technique of change detection was combined and results obtained were exploited to reveal the information about land use changes in the area under study. According to results, it was observed that built-up area exhibited positive trend in case of all the years under study. Agricultural area was found the largest land use class in district Sialkot and showed a negative trend during 1990 to 2000, however, a positive trend was recorded for agriculture area from 1990 to 2006. It was observed that from 2000 to 2016, agricultural land increased up to 10.84 %, while between these 26 years' agriculture class shown an increase in its land cover by 8.10 %. Bare soil area also exhibited a positive trend firstly but follows the negative trend during later years. During the year 1990-2000 the bare soil increased by 1.38 %, while during the year 2000-2016, bare soil area was decreased by 15.24 %. Overall bare soil decreased by the 13.86 % during 26 years. However, water bodies exhibited a positive trend throughout the 26 years. During the year of 1990-2000 water bodies showed negligible decline (0.55%) followed by 0.31% decline during 2000-2016. Overall, it was recorded that water bodies showed positive trend (0.87 % increase) from 1990 to 2016. The details of land use change and percentages are given in table 4.

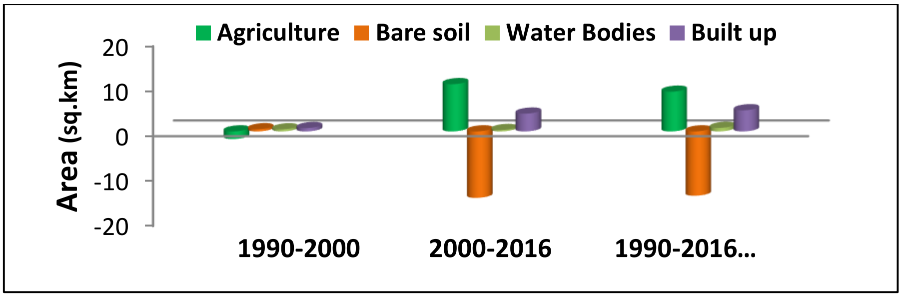

Fig 5. Change detection rate of different land uses in district Sialkot

Table 4: Land use change detection rate

Land use classes	1990-2000		2000-2016		1990-2016	
	Area (km^2)	% Change	Area (km^2)	% Change	Area (km^2)	% Change
Agriculture	82.52	2.73	327.13	10.84	244.60	8.10
Bare soil	41.81	1.38	-460.06	-15.24	-418.25	-13.86
Water Bodies	16.75	0.55	9.64	0.31	26.39	0.87
Built up	23.96	0.79	123.28	4.08	147.24	4.88

4. CONCLUSION

Based on the results of present study, it can be concluded that district Sialkot (total geographical area of 3017.28 km^2) has experienced severe land use changes during the years 1990 to 2016. Results also revealed that digital image processing coupled with supervised classification was found a useful tool and exhibited accurate land use classification of the study area. The area under study was classified in to four classes i.e., agriculture land, bare soil, build up area and water bodies. It can be observed from the results that agriculture land is still the largest land use class of district Sialkot and covered and area of 2109.6 km^2 in 2016 but it is experiencing a gradual decrease by increase in built up area. Moreover, results also concluded that land use changes have not exhibited harmful impacts on agriculture in the study area while it is expanding and providing more area for cultivation in the recent years. Moreover, it was recorded that bare soil area was decreased and build up area was increased in 2016 and covered an area of 391.45 Km^2 and 176.59 Km^2, respectively. However, all these changes show a great modification in land use classification of district Sialkot which can be assessed or evaluated for the planning purpose.

5. Suggestions and Recommendations

At the end of this paper some important recommendations are given below;

- Urban database should be updates and monitored regularly by advance geo-spatial techniques like, remote sensing and GIS and others
- Irregular expansion of urban area is harmful for agricultural land so there should be a proper department to see these changes as per law. Development department of Government should take strict actions against violations.
- Municipal Corporation of the District should play a vital role in urbanization and should take admirable steps and try to lift its workforces through finance to identify variations in land use on regular

basis so our state can be protected from the bigger difficulties like pollution, rise in temperature, traffic issues, lake of facilities and other domestic.

- Further exploration should be focused on the formulating of helpful planning and policies so that defensible development must be attain in this district.

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