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Spatio-Temporal Changes in Patterns of Land Use and Land Cover in Peri - Urban Areas of Faisalabad City

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ABSTRACT

The changes in land use occurs with the passage of time in an area where the priorities of living standard changes. The increase in population and better socio-economic opportunities within urban localities influences the peripheral areas as well as the proximities. The aims of the study changes in land use patterns in peri urban areas. The current research evaluated the variation in land use preferences in Faisalabad city during the 2000, 2010 and 2017, covering 18 years. The change is detected through satellite images by applying the supervised classification in specified classes including vegetation, built up areas, barren land and water bodies. The analyses of the acquired images disclosed that the dominant land utilization in the peri-urban zone is the built-up or infrastructure development. This urban expansion and development mostly influenced the agricultural land or vegetation cover, as results vegetation cover reduced rapidly. Out of the total land area, the urban infrastructure area with 24% in 2000, increased to 46% in 2017. The results further indicated that the city is expanding rapidly towards the peri-urban areas. For the most part of the peri-urban, land is converted to urban land uses as for housing, infrastructure and commercial activities.

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1. Introduction

Land use of a country is the spitting image of the people's living. Actually the land use of an area is consistently categorized by the spatial disparity and is intensely affected by socioeconomic elements (Bolca et al., 2007; Kapadnis, 2003). Land use either reflects or defines where and in what way communities are developing, and where an economic activity takes place (Gwamna & Yusoff, 2016). Land use specifies the reasons for which humans utilize land cover (Agarwal, 2002). The LULC patterns of any city are significance of regular, social and economic characteristics, in addition to their manipulation via through human (Balogun, Adeyewa, Balogun, & Morakinyo, 2011).

Land conversion from vegetation covered areas to other land uses is emphasized by the human persuaded environmental change (Arowolo & Deng, 2018; de Mello, Gulinck, Van den Broeck, & Parra, 2023). The unintended growth of urban localities and encroaching nature of population for numerous purposes is also contributing to LULC changes, consequently in peri-urban areas (Asamoah, 2010). Peri-urban areas display unusual distinctiveness that makes them separate from urban and rural areas (Amoateng, Cobbinah, & Owusu-Adade, 2013). Thus, this peripheral area devours entrance to vital and flattering links among urban and rural areas, (Samat, Hasni, & Elhadary, 2011). To maintain the environment along the living there is a need of land use and land cover information. Detection of the land use and land cover is very important to analyze the global change detection at spatio-temporal scales. For the collection of the information on the thematic change, the analysis on multi-spectral datasets are required under the adequate framework (Gul et al., 2023). Transformations of lands for human practices

or altering management practices on human conquered land, is transforming the earth's land surface (Ouédraogo, 2006). A reasonable area of land surface is being altered by humans (Ellis, 2011; Vitousek, Mooney, Lubchenco, & Melillo, 1997) and the land-use range is expected to increase in the upcoming time to provide somewhere to stay a growing demand for land (Brovkin et al., 2013). Various influences of changes in land use are recognized during the last couple of decades (Lambin & Geist, 2008). Manifold interrelating elements are caused land use changes, that initiating from diverse levels of association of the connected human induced environmental systems (Lambin, Geist, & Lepers, 2003)

Urbanization is transforming the spatial patterns of agricultural landscapes (Pham, Pham, Tong, Nguyen, & Pham, 2015). The anthropogenic practice and various biological factor effects the population growth socio-economic aspects and the modernization and cause of urban sprawl. The land modification, deforestation, loss of biodiversity, floods, atmospheric process and global warming are adversely affected by the LULC (Ahmad, 2023). In relations to the degree and influence on land configuration and patterns urbanization is considerably the most vital changing procedure (Rani, 2014). Pakistan is also being undergoing the urbanization since its formation. Urban population (% of total) in Pakistan is reported 39% to 40% according to the World Bank. Currently, the total urban population of Pakistan is 39.7% of the total population and the growth of urban population rate is 2.77% annually.

Patterns and procedures of land use and urban development may better be examined in the urban peripheries (Tacoli, 1998). Land use changes are imitated in the shape of residence and satellite settlements that are being developing in the urban fringes which is agricultural land in the urban venue (Naab, Dinye, & Kasanga, 2013). People throughout the world have a propensity to urbanized on peripheral lands (Dey, Pramanik, & Dey, 2010). As a result, urban development takes place in an indiscriminate way ensuing to urban area enhancement and thus unsustainable use of land (Mundia & ANIYA, 2007). Urbanization indicates to the outer growth from inside urban areas on the way to peripheral areas (Owusu & Agyei, 2007). Because of unintended poor management for population accommodation cities are overwhelmed by the problems of congestion and expansion (Henderson, Quigley, & Lim, 2009). Thus, such areas are facing the transformation of land for urban land uses where lots of variations are fascinating residence (Adam, 2016; Wehrmann, 2008).

A peri-urban area generally occurs when the arable or agricultural land beyond the urban zones is purchased up by urban dwellers (Mugish & Nyandwi, 2015). Migration within the cities and cultural changes symbolize related components for the growth of development activities in peripheries (Zasada, Fertner, Piorr, & Nielsen, 2011). The rapid expansion of urban locality has transformed the land use from agricultural areas to urban infrastructures (Riaz, Ghaffar, & Butt, 2014). Land use change pattern in suburb is influenced by three major factors which includes the excessive existing rural settlements which, if promoted, change the uniqueness and execution of the territory, the upcoming classification of larger lands and the fragmentation in urban uses (Auster & Epps, 1993).

In addition, two forceful factors for the conversion of land in peripheral zones, remain the demands of lodging to accommodate ever-increasing population and urban services (Masanja, 1999), and the worsening housing situations and insufficient urban amenities (Döös, 2002). Therefore, cities are extending rapidly over the peri-urban areas. The urban centers extend, the leading sector for explicit influence remains the urban peripheral zones(Napari & Cobbinah, 2014), that are described by distinct land usage, which generally diversify in connection to practical relations to urban-rural regions. The migration from the rural areas towards city that affects the urban population in the city and play a vital role in the urban sprawl (Haldar, Mandal, Bhattacharya, & Paul, 2023). Amalgamation of impulsive persistent outward urban growth is headed to a new tendency of development on urban peripheries (Busko & Szafranska, 2018; Sfeir, 2023). The peripheral zones occurs rapidly fascinating the working class and high class societies,(Simon, 2008). Therefore, the growth actions are dependable for LULC in urban peripheries,(Tacoli, 1998) and these areas are most vulnerable for the loss of cultivated land (Namara, 2011). Peri-urban areas can consist of unsystematic cluster of commercial, resident, rural-resident, and usually diverse agricultural uses (Nicodemus & Ness, 2010). The best extents of fiscal, societal and physical variation are the methods of development in developing nations. Furthermore rural-urban peripheral areas are affected by this growing

demand of land use (Abdulai, Enu-kwesi, & Agyenim, 2020; Thuo, 2013; Yiran, Ablo, Asem, & Owusu, 2020). It is recognize that in the suburbs the stability of land tenure method is shivering because of analytical and geographical variations in the city centers (Adam, 2016; Jones, 2023). The leading urban procedure and the geographical arrangement contest in the 21steracould be the peri-urban. The urban proximity is frequently an area of disordered and unplanned urbanization a form of urban extension. Relatively peripheral zone is an innovative type of multifunctional sector (Ravetz, Fertner, & Nielsen, 2013). This prediction raises the statement, that attached lands are being transformed into peri-urban uses and eventually for urban (Appiah, Asante, & Nketia, 2017). The land in the urban fringes is underdevelopment. In the proximity zones, land is being transformed to urban uses deprived of any efficient development strategy (Abera, Ahmedin, & Muluneh, 2022; Carra, Caselli, Rossetti, & Zazzi, 2023; Matsa, Mupepi, & Musasa, 2021; Ukoje, 2016). This urban growth is absorbing countryside land and vegetation fields at a ratio twofold, therefore the unrestrained and chaotic urban sprawl is a problem of abundant interest (Feng, 2022; Riaz et al., 2014).

In the peri-urban zone the practice of unrestrained urbanization that springs up in scarcity are measured a catalytic aspect for land use changes. Moreover, model of peri-urban development rarely esteem the see the master plans (Kimengsi, Nguh, & Nafoin, 2017; Signorini, 2021). The future in regard to urban might remain allocating with multifaceted variations in the shape of urban residents and outside the commuter belt comprising urban sprawl to retrain the precarious ecosystem services that sustained the population growth (Xavier, 2013).

The future of cities and urban areas is recognized by a collection of optimistic or adverse aspects, not certainly interrelated to their existing scale or functions, because these are dynamic, not stationary (Hefferan, 2014). This is with concern to the fact that development is dynamic and land use transition is not deterministic. In this framework the peri urban arable land use is the concentration as it is well thought-out to be considerably expensive and if not measured, might leads to loss of the vegetation cover, as well as cultural and environmental loss. Dynamic scientific innovations and economic situations are arbitrated by official elements and donated to the several important stubborn LULC changes in peripheral zones (Appiah et al., 2017).

This urban expansion, if not properly planned in keeping with the practices of many developing countries, frequently indicates to unsustainable development, loss of cultivated land and rise in poverty, crime and insecurity in cities and rural settings (Ejaro & Abubakar, 2013). Justify and preventive land use changes are the properties of land ingestion, which consequently signify an imperative problem of concern for regional and local planning (Salvati, Smiraglia, Bajocco, & Munafò, 2014). Planning of LULC is considered very significant is management of land in sustainable way and it is also a mechanism that influences the decrease of stress on land properties (Živanović-Miljković, Crnčević, & Marić, 2012). All anthropoid settlements endure on land, which establishes the solitary most imperative element of total environment. Urban planning must start with a complete expression at the use of land (Busko & Szafranska, 2018). Urban and rural land use change can be monitor, planned and manage over the computerized system since the initiation of earth mapping system. For this purpose GIS is hosted for modeling, spatial analysis and demonstrate the geographical features (Bhalli, Ghaffar, Shirazi, Parveen, & Anwar, 2012).

2. The Study Area

According to population Faisalabad (Lyallpur till 1979) is ranked third populous city of Pakistan. The city is located 360 kilometers south to Islamabad. Its absolute location is 30°42' and 31°47' North latitudes and 72°40' and 73°40' East longitudes (Figure 1). The elevation of city is 186 m over sea level. The growth rate annually is 1.97% from 1998 to 2017. According to the last census of 2017 the population of Faisalabad District is more than 7.8 million, while population of Faisalabad City is more than 3.2 million or 65,00,000 souls. There was an enhancement of 1.2 million individuals in last 19 years- or a 59.43% development since 1998. According to the population census of 2017 the total urban population is 47% of the total population. The total area of Faisalabad District is 5,960 km^2 but the area under FDA is 1,280 sq. km.

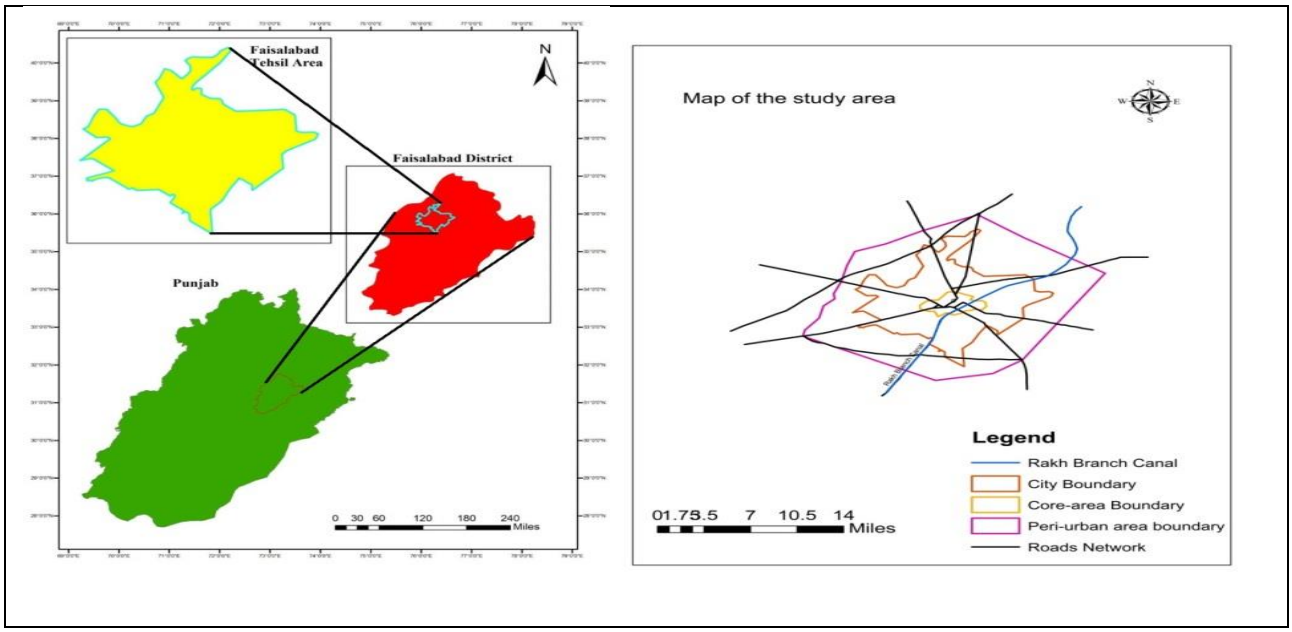


Figure 1: Study Area Location
Source (Author)

3. Materials and Methods

The current research is designed to analyze LULC changes in the Faisalabad city spatially and temporally. To evaluate the changes, a study period with three different study years was adopted. The study period covered 17 years of last three decades from 2000 to 2017. The study years were 2000, 2010 and 2017.

3.1. Data Source

The data acquired from United State Geological Survey website (https://earthexplorer.usgs.gov/) (Table 1) of the study area of Landsat 5 and 8, with minimum cloud cover were used. The Landsat 5 imageries have 60-meter resolution and the Landsat 8 have 30-meter resolution as multispectral band and 15-meter resolution as panchromatic band. The software used for Land Use and Land Cover Change detection are Erdas Imagine 2014 and Arc GIS 10.4.2.

Table 1: Data of Satellite Images

Info	Date_ Acquired	Space craft Id	Sensor_ Id	Wrs_ Path	Wrs _ Row	Landsat _ Id
2000	1/5/2000	LANDSAT_5	TM	150	38	LT51500381999363XXX01
2010	12/27/2010	LANDSAT_5	TM	150	38	LT51500382010361KHC00
2017	12/30/2017	LANDSAT_8	OLI_TIRS	150	38	LC81500382017364LGN00

Source (USGS)

3.2. Methodology

For the detection of Land Use and Land Cover changes these steps were used.

3.3. Data preprocessing

All bands are stacked by the process of layer stacking excluding the thermal bands. To correct the distortions resulting in the acquiring image is done by image rectification. To enhance the spatial resolution of the images the panchromatic band were added in the process of layer stacking. Both images downloaded are in UTM-WGS84.

3.4. Image Classification

The pixels are categorized according to the data carried out by each pixel for land cover types in supervised classification. Before categorization, the area is finalized as training area having different land cover. Generally, this shows the study area and for this study, the training area is Faisalabad city. The algorithms in the computer are then trained to obtain the spatial values. The algorithms specify and associate each pixel with the spectral data. The results of

such classification are typically depicted through maps having specified land cover. The spatial extent and distribution of specified land cover can be identified through the map.
For specification of desired classes of LULC, supervised classification is generally used. The classification analyzes and recognizes the spectral values in different bands which are associated with the spatial data(Hong et al., 2020; Liaqat et al., 2021). Signature file will used to apply the maximum likelihood image classification(Stateczny, Bolugallu, Divakarachari, Ganesan, & Muthu, 2022). So, the signature file will made to performed the supervised image classification and training samples of the different land cove are taken. The classes in this study are Vegetation, Built up land, Water bodies and Barren land(Gondo, Kolawole, & Mfundisi, 2023; Hussain et al., 2022; Tariq, Shu, Siddiqui, Imran, & Farhan, 2021).

4. Results and Analyses

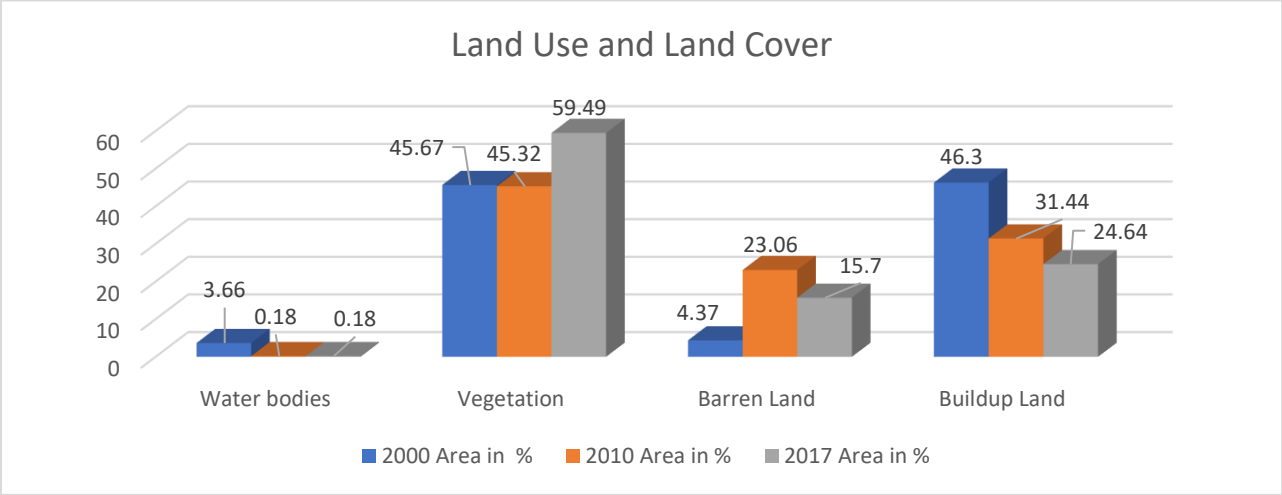
4.1. LULC from 2000 to 2017

Land use change is always remained a significant area of research in relation to RS and GIS applications in research circles all over the world. Subsequently, the techniques of GIS provide a substitute for land use changes to be excellently mapped and supervised. Such technology as like geo-informatics advance vital technologies to overcome the spatial problems and as a result shows the significant role in sustainable land use management. The data show in the table is the results of all Landsat images from 2000 to 2017.

Table 2: LULC Changes during the Study Period

Classes	Area sq. m	%	Area sq. m	%	Area sq. m	%
Water bodies	180682000	3.66	1045800	0.18	1027800	0.18
Vegetation	225440900	45.67	265595400	45.32	348612300	59.49
Barren Land	215869300	4.37	135153900	23.06	92009700	15.70
Buildup Land	228532000	46.30	184228200	31.44	144373500	24.64
total land area	4936280300	100	586023300	100	586023300	100

Source (Author)



The spatial and temporal analysis of LULC of the Faisalabad city (Peri urban locality) on 2000 image evidently shows that area has diverse mixture of covers and variations in land during past. The core of the study area is generally containing of highly dense older urban sector which is bounded by latterly urbanized low compactness urban area. The vegetation cover is 59.49 % of total land, barren land is consisting of 11.09 %, water bodies 0.18 % while built-up area 15.70 % of the total study area which comprising of residential, industrial and commercial units. The urban population of study area in year 2000 was more than 21, 09,871 with an annual growth of 3.59 %.

The LULC of year 2010, green area decreased and encompasses the 45.32 %, while the built-up area is 31.44 % which is increased as compare to 2000 in Faisalabad. The enhancement in built-up exposure is ascribed to the further boost of population that incessant to elevate the demand for commercial uses, residential infrastructure and other services (facilities, amenities). The population in Faisalabad city is on the enhancement showing the projection up to 25, 52,000 with a growth rate of 2.01 annually by 2010. The area covered by water remained same 0.18 % as in year 2000; on the other side the area comprised of barren land is 31.44 %.

The spatial distribution of study area of 2017, the vegetation covers an area about 45.67 %, water 3.66 % and built up area 46.30 %. Again, the built-up area increases in the Faisalabad city which is highly linked with population increase. The census of 2017 showed the total population of study area is 3.204 million, 47.8 % of which is urbanized. To fulfill the requirements of this population more and more peri-urban land is used under build up. The barren land in study area is decrease as compared to 2010, which constitutes the 4.37 % of the total area.

It is apparent that the area sheltered by vegetation is decreasing till 2017. The study duration from 2000 to 2017 is confirmations a minutest overall decline in vegetation cover where it occupied 348,612,300 sq. m and 225,440,900 sq. m, which is covered a decline of 123,171,400 sq. m until 2017. There is observed a swift enhancement of population throughout the study duration from 2000 to 2017. This highly shared to enhance the claim for land for city development, significantly for the building of residential infrastructures. Therefore, the buildup area is fluctuating with population distribution, is associated with inclusive increase in area.

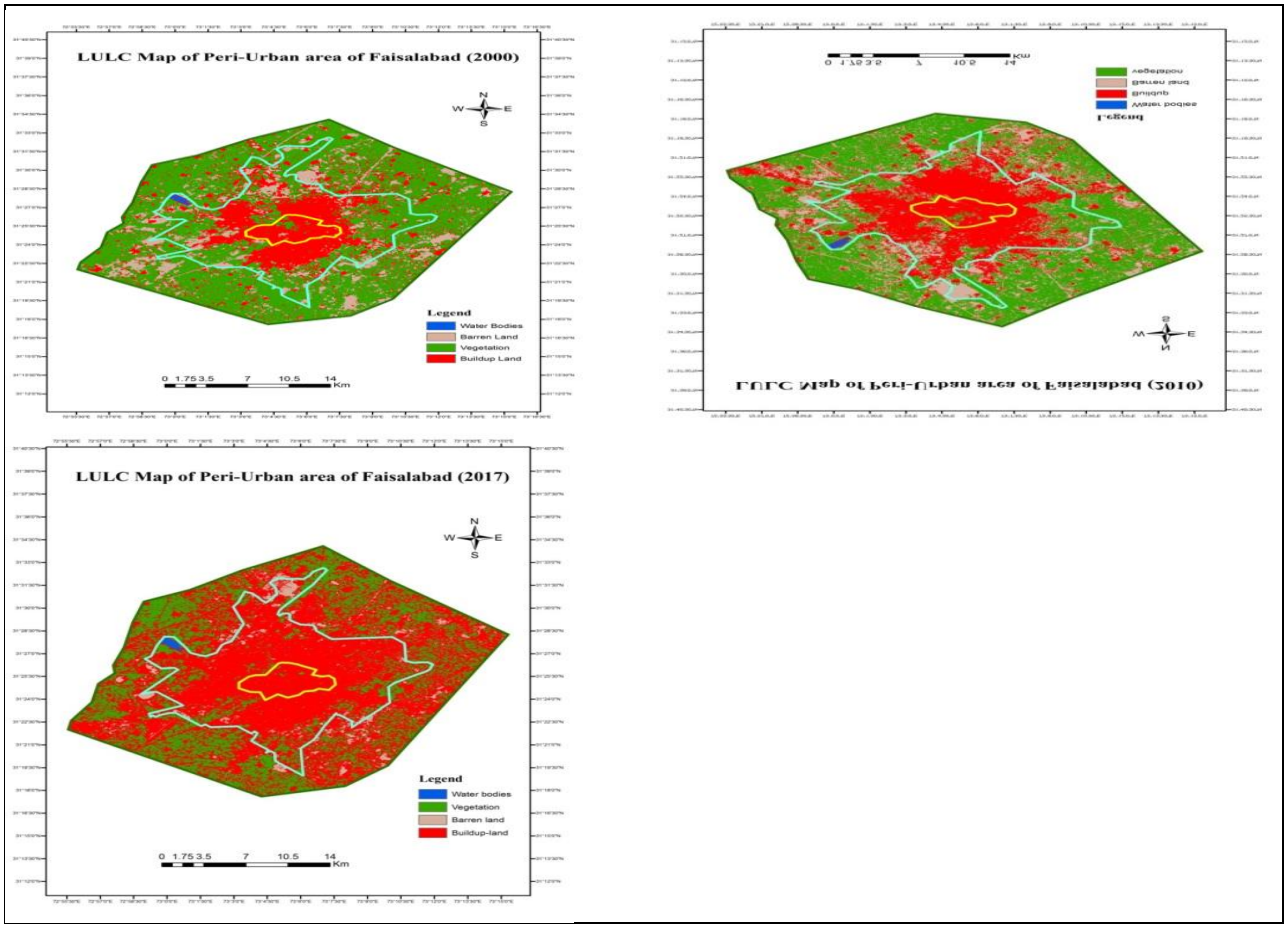


Figure 3: LULC 2000 – 2017 in the Study Area
Source (Author)

4.2. Change Detection: 2000 - 2017

The change detection during the years 2000 to 2010, the findings reveals that there seems to exist a growth in built-up area around the urban localities in the peri-urban, and is spreading over the agricultural land without any specific pattern of change. The detected land use change from year 2010 to 2017 shows the highest increase in the buildup area as compared to previous years. Because the population of study area is increase rapidly with a normal annual growth rate of 1.97% during 2000 - 2017. With the growing rate of population and their land use requirements vegetation cove is decreases in the urban fringe areas. The land use change detection from year 2000 to 2017, clearly defined that the built up area of study area is more than the vegetation cover.

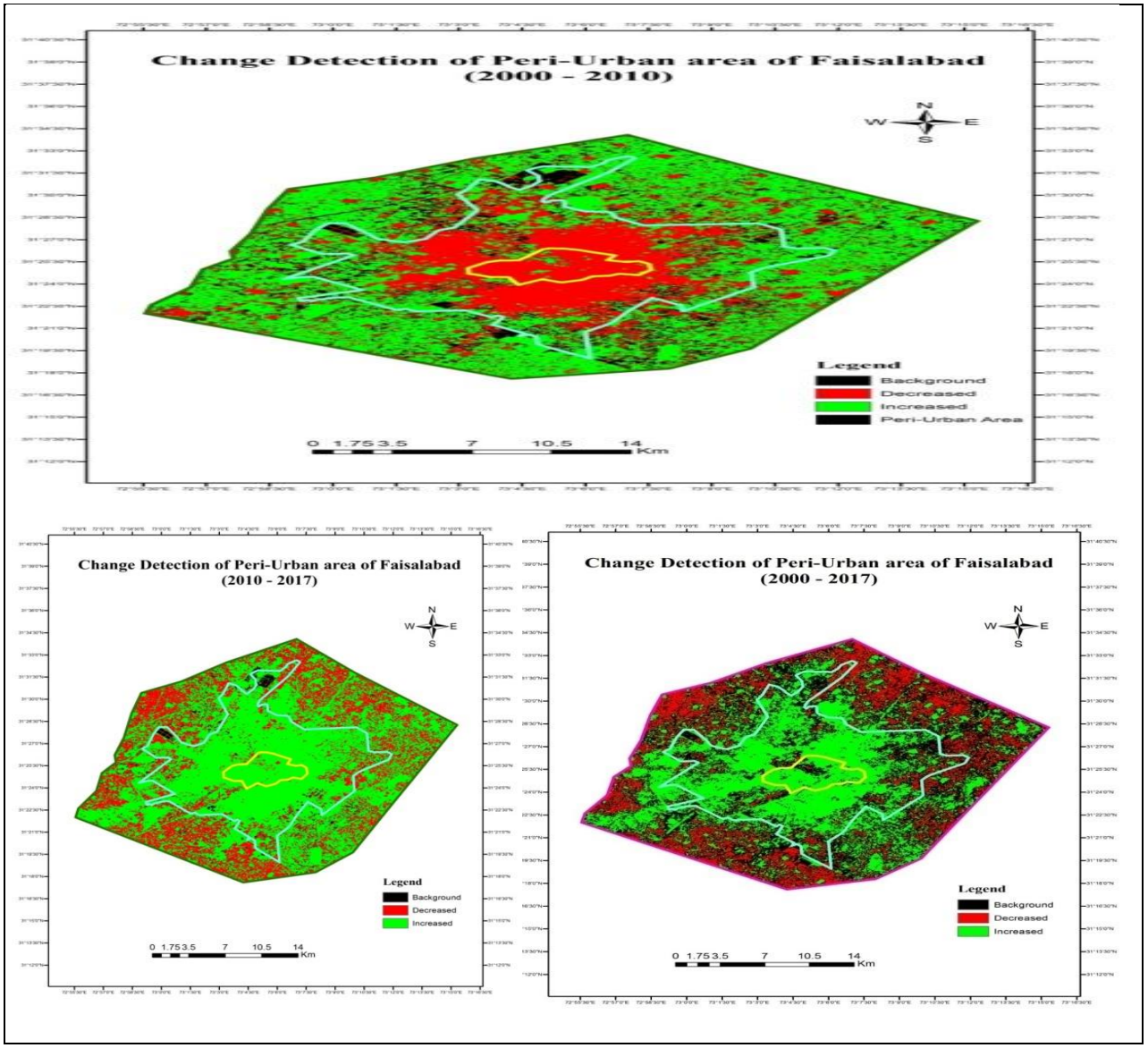


Figure 4: Change Detection 2000 - 2017

Source (Author)

Table 3: Change in Classes from 2000 to 2010

LULC change detection from years 2000-2010			
Classes	Change in %	Decrease in %	increase in %
Water bodies	0	-	-
Vegetation cover	23.81913	14.71	-
Barren land	46.879	-	7.36
Built up area	25.5974	-	6.8

Source (Author)

Table 4: Change in Classes from 2010 to 2017

LULC change detection from years 2010-2017			
Classes	Change in %	Decrease in %	Increase in %
Water bodies	1933.3	-	3.48
Vegetation cover	0.772286	0.36	-
Barren land	18.0494	18.69	-
Built up area	47.2646	-	14.86

Source (Author)

Table 5: Change in Classes from 2000 to 2017

LULC change detection from years 2000-2017			
Classes	Change in %	Decrease in %	Increase in %
Water bodies	713.3	-	3.21
Vegetation cover	8.71477	4.36	-
Barren land	60.4882	6.69	-

Built up area	20.35352	-	7.83

Source (Author)

5. Conclusion

As observed by the remotely sensed Landsat images and spatio temporal analysis in Faisalabad city (Peri-urban areas), it is concluded that LULC changes is resulted to increased compression on the green land in peri-urban areas. The land use changes create a variance between agricultural land along with the built-up land. Drastically, the built-up increased while as a result the agricultural land decreased in the study area. The results implicit from the remotely sensed classified Landsat images, the digital data declared that in 2000 the total built-up land was 24.64% of total study area, while as 2017 it increased to 46.30% of Faisalabad city. While the vegetation covered 59.49% area in 2000, but it decreased to 45.67% in the 2017, which is modified and converted into built-up land throughout the study area. This exceptional development and growth is noticeable all over the place from the formerly existing built-up land to areas the minute cultivated in the rural urban peripheries.

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