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Monitoring of Land Use/Land Cover Changes and Urban Sprawl in Peshawar City in Khyber Pakhtunkhwa: An Application of Geo-Information Techniques Using of Multi-Temporal Satellite Data

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Abstract

This paper presenting land use and land cover changes in the Khyber Pakhtunkhwa city of Peshawar, Pakistan, this study is the first to use satellite remote sensing data to examine the 17 years land cover changes in the city of Peshawar between 1999 and 2016. Particularly, it employed maximum likelihood classification algorithm to classify Landsat 7 ETM+, and Landsat 8, OLI data collected from 1999 and 2016 and then detected changes in the land cover in the study area, it then measure urban sprawl by applying raster Boolean techniques to extract the urban area, Then compute the changes between the two composite classified images of 1999 and 2016. A scatterplots and histograms techniques is employed to evaluating training samples in confirming the degree of spectral separation acceptability of the bands used for each of the land use and land cover (LULC) classes conversion analysis in Environmental Systems Research Institute ESRI;s Arc Map was applied. Some post classification filters techniques is used to remove the small noise objects. The classification results over the two periods depicted that built up land increased in term of percentages 26.59% between 1999 and 2016. While rapid decreased is found in agricultural land 23.56%, barren land 3.30%. Water body is increased 0.27%. Similarly the built up land is increased 24.55 ha, whilst agricultural land is decreased 21.74 ha, barren land 3.04 ha, water body is increased 0.25 ha between 1999 and 2016. Our findings depict some of the significant changes in the land use and land cover patterns are analyzed in the city of Peshawar. The experimental results showed that major changes are observed in the built up area which rapidly increased at 26.59%, however the substantial decreased is found in the agricultural land, barren land in 1999 and 2016. Future studies should examine the entire district of Peshawar the current challenges faced by the city's resident due to urban growth and attempt to find ways to resolve them in the future.

Keywords: Land use; Land cover; Change detection; Urban sprawl; Spectral signature separability; GIS; Urban area; Peshawar city Pakistan; Operational land imager; Enhanced thematic mapper

Introduction

Geographical information systems (GIS) and remote sensing application in land and natural resources management is widely used globally. Land use and land cover changes as one of the main force of global environmental changes, and for sustainable development. Current technologies such as geographical information systems (GIS) and remote sensing provide a cost effective and accurate alternative to understand the dynamics of landscape. Digital image base detection of LULC based on multi-temporal and multi- spectral remotely sensed data have depicted a great potential to understanding landscape dynamics to detect, identify map and monitor differences in LULC pattern over time. Land use and land cover changes detection is important landscape dynamic for a specific period of time having sustainable management. The land use and land cover (LULC) changes have significant application in environmental management and for planning of peri-urban area [1-8].

Urbanization can be defined as the fraction of peoples lived in urban circles of any country later on converted to settlement, which constitute over 5000 person or more, covered with specific criteria includes civic facilities, socioeconomic base and access of basic infrastructure in Pakistan's point a view. The growth rate of urban area is higher than rural fringe characterized by rural to urban migration due to the lack of rural basic infrastructure and rapid growth of Population [9]. In term of population Peshawar is the major city of Khyber Paktunkhwa (KPK). According to the census report of 1961, Peshawar share 29% of the total urban population of KPK, and hence was representative of the old city. In addition to the 1998 census calculation 33% population found and share of the total urban population. This mass increase in population found the migrants from Afghanistan where life and living situation were not friendly. Peshawar, sharing the social and cultural values, located closer to the border of Afghanistan proved to be the best option to live without any favoritism. Therefore, Peshawar is more vulnerable to urban sprawl. This situation is a challenging task to provide and supplying of quality foods, educational facilities, health, housing and enough infrastructures to the common people. Urban sprawl will affected the environment and climate of the city and lead to poor sanitation, industrial connections, emission of CO_2 and other gasses to the air. Transportation is the main contributing source of greenhouse gases (GHG) and consequently climate change occurs. Due to the GHGs the amount of carbon dioxide (CO_2) is increased in air as a result the average world temperature about 1.4-5.8 degree Celsius [10,11]. The application of remote sensing and GIS play important role in land use and land cover assessments of land suitability and capability

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particularly for agricultural, land cover change analysis, change detection and post classification techniques, spatiotemporal analysis of urban sprawl and its contribution to climate and environment, detection of land use/land cover changes, urban sprawl and analysis of multi-temporal remote sensing data [12-16].

Urban encroachment and land use/land cover changes growing very fast particularly cities in the developing countries has drawn significant attention from urban and regional planner. Increasing population growth and density is the major factor causing LULC changes and urban sprawl [17-20]. Urban population growth demands is urban facilities, construction of residential area, commercial, public utility and road network infrastructures. Consequently, Agricultural, forest, farmlands, barren land, is causing LULC changes and urban sprawl. Urban sprawl has it threshold limits. A city ramming uniform and vulnerable to change while, fast unplanned urban sprawl exceeding its maximum threshold limit creates chaos and deteriorates the quality of city transportation and public utility services. Therefore, it need well planned urban sprawl is essential to build a socially, economically and environmentally friendly sustainable society [21].

Population growth and urban sprawl pointed regional economic growth. However, human caused deforestation and changes of natural landscape to construct high-rise buildings, water supplies, sewage and transportation works put negative impacts on land and soil, biodiversity, vegetation, noise level, air and water qualities, and contributes to an environmental degradation both inside a city and in its surrounding [22-26]. In addition, the occurrences of flood and natural hazards are due to the major construction works transform cities into impervious surface in which the formation of heat island contribute climate changes [1,26-31]. Urban sprawl also increase land values, cost of living, economic, and social stratification [6,31]. In order to cope these negative impact of urban sprawl and for planning a city future expansion, government official, urban planner and policy maker need careful attention of its current LULC pattern and their Spatiotemporal changes. Urban sprawl is occurring within the city respect to population growth and economic development [4,32]. The LULC change requires an analysis of a large amount of spatiotemporal data that were traditionally collected through field surveys. From the last few decades, with the advent of remote sensing technologies, particularly due to their low prices, large spatial coverage's repetitive observations, and efficient data-processing capabilities, has promoted urban researcher and city planner to use remote sensing data to monitor the spatiotemporal LULC changes and urban sprawl [2,4,5,27,33-38]. The method of identification of LULC changes using remote sensing data fall into pre-classification and post calcifications [39]. The pre-classification method process a set of multi-temporal remote sensing images to create maps identifying area of changes or no-changes in LULC without classifying the nature of changes [29,32,39-41]. In contrast, the post-classification method compare two classified temporal remotely sensed images to produce maps to that would depict changes within and between LULC classes over time. Therefore, it helps researcher and planner to detect the nature and direction of LULC changes and urban sprawl surrounding the cities [39,42-44]. The mass migration from rural to urban area, the rapid growth creating challenging problems such as crowding and land use dispute for the residents and for the urban and city planning and management system of the urban area. In addition, the outcomes from agricultural area will be reduced, unplanned housing areas, costly arable land, and developer's assumption about land cost, adulteration of public's atmosphere [8,45,46].

This paper analyzes the LULC changes and urban sprawl in the city of Peshawar using remote sensing Landsat's data for the years 1999, and 2016. The objective is to classify LULC classes in two years changes detection that occurred in each LULC classes and calculate and monitoring the urban sprawl change detections and response to the population growth in the city of Peshawar over the last seventeen 17 years. Section 4 describes the material and method used in the study area, whilst results and discussions are presenting in section 5 and 6. Finally, Section 7 describes conclusion and future research direction.

Materials and Methods

Study area

Peshawar is the heart and capital city of Khyber Pakhtunkhwa Pakistan and carrying multicultural denizen of the province. Historically, Peshawar city is beautiful and important hub economically, politically and military for the province and Pakistan. Peshawar city is bounded to the west, the Federally Administered Tribal area (FATA), and Mohmand Agency is located at its North. Similarly, district Kohat is at its Southern side. Charsadda and Nowshera are linked it North and North-East respectively. However, Afghan boundary is 40 Km away from West of Peshawar city. Geographically Peshawar city is located at 34.025917 North Latitude; 71.560135 East Longitude. It is spatially extended to 1257 square kilometer [10]. Figure 1 shows geographical location map of the study area.

Landsat images pre-processing

Two separated free from atmosphere Landsat 7 ETM+ and Landsat 8 OLI data from 1999 and 2016 covering the study area were acquired freely from the US Geological Survey's (USGS) Earth explorer website (http://earthexplorer.usgs.gov). Due to the free availability and affordability of high resolution Landsat scenes were chooses for this study. Table 1 depicts detail about the data. The data for this study is already pre-processed by USGS and provided level-one terrain-corrected (LIT) Landsat data in WGS84 geodetic datum, Universal transverse Mercator Map projection (UTM, Zone 42N), due to the LIT nature of the data the geometric and radiometric distortion were already corrected before delivery [3,16,26].

Method

The supervised maximum likelihood classification method is used to classify the Landsat images from 1999 and 2016 into four LULC classes. Such as built up area,agricultural land and water body. The MLC provide excellent result in both Landsat images. However, the land use and land cover classes signatures are further analyzed using the scatter plot and histogram techniques to separabality of the bands used in the LULC classes. Figure 2 show flow chart of the proposed method, in which two years data is selected for experiment such as Landsat 7, 1999 and Landsat 8, 2016. Firstly the study area is cropped and creates signatures for LULC classes. Scatterplot and histogram is performed to evaluate the training samples of LULC [47,48]. Secondly supervised MLC is employed to classify the two images and Boolean techniques were performed to extract the urban area from both images and calculate the statistics of LULC classes. Some post-calcification techniques are used to purified all the LULC classified image and remove the noise, the filter which are used in this paper are the majority filter 3×3 neighborhood relationship. Finally, raster calculator is used to calculate the statistic of LULC in both in term of percentage and hectare. The entire processes are performed in the ESRI software Arc GIS 10.3.

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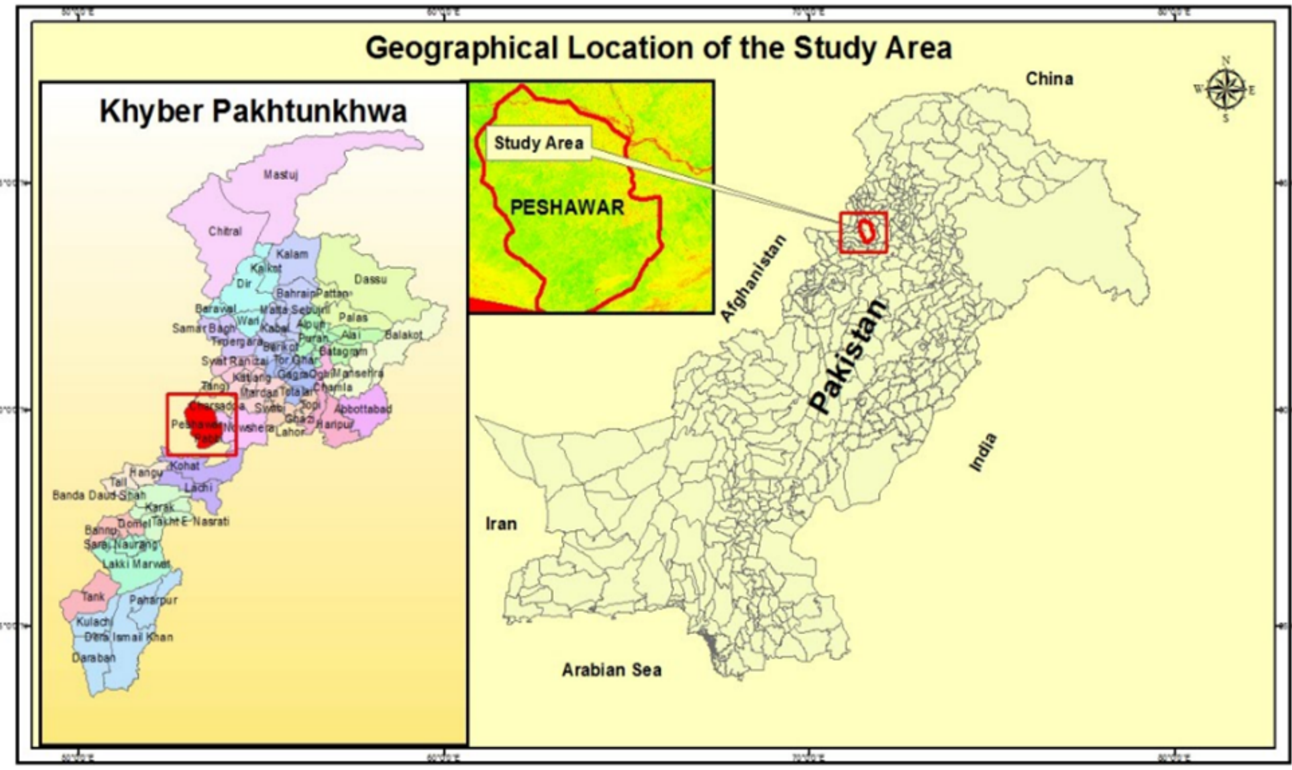

Figure 1: Geographical location of the study area.

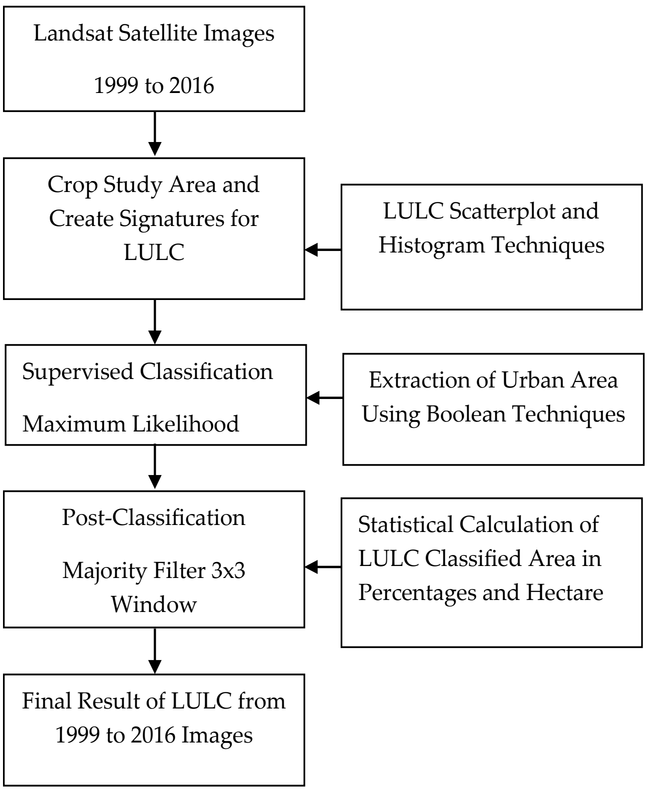

Figure 2: Flow chart of the proposed method.

Results

Creation and evaluating of training samples signatures between 1999 and 2016 images

To analyze the signatures of LULC using scatterplot and histogram techniques for the bands 1-5 is selected for details study from images of 1999 and 2016. The spectral signature of LULC as, built up area red, agricultural green, barren land is topaz sandy color and water body is presented in blue color. The signatures of LULC scatterplot (Figure 3) from the 1999 image yielded better results of bands separability and to explore the spectral characteristics of different classes' areas an excellent manner. It depicts that majority of the land use and land cover classes reasonably separated. Particularly in bands 1-2, 1-3, the entire land use classes the agricultural land is separated well in all bands. However, Figure 4 show the outputs histogram from the 1999 image depicts best evaluating of training samples to separation between the classes especially, in band 1 and 2, the built up area yielded best results. While in the band 3 and 5 the agricultural land has high spectral and separation results. Water body shows best separation in bands 4 and 5, the barren land in band 4 have high spectral values in 1999 image histogram result.

Separability in the 2016 (Figure 5) image signatures indicated best minimum separabality in all classes of land use and land cover from reasonably separated to moderately separate. Particularly in the 1 and 5, all the land use classes are separated well. However in the 1, 2 and 1, 3 is low separation results, while in bands 1 and 4 is much better separation then 1,2 and 1,3 in land use and land cover classes. The result of histogram techniques in Figure 6 from image signature of 2016 is not better result as to compare with the

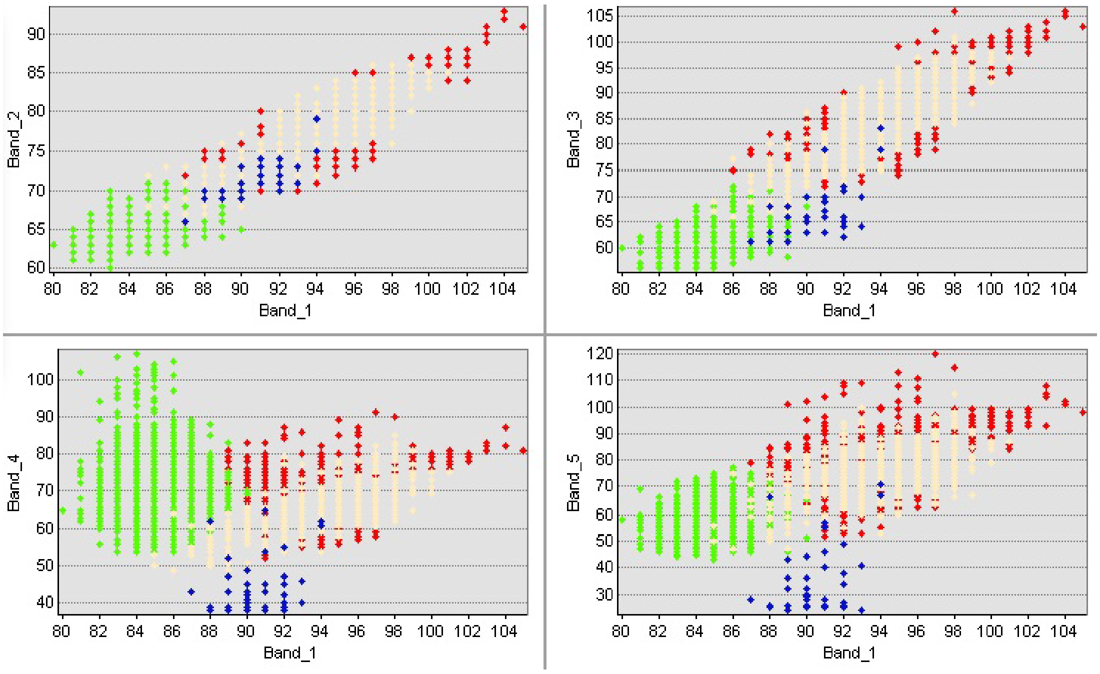

Figure 3: LULC signatures and scatterplot techniques depict different bands from 1999 image.

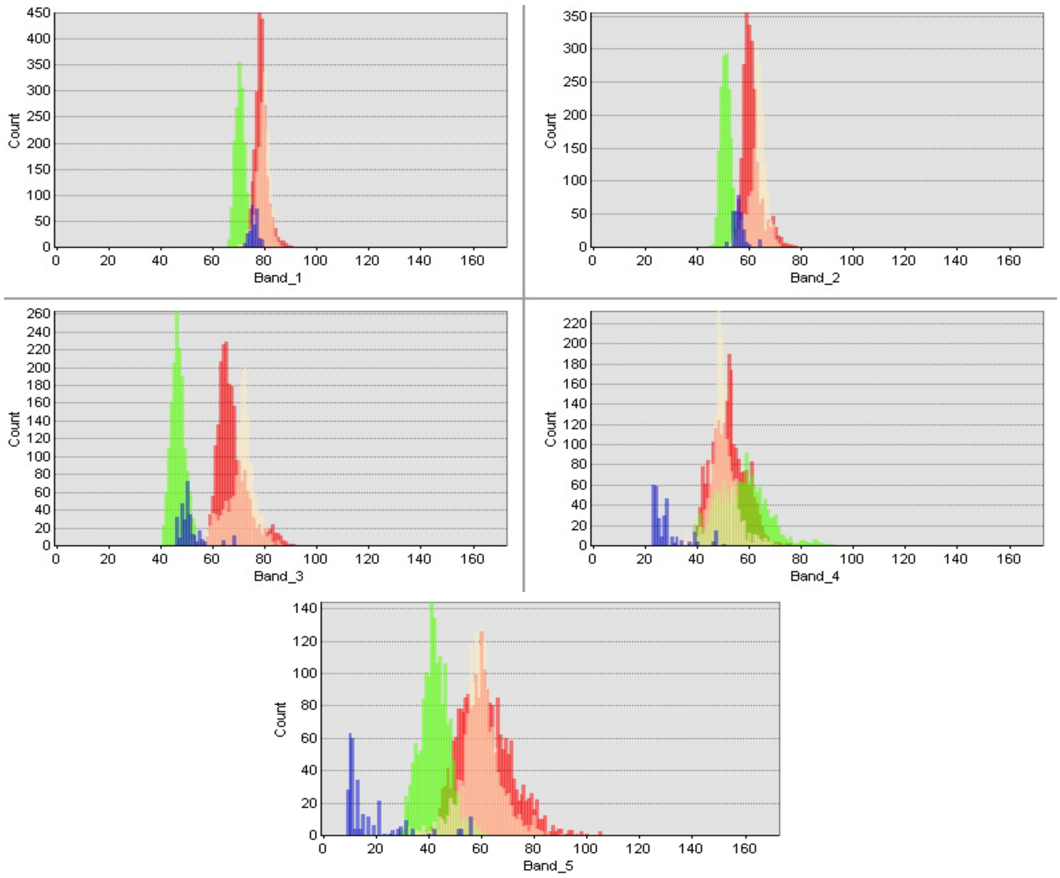

Figure 4: LULC signatures and histogram techniques depict different bands from 1999 image.

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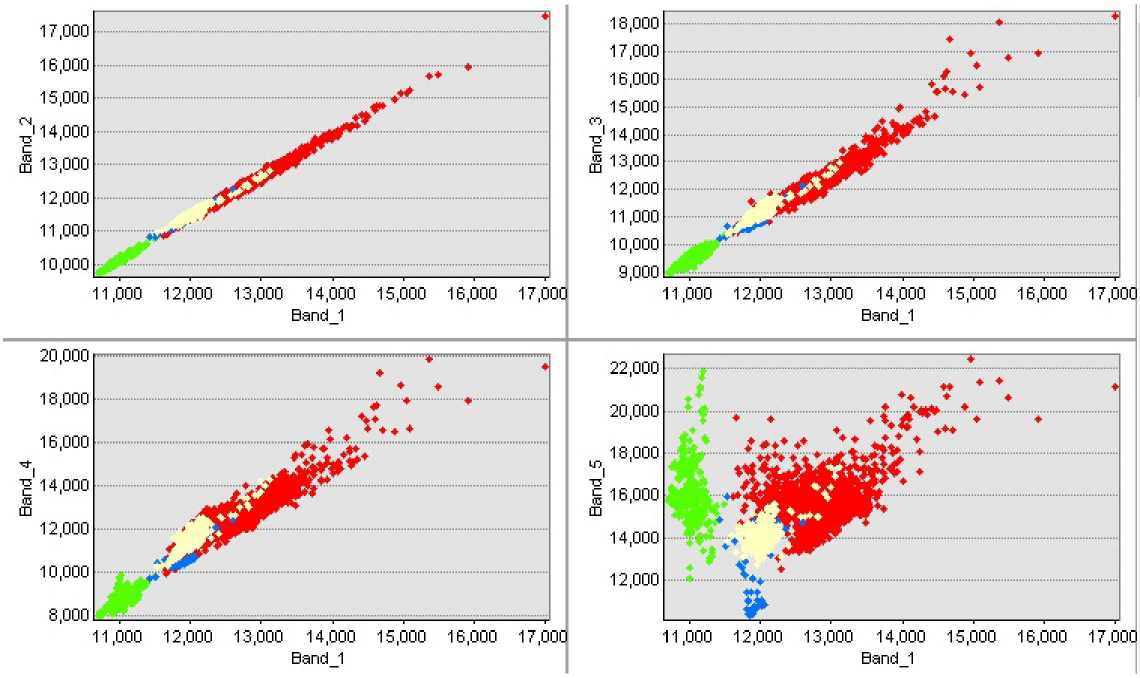

Figure 5: LULC signatures and scatterplot techniques depict different bands from 2016 image.

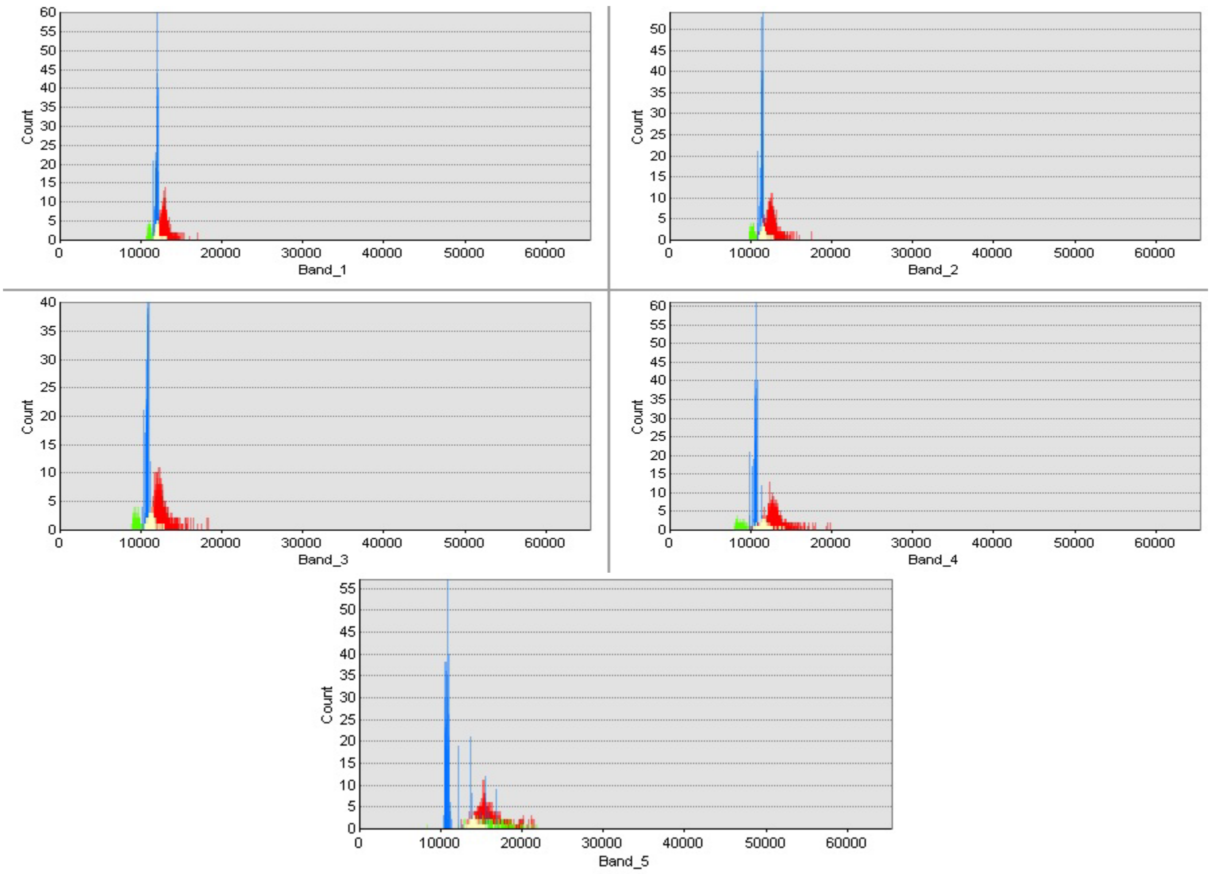

Figure 6: LULC signatures and histogram techniques depict different bands from 2016 image.

result of 1999 image histogram signature of land use and land cover classes. In 2016 image of Figure 6 the signatures of histogram shows water body excellently separated in all five bands. Built up area is separated fairly, however, the barren land and agriculture area is not separated perfectly [49-51].

Classification of land use and land cover images analysis

The classification of land use and land cover images analyses were conducted from the 1999 Landsat 7 and 2016 Landsat 8 OLI images using the maximum likelihood classification algorithm. The selected study area is cropped from the Landsat images and created three hundred eighteen signatures to classify the images into four LULC classes, such as built up area, agricultural land, barren land and water body. The signature is further analyzed to create a scatterplot and histogram techniques to observe the characteristic of each bands separabality of LULC classes. Boolean techniques are applied to extract the built up area from both LULC classified images of 1999 and 2016, and compare the result and overlays each other's. Increase of urban sprawl is clearly observed in the past seventeen years. Majority filters are used to purify the classified images by applying 3 × 3 neighborhood relationship. Statistical techniques are applied to calculate the LULC area in terms of percentages and hectare and make graphical presentation by bar graph.

Analysis of LULC classes for the year of 1999 Landsat image: The land use and land cover classification results using the maximum likelihood classification method for the two time periods within the study area are given in Figures 7 and 8, while the urban sprawl classification results are given in Figures 9 and 10. For both of the images four classes are selected to classify the Landsat 7, 1999 and Landsat 8 OLI images to produce accurate results. The statistics for each land cover class from the 1999 Landsat 7 images are shown in Table 2. However, the maximum likelihood classifications output of 1999 image are given in Figure 7. According to the statistics calculation of 1999 images classification result the built up area in term of percentages is 44.80%, agricultural land is 46.34%, barren land 8.58% and water body are 0.26%. Whilst, in term of hectare the built up area 41.3644 ha, agricultural land 42.7808 ha, barren land 7.9299 ha and water body is 0.2406 ha. A very small change is observed in the classification results

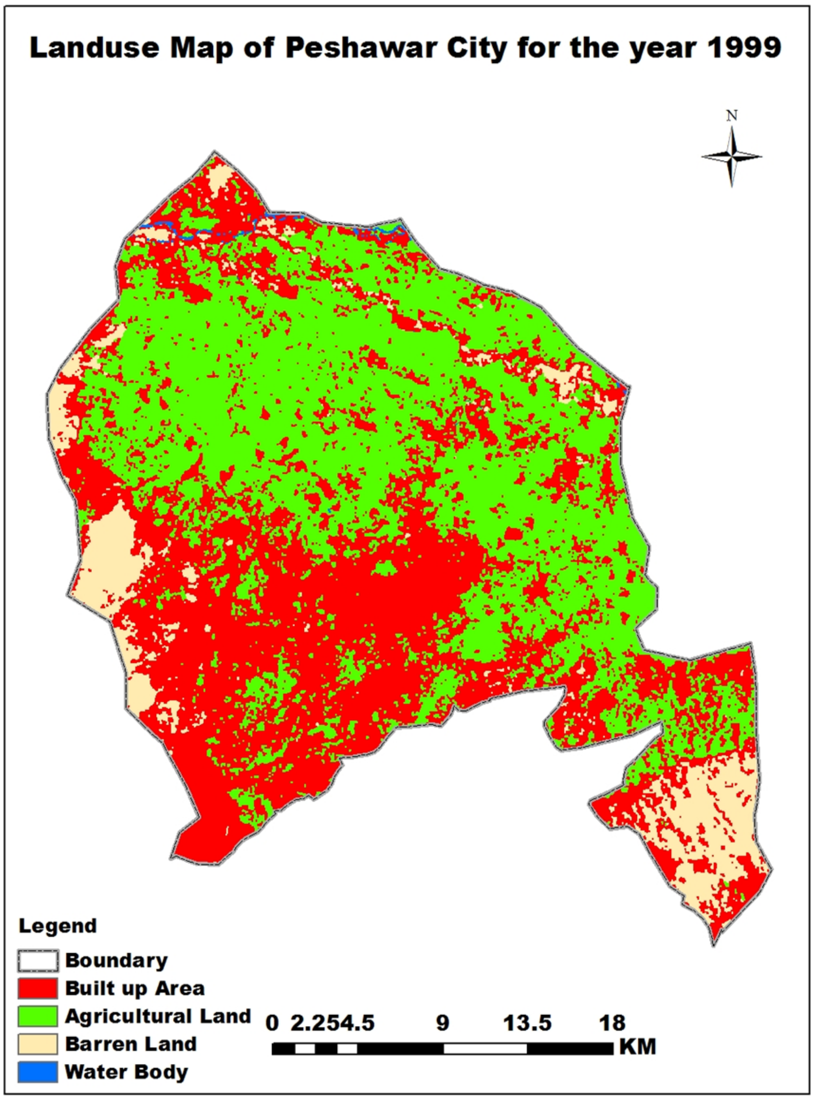

Figure 7: LULC Map for the year of 1999 Landsat ETM+ image.

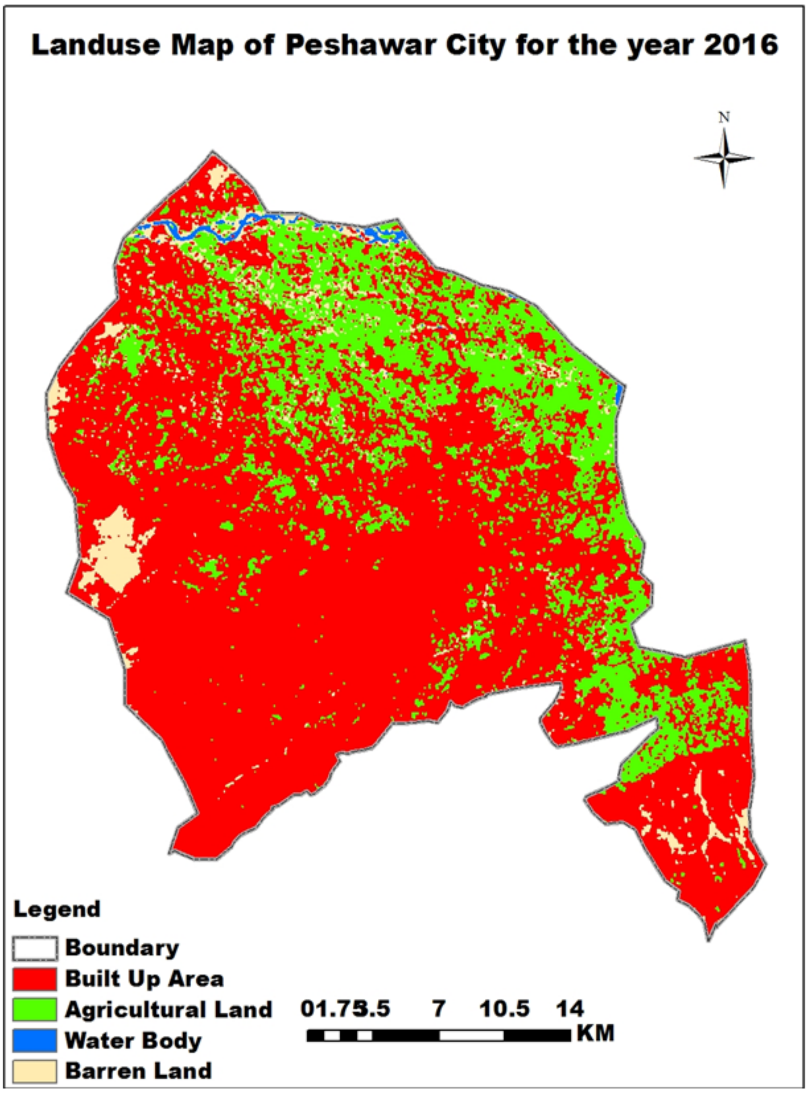

Figure 8: LULC map for the year of 2016 Landsat 8 OLI image.

1	Sensor	Path/Row	Spatial Resolution	Cloud (%)	Number of Bands	Format
25 October 1999	Landsat 7 ETM+	151/36	30	0	7	Geo TIFF
09 June 2016	Landsat 8 OLI	151/36	30	0	11	Geo TIFF

Table 1: Detail of the Landsat datasets used in the study area.

Land use Classes	Hectare (ha)	Percentage (%)
Built Up Area	41.3644	44.807546
Agricultural Land	42.7808	46.341847
Barren Land	7.9299	8.58998
Water Body	0.2406	0.260627
Total Area	92.3157	100

Table 2: Land use and land cover area of classified image from 1999.

of 1999 image between the agricultural lands and built up area both are calculated in term of percentages 1.53 (%) and 1.41 hectare (ha).

Analysis of LULC classes for the year of 2016 Landsat image: Result from the classified image from 2016 Landsat 8 OLI in Figure 8 shows rapid increase in the built up area. According, to the statistics calculation in Table 3, the built up area is 71.39%, and agricultural land 22.78%, barren land 5.28%, and water body 0.53% is detected. While, the land use and land cover classes area statistics are calculated in hectare in Table 3 shows that similarly, in term of hectare the built up area is increased 65.9168 ha, agricultural land 21.0321 ha, barren land 4.8805 ha and water body 0.4921 ha. It has been observed that rapid increase is occurs in built up area however, some major decrease is discovered in the agricultural land and barren land. The changes and difference between built up area and agricultural land in Table 3 are study 48.61%. While the area in hectare is 44.8847 ha is found.

Change detection between 1999 and 2016 Landsat images: The overall changes detection comparison from 1999 Landsat 7 ETM+ and 2016 Landsat 8 OLI images result are given as a classified image

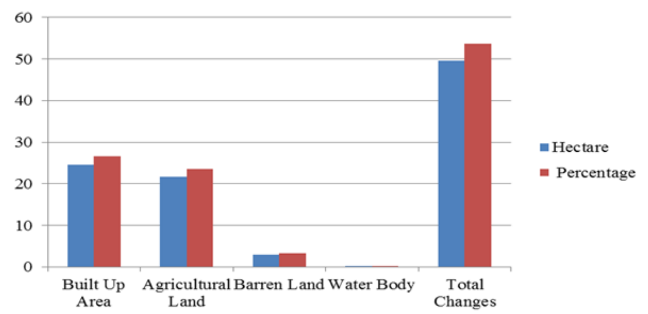

Figure 9: Bar graph depicts changes trend of LULC between 1999 to 2016.

Land use Classes	Hectare (ha)	Percentage (%)
Built Up Area	65.9168	71.399187
Agricultural Land	21.0321	22.781367
Barren Land	4.8805	5.286418
Water Body	0.4921	0.533029
Total Area	92.3215	100

Table 3: Land use and land cover area of classified image from 2016.

Land use Classes	Hectare (ha)	Percentage (%)
Built Up Area	24.5524	26.591641
Agricultural Land	21.7487	23.56048
Barren Land	3.0494	3.303562
Water Body	0.2515	0.272402
Total Changes	49.602	53.728085

Table 4: Land use and land cover changes detection trend from 1999 and 2016.

in Figure 9. Statistical calculations are employed to obtain the changes result from the two already classified images of 1999 and 2016. In Table 4 the land use and land cover area changes are given in percentages and hectare, in which abrupt changes are observed in all LULC, particularly the built up area received major changes between 1999 and 2016 period is 26.59%, agricultural land is 23.56%, barren land 3.30% and the water body is 0.27%. The total fluctuating is found between these two periods is 53.72% in all classes. Similarly in term of hectare built up area received major changes 24.5524 ha, agricultural land is 21.7487 ha, barren land is 3.0494 ha, and water body is 0.2515 ha. According, to the statistics calculations all land use and land cover classes area is change 49.602 ha. In order to summarize the LULC changes in the past seventeen years images form 1999 and 2016 the built up area increased rapidly due to the local population growth and from the surrounding rural area conversion to urban and the migrant of Afghanistan to Peshawar city affect the urban sprawl and built up area. However, the agricultural land and barren land are converted into built up area in rapid increased is observed in urban sprawl from the last seventeen years.

Urban sprawl and extraction of urban area from 1999 and 2016 images: Urban sprawl from the classified images of 1999 Landsat 7 ETM and 2016 Landsat OLI shows significant changes and comparisons are depicting in Figure 10. Our experimental results yielded 44.80% of the urban area from 1999 Landsat image, While, rapid increased is observed in the 2016 Landsat 8 classified image 71.39%, The total changes increased in urban area are occurred between 1999 and 2016 are 26.59%. However, urban area in term of hectare from 1999 image 41.3644 ha, and 2016 image, 65.9168 ha urban area is observed which demonstrate rapid growths in urban area (Table 5). The total changes differences are calculated between 1999 and 2016 in hectare 24.5524 ha.

Figure 11 bar graph shows graphical representations of LULC urban sprawl between 1999 and 2016 in efficient way.

Discussion

Experiments are conducted using the Landsat images for the years 1999 and 2016, this study identified built up area, agricultural land, barren land and water body as four major LULC classes that have provided a substantial change in the city of Peshawar Khyber Pakhtunkhwa Pakistan. However, rapid urban sprawl is observed due to the population growth and the infrastructure facilities in the city, for instance, education and health facilities etc. it has been observed in the LULC classification that major parts of the agricultural land and barren land are converted into urban area. Supervised MLC methodology is used to classify the Landsat images of LULC yielded high level of accuracy of all four classes with the selection of minimum spectral signatures. Three hundred eighteen spectral signatures are created for both images of Landsat from 1999 and 2016. Spectral signatures of all the four classes are also analyzed using scatterplot and histogram techniques and employed to bands separability and to explore the spectral characteristics of different LULC classes'. Some post classification majority filter techniques was used in the experiment with 3 × 3 neighborhood of kernel window to extract the desire result.

Two major finding are study in this research first of all MLC are accurately classified the Landsat images from 1999 and 2016 into four classes, the agricultural land and barren land are mostly converted into built up area rapidly. Secondly the urban sprawl expansion is analyzed in seventeen years period between the Landsat images of 1999 and 2016, the experiment depicts that important LULC classes and speedy urban sprawl is notable in the city of Peshawar. Therefore careful demanding is needed during construction. With the passage of time the urban sprawl has developed in size, from the center of the city urbanization is grown fast while, in the periphery as little slow growth. Such a rapid increase of urbanization modified the natural landscape and affected the water drainage system of the city which leads to become a flood when rain is occurs. Urbanization deteriorated water sewerage system, Transportation system in the study area as the evidences of traffic congestions particularly in the center of Peshawar City.

Conclusions

This paper has taken significant concern in analyzing and understanding the LULC changes and urban sprawl in the city of Peshawar Khyber Pakhtunkhwa Pakistan using multi-temporal Landsat data. Using the Landsat images of 1999 and 2016, the study has classified LULC classes of the city of Peshawar by applying maximum likelihood classification (MLC) techniques and algorithm. The MLC presented good result in both years of multi-temporal satellite images. The MLC detected the LULC changes from the last seventeen years periods and observed substantial increase in the built up area due to which most of the agricultural land and barren land are conversion indicating major urban sprawl in the Period of 1999 and 2016. The classification results over the two periods depicted that built up land increased in term of percentages 26.59% between 1999 to 2016. While rapid decreased is found in agricultural land 23.56%, barren land 3.30%.

Years	Hectare (Ha)	Percentage (%)
1999	41.3644	44.807546
2016	65.9168	71.399187
Total changes	24.5524	26.591641

Table 5: Urban sprawl changes trend from 1999 to 2016.

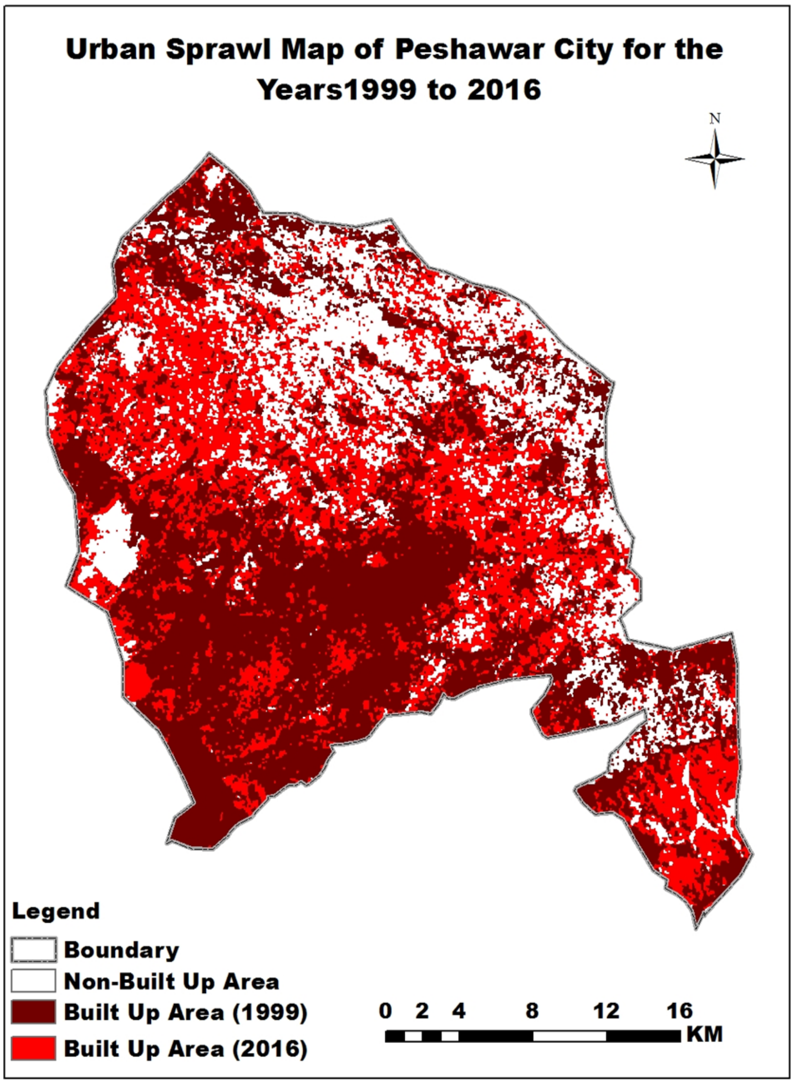

Figure 10: Urban sprawl change map for the years of 1999 to 2016 images.

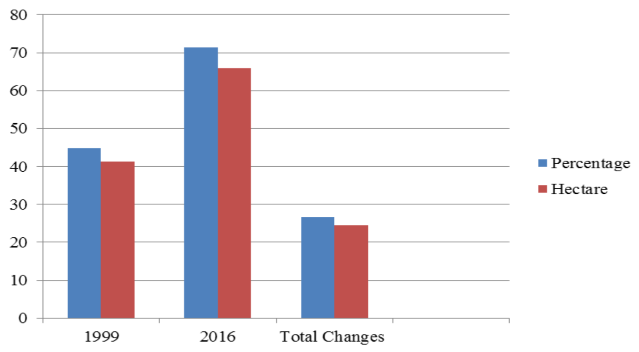

Figure 11: Bar graph depicts urban sprawl changes trend of LULC between 1999 and 2016.

Water body is increased 0.27%. Similarly the built up land is increased 24.55 ha, whilst agricultural land is decreased 21.74 ha, barren land 3.04 ha, water body is increased 0.25 ha between 1999 and 2016. Some of the significant changes in the land use and land cover patterns are analyzed in the city of Peshawar. Major changes are observed in the built up area which rapidly increased at 26.59%, however the substantial decreased is found in the agricultural land, barren land in 1999 to 2016.

Increasing of population growth and infrastructures were two major factors which bringing rapid urban sprawl. At the center of the city compact urban development and its immediate locality, the development of urban is scattered in the city fringe and well dense in the city center and the city periphery describes the urban sprawl pattern in the city. Spectral signatures of all the four classes are also analyzed using scatterplot and histogram techniques are employed to bands separability and to explore the spectral characteristics of different

LULC classes' as excellent result. The study observed significant changes in land use and land cover pattern in the city of Peshawar. The study results have good methodological and practical applications; future research will be conducted on the entire city of Peshawar and to research on the environmental, socio-ecological characteristics of urban sprawl. This future research would help for urban planning and the growth of an environmentally capable city in the Khyber Pakhtunkhwa Pakistan.

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Conflicts of Interest

The authors declare no conflict of interest.

References

1. Deng JS, Wang K, Hong Y, Qi JG (2009) Spatio-temporal dynamics and evolution of land use change and landscape pattern in response to rapid urbanization. Landscape and urban planning 92: 187-198.
2. Lambin EF, Rounsevell MD, Geist HJ (2000) Are agricultural land-use models able to predict changes in land-use intensity?. Agriculture, Ecosystems and Environment 82: 321-331.
3. Jensen JR (1996) "Introductory digital processing": A remote sensing perspective. 2nd edn. Upper Saddle River, Prentice-Hall, USA.
4. Zhou Q (1995) The integration of GIS and remote sensing for land resource and environment management. In: Proceedings of United Nation ESCAP Workshop on Remote Sensing and GIS for Land and Marine Resources and Environmental Management. Fiji, pp: 13-17.
5. Regos A, Ninyerola M, Moré G, Pons X (2015) Linking land cover dynamics with driving forces in mountain landscape of the Northwestern Iberian Peninsula. International Journal of Applied Earth Observation and Geoinformation 38: 1-14.
6. Rimal B (2011) Application of Remote Sensing and Gis, Land Use/Land Cover Change in Kathmandu Metropolitan City, Nepal. Journal of Theoretical & Applied Information Technology 23: 80-86
7. Asselen S, Verburg PH (2013) Land cover change or land□use intensification: Simulating land system change with a global□scale land change model. Global change biology 19: 3648-3667.
8. Vizzari M (2011) Peri-urban transformations in agricultural landscapes of Perugia, Italy. Journal of geographic information system 3: 145-152.
9. Mehmood R, Mehmood SA, Butt MA, Younas I, Adrees M (2016) Spatiotemporal Analysis of Urban Sprawl and Its Contributions to Climate and Environment of Peshawar Using Remote Sensing and GIS Techniques. Journal of Geographic Information System 8: 137-148.
10. Dewan AM, Yamaguchi Y, Rahman MZ (2012) Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan, Bangladesh. Geo Journal 77: 315-330.
11. El-Hattab MM (2016) Applying post classification change detection technique to monitor an Egyptian coastal zone (Abu Qir Bay). The Egyptian Journal of Remote Sensing and Space Science 19: 23-36.
12. AbdelRahman MA, Natarajan A, Hegde R (2016) Assessment of land suitability and capability by integrating remote sensing and GIS for agriculture in Chamarajanagar district, Karnataka, India. The Egyptian Journal of Remote Sensing and Space Science 19: 125-141.
13. Appiah DO, Schröder D, Forkuo EK, Bugri JT (2015) Application of geo-information techniques in land use and land cover change analysis in a Peri-Urban District of Ghana. ISPRS International Journal of Geo-Information 4: 1265-1289.
14. Population Census Organization (Pakistan), Statistics Division (1999) 1998 District Census Report of Peshawar. Khyber Pakhtoon Khawa, p: 233.
15. National Aeronautics and Space Administration (2016) Landsat 7 Science Data Users Handbook. Landsat Science, USA, pp: 1-186.
16. Nahiduzzaman KM, Aldosary AS, Rahman MT (2015) Flood induced vulnerability in strategic plan making process of Riyadh city. Habitat International 49: 375-385.
17. Al-Dosary AS, Khan F (2010) A GIS based assessment of urban sprawl in North Khobar. International Journal of Arab Culture, Management and Sustainable Development 1: 254-275.
18. Alphan H (2003) Land-use change and urbanization of Adana, Turkey. Land degradation and development, 14: 575-586.
19. Dewan AM, Kabir MH, Nahar K, Rahman MZ (2012) Urbanisation and environmental degradation in Dhaka Metropolitan Area of Bangladesh. International Journal of Environment and Sustainable Development 11: 118-147.
20. Yuan F, Sawaya KE, Loeffelholz BC, Bauer ME (2005) Land cover classification and change analysis of the Twin Cities (Minnesota) Metropolitan Area by multitemporal Landsat remote sensing. Remote sensing of Environment 98: 317-328.
21. Seto KC, Güneralp B, Hutyra LR (2012) Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. Proceedings of the National Academy of Sciences 109: 16083-16088.
22. Benítez G, Pérez-Vázquez A, Nava-Tablada M, Equihua M, Álvarez-Palacios JL (2012) Urban expansion and the environmental effects of informal settlements on the outskirts of Xalapa city, Veracruz, Mexico. Environment and Urbanization 24: 149-166.
23. Byomkesh T, Nakagoshi N, Dewan AM (2012) Urbanization and green space dynamics in Greater Dhaka, Bangladesh. Landscape and Ecological Engineering 8: 45-58.
24. Rahman MT, Rashed T (2015) Urban tree damage estimation using airborne laser scanner data and geographic information systems: An example from 2007 Oklahoma ice storm. Urban Forestry and Urban Greening 14: 562-572.
25. Dewan AM, Islam MM, Kumamoto T, Nishigaki M (2007) Evaluating flood hazard for land-use planning in Greater Dhaka of Bangladesh using remote sensing and GIS techniques. Water Resources Management 21: 1601-1612.
26. Seilheimer TS, Wei A, Chow-Fraser P, Eyles N (2007) Impact of urbanization on the water quality, fish habitat, and fish community of a Lake Ontario marsh, Frenchman's Bay. Urban Ecosystems 10: 299-319.
27. Corner RJ, Dewan AM, Chakma S (2014) Monitoring and prediction of land-use and land-cover (LULC) change. In Dhaka Megacity, Springer, Netherlands, pp: 75-97.
28. Mallupattu PK, Sreenivasula Reddy JR (2013) Analysis of land use/land cover changes using remote sensing data and GIS at an Urban Area, Tirupati, India. The Scientific World Journal pp: 1-6.
29. Singh A (1989) Review article digital change detection techniques using remotely-sensed data. International journal of remote sensing 10: 989-1003.
30. Maktav, D, Erbek FS (2005) Analysis of urban growth using multi□temporal satellite data in Istanbul, Turkey. International Journal of Remote Sensing 26: 797-810.
31. Rahman MT (2011) Integration of remote sensing and GIS for tree damage estimation from natural disasters. In Proceedings of the 34th International Symposium on Remote Sensing of Environment, The GEOSS Era: Towards Operational Environmental Monitoring, Sydney, NSW, Australia.
32. Houghton JT, Ding Y, Griggs DJ, Noguer M, van der Linden PJ (2010) Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, USA, p: 866.
33. Dewan AM, Yamaguchi Y (2009) Land use and land cover change in Greater Dhaka, Bangladesh: Using remote sensing to promote sustainable urbanization. Appl Geogr 29: 390-401.
34. Ahmed B, Kamruzzaman M, Zhu X, Rahman MS, Choi K (2013) Simulating land cover changes and their impacts on land surface temperature in Dhaka, Bangladesh. Remote Sens 5: 5969-5998.
35. Ryngganga PK, Rynthathiang BBL (2013) Dynamics of land use land cover for sustainability: A case of Shillong, Meghalaya, India. Int J Sci Technol Res 2: 235-239.
36. Ahmed S, Bramley G, Dewan A (2012) Exploratory growth analysis of a megacity through different spatial metrics: A case study on Dhaka, Bangladesh (1960–2005). URISA J 24: 9-24.
37. Qiao Z, Tian G, Xiao L (2013) Diurnal and seasonal impacts of urbanization on the urban thermal environment: A case study of Beijing using MODIS data. ISPRS J Photogramm Remote Sens 85: 93-101.

38. Yuan D, Elvidge CD, Lunetta RS (1998) Survey of multispectral methods for land cover change analysis. In Remote Sensing Change Detection: Environmental Monitoring Methods and Applications; Ann Arbor Press: Ann Arbor, MI, USA, pp: 21-39.

39. Shalaby A, Tateishi R (2007) Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. Applied Geography 27: 28-41.

40. Rahim T, Zeb A, Shoukat S (2007) Urbanization in North West Frontier Province. Sarhad Journal Database p: 23.

41. Ridd M, Liu JA (1998) comparison of four algorithms for change detection in an urban environment. Remote Sens Environ 63: 95-100.

42. Hassan S, Mahmud-Ul-Islam S, Rahman MT (2015) Integration of remote sensing and GIS to assess vulnerability of environmental degradation in North-Western Bangladesh. J Geogr Inf Syst 7: 494-505.

43. Coppin P, Jonckheere I, Nackaerts K, Muys B, Lambin E (2004) Review ArticleDigital change detection methods in ecosystem monitoring: a review. International journal of remote sensing 25: 1565-1596.

44. Xu L, Li Z, Song H, Yin H (2013) Land-use planning for urban sprawl based on the clue-s model: A Case study of Guangzhou, China. Entropy 15: 3490-3506.

45. Jensen JR (2004) Digital change detection. In Introductory Digital Image Processing: A Remote Sensing Perspective; Prentice-Hall: Upper Saddle River, NJ, USA, pp: 467-494.

46. Wilson B, Chakraborty A (2013) The environmental impacts of sprawl: emergent themes from the past decade of planning research. Sustainability 5: 3302-3327.

47. Bhatta B (2010) Urban growth and sprawl. In Analysis of Urban Growth and Sprawl from Remote Sensing Data. Springer: Berlin, Germany, pp: 13-17.

48. Chen M, Zhang H, Liu W, Zhang W (2014) The global pattern of urbanization and economic growth: Evidence from the last three decades. PLoS ONE 9: e103799.

49. Lillesand TM, Kiefer RW, Chipman JW (2008) Digital image interpretation and analysis. In Remote Sensing and Image Interpretation; John Wiley and Sons: Hoboken, NJ, USA, pp: 482-625.

50. Rahman MT (2016) Detection of Land Use/Land Cover Changes and Urban Sprawl in Al-Khobar, Saudi Arabia: An Analysis of Multi-Temporal Remote Sensing Data. ISPRS International Journal of Geo-Information 5: 15.

51. Squires GD (2002) Urban Sprawl: Causes, Consequences and Policy Responses. The Urban Institute Press: Washington, DC, USA.

52. Sun H, Forsythe W, Waters N (2007) Modeling urban land use change and urban sprawl: Calgary, AB, Canada. Netw Spat Econ 7: 353-376.

53. USGS (2016) Landsat 8 (L8) Data Users Handbook Version 1.0. Department of the Interior, US Geological Survey, USA.