Int. J. Econ. Environ. Geol. Vol. 10 (3) 102-108, 2019
Journal home page: www.econ-environ-geol.org

Open Access
ISSN: 2223-957X

Analytical Study on Urban Expansion Using the Spatial and Temporal Dynamics of Land Use Change in Faisalabad City, Pakistan

Nusrat Parveen[1*], Abdul Ghaffar[2], Muhammad Nasar-u-Minallah[3], and Muhammad Ali[4]

[1]Department of Geography, GC University Faisalabad, Pakistan
[2]Department of Geography, Punjab University Lahore, Pakistan
[3]Department of Geography, Govt. Postgraduate College Gojra, Pakistan
[4]Department of Meteorology, COMSATS University Islamabad, Pakistan

*****Email: nusrat.siddiq@gmail.com

Received: *27 July, 2019* ***Accepted:*** *25 September, 2019*

Abstract: Urban expansion and unparalleled rural to urban conversion, along with an enormous population growth are influential forces changing land use in metropolitan areas. The current work determined temporal and spatial alteration in built-up area, agriculture land, barren land and water area by using Landsat imageries of Faisalabad city from 2003 to 2017.The supervised classification technique has been performed on all the images to produce the land use change maps using the maximum likelihood algorithm and accuracy assessment of the classification has been performed. It has been concluded maximum increase of built-up land were from 30% in 2003 to 50% in 2017 whereas the maximum decrease in agriculture land class has been observed from 36% of 2003 to 10% in 2017. Urban population of Faisalabad city has increased from 2 million in 1998 to population statistics reached up to 3.2 million in 2017. Faisalabad 3rd largest city of Pakistan facing lot of issues due to urban expansion, analyzing the reasons and penalties of land use changes facilitate local government and urban planners for the better management of future plans regarding the urban settlements and reduce the negative consequences.

Keywords: Urban expansion, land use, temporal change, GIS, Faisalabad city.

Introduction

Urbanization, human migration and population growth contributed to alter their environment moreover anthropogenic activities induce change in land use pattern (Osgouei and Kaya, 2017; Riaz et al., 2017; Drummond and Loveland, 2010). From 1950 the world urban population has been enormously increased from 246 million to almost 4 billion in 2014 moreover the world urbanization prospect suggested that in 2030 world urban population will get to 8.3 billion (Chen et al., 2006; Carlson and Arthur, 2000). The urban expansion has been accompanied with the loss of agricultural land and quantification of the land use change with series of satellite image to analyse and monitor the temporal changes in the rapidly growing metropolitan areas is indispensable (Fan and Ding, 2016; Minallah et al., 2016; Shao et al., 2016; Fonji and Taff, 2014). Urbanization has long been identified to affect air and surface temperature, thus changing the local climate (Nasar-u-Minallah, 2018). Therefore, understanding the spatiotemporal dynamic procedures are essential and valuable for urban managers to guard and manage urban environments (Chen et al., 2018).

Changes in land use modification can be categorized by the complicated interface of structural, social and technical factors that affect the local environment (Butt et al., 2015). Change detection analysis used to measure the distinctive data framework and thematic change is indispensable for assessment of natural and anthropogenic interactions through applying multi-temporal datasets to quantifications of historical modification consequently aid in determining the modification linked with land use properties (Seif and Mokarram, 2012; Ahmad, 2012). Urban growth measurements using spatial and attribute data along with the satellite images used to determine the procedure of urban land use alteration (Dadras et al., 2015; Bhalli et al., 2012) Classification methods are most prevalent methods to investigate the land use changes. Monitoring and measuring the land use change by using the temporal data sets of multi scale level by using the different sensors are guiding different dimensions in remotely sensed data on global scale (Giuliani et al., 2017; Lewis et al., 2016).

Latifovic et al., (2005) used Landsat imagery to investigate land use change because of mining growth in part of Canada, declared that the causes for the change in the land use make it possible to differentiate between natural and human-induced coexistence. The land use changes mapped during 1999-2017 (Sweden) using RS and GIS techniques (Tijssen, 2018). The current progress in remote sensing leading to the availability of high spectral, temporal and spatial resolution remote sensing imageries along with new techniques for analyses to gauge change in urban systems in timely and more efficiently (Xian et al., 2006). Therefore, it is significant for the urban land use planning, management and utilization (Abebe, 2013). The study aims to investigate urban land use change in Faisalabad city from 2003-2017. Moreover, the study also focussed on the urban expansion along with the population increase.

Materials and Methods

Study Area

Faisalabad city comprises of alluvial soil and lies at 30°42' to 31°47' north and 72°40' to 73°40' east (Fig. 1). The city is located on the flat land with suitable open lands to fulfil the need of future. The city is geographically connected to other cities of the Punjab and Pakistan that leads to strategic significance of this urban place. The city lies on M3 highway, which connects it to Islamabad and Lahore through Motorway (M2) and possibly will connect to Multan-Karachi via M4. The Faisalabad district occupied an area of 5,856 sq. km. While the metropolitan area is 1295 sq. km. Moreover, the current study conducted on the city area of 213 km^2 (Ahmed, 2010). The city have mixed types of land use patterns with slight planning on the physical development, whereas the most of the economics and industrial centre are located on the trunk roads (Arshad et al., 2018).

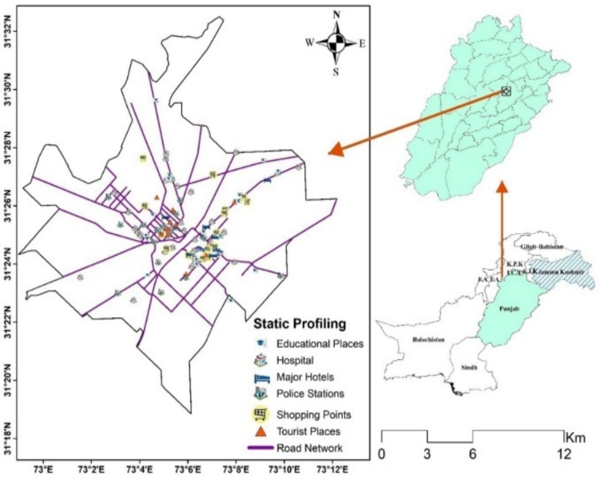

Fig. 1 Location map of the study area Faisalabad city.

In few last decades, this city has observed a hasty urban and industrial expansion and has been changed to a metropolitan and industrial centre with population of 3.2 million (GoP, 2017). So, this study was aimed to evaluate the study area urban expansion along with built-up and population change.

Satellite-derived data of Landsat 5_TM, 7_ETM+ and Landsat 8_OLI/TIRS are among the mainly functional datasets, which provide data for analyzing the temporal land use modification and also for the reason of the accessibility of long-term image archives (Zaharaddeen, Baba and Zachariah, 2016; Li et al., 2015; Gazioğlu et al., 2014; Coban, Koc and Eker, 2010).

Table 1 Basic characteristic of the Landsat images.

Satellite	Sensor	Spatial Resolution (m)	Years
Landsat 7	ETM+	30	2003
Landsat 5	TM	30	2010
Landsat 8	OLI	30	2017

The Satellite imageries were acquired of Landsat 5, 7 and 8 with TM and ETM+ and OLI/TIRS series respectively from https://earthexplorer.usgs.gov/ (Table 1). The acquired images were staked and clipped after the radiometric and atmospheric correction in ERDAS IMAGINE 2014.

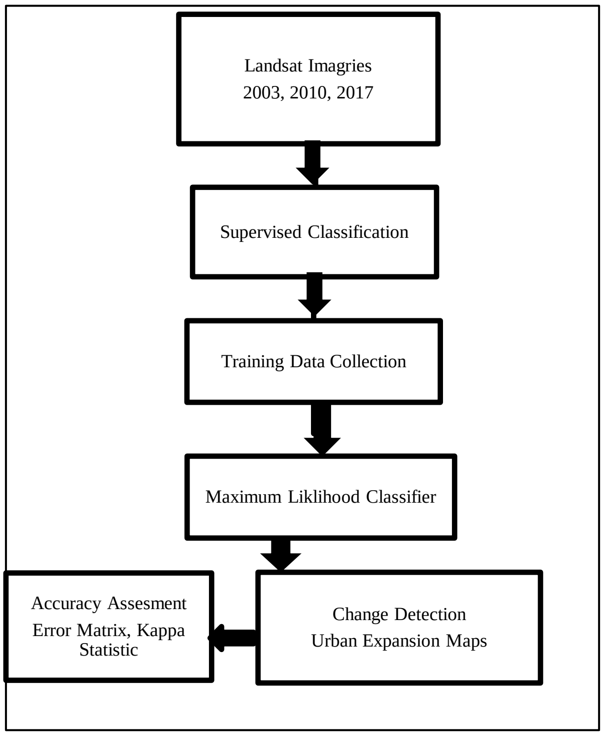

Fig. 2 Methodology Flow Chart.

In classification techniques of satellite imageries where every pixel is attributed into a separate land use class interpretation of satellite images with criteria of spectral and land analysis are used to recognize the land use classes. Then, a supervised image classification with maximum likelihood Algorithm applied for the imageries of three selected time spans 2003, 2010 and 2017 respectively. In addition, four land use classes were recognized and utilized in this study including built-up area, barren land, agricultural land and water bodies (Bhalli and Ghaffar, 2015; Prakasam, et al., 2018). The supervised classification technique (Rawat, Biswas and Kumar, 2013; Bhalli et al., 2012; Bagan and Yamagata, 2012; Bhatta, 2009) of satellite images through selecting the training samples has been performed and accuracy assessment conceded by using random sample points obtained from Google earth and then computed the overall, user and producer's accuracy moreover, the Kappa coefficient was calculated as well (Akar et al., 2017; Shao et al., 2016). The post-classification methods considered to be wide spread process to gauge the change detection. In the current study this process was applied to conclude changes in land use during three-time intervals (i.e. 2003–2010, 2010–2017, and 2003–2017). Pixel-by pixel analysis of cross tabulation has been applied for the quantification of conversions from each land use class to other categories (Fig. 2).

Results and Discussion

Land use Change

Total four classes were formed for the land use change detection including water, agriculture, built-up area and bare land for the satellite images of the years (2003, 2010, 2017).

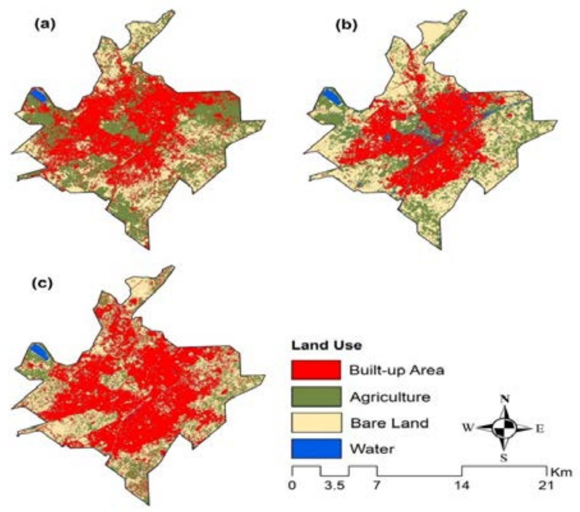

Fig. 3 Land use map of Faialabad city from 2003 to 2017.

From the classification process, it was calculated that till 2003 maximum area occupied by agriculture class (Fig. 3a) showing outskirts of city with green Colour indicating rich agriculture area, while in figure 3b of the year 2010, it has been clearly exposed in the map that agriculture land decreased and built-up area increased as compared to the year 2003. A gradual decrease in bare land and a slight decrease in water area have been observed. Moreover, in year 2017 (Fig. 3c), it has been examined that built-up area indicated the continuous increase in comparison with the area of years 2003 and 2010. The results also demonstrated that in 2017 the agricultural area has been decreased.

Table 2 Land use change in Faisalabad city from 2003 to 2017.

Classes	2003		2010		2017	
	Area (Ha)	Area (%)	Area (Ha)	Area (%)	Area (Ha)	Area (%)
Built-up area	6230.79	29.2	7385.4	34.6	10211.13	47.9
Agriculture land	7371	34.5	5162.94	24.2	2734.65	12.8
Bare land	7199.28	33.8	8273.88	38.8	7936.11	37.2
Water bodies	538.2	2.5	503.73	2.4	444.96	2.1
Total	21339.27	100	21325.95	100	21326.85	100

In 2003, the built-up area was 6230.79 hectares (29.2%) while the agriculture land covered 7371 hectares (34.5%) and bare land occupied 7199.28 hectares, (33.8%) of the study area. Moreover, in 2010 built-up area increased to 7385.4 hectares (34.6%). Therefore 5.4% increase in built-up area has been observed during the period of seven years while the agricultural land reduced to 5162.94 hectares (24.2%) with total 10.3% of decrease in from the previous year of study while bare land shown area of 8273.88 hectors, 38.8%. However, it is evident from land use maps that built-up area in 2017 rapidly increased among all the classes, which is 10211.13 hectares (47.9%) with 13.3% increase as compared to built-up area in 2010. In contrary to built-up class the substantial decrease in agriculture land has been seen to 2734.65 hectares (12.8%) with 11.4% decrease as compared to 2010 and bare land area was 7936.11 hectares (37.2%) with 1.6% decrease as compared to 2010 (Table 2, Fig. 3).

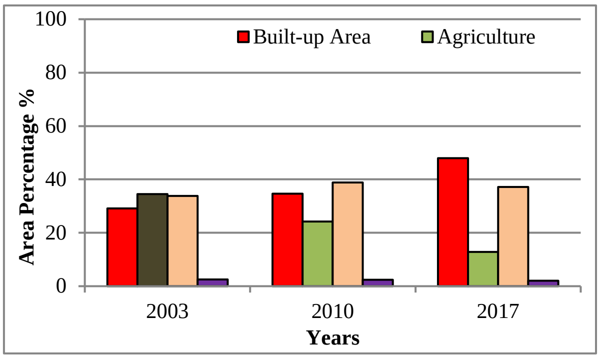

Fig. 4 Land use change detection from 2003 to 2017

It has also been observed during the change detection method that maximum agricultural area was in 2003 and maximum area of built-up land has been seen during 2017. So, it has been concluded that maximum increase of built-up land was from 30% to 50% of the area from 2003 to 2017, while maximum decrease in agriculture land area from 36% to 10% has been observed during 2003 to 2017 (Fig. 5).

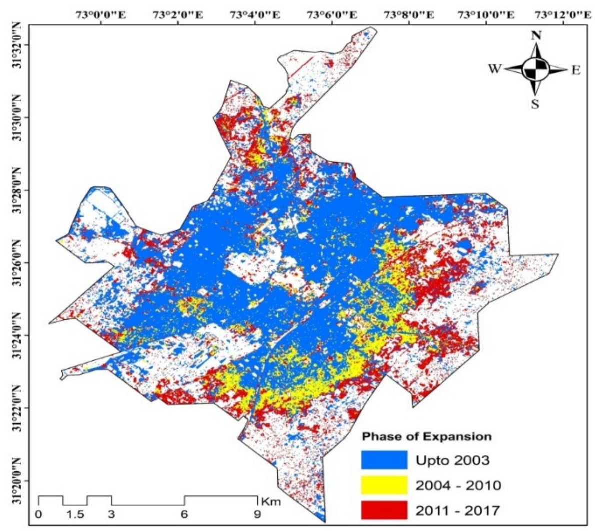

Fig. 5 Urban expansion in study area up to 2003 till 2017.

Urban Expansion

The urbanization process spotlighted the land use changes, consequences after the human activities. With the population increase and economic development in the world maximum number of people moved to urban areas contributed towards urban expansion.

According to the obtained results from supervised classification of year 2003 to 2017, built-up area maintains the continuous increase due to the increase in population and the economic growth of the area.

Estimation of land Conversion

During the first period of study i.e., 2003-2010, 216.54 hectare 79.9% of the agricultural land area has been converted into built-up area, while 51.12 hectares (18.9%) has been changed into built-up area.

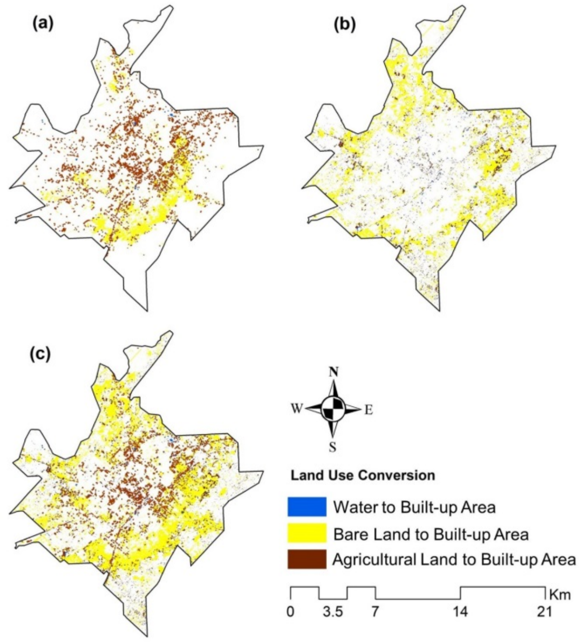

Fig. 6 Map shows the time series analysis of land use conversion of Faisalabad city.

Table 3. Estimated land use class conversion from 2003 to 2017.

LULC Changes	2003-2010		2010-2017		2003-2017	
	Area (ha)	Area (%)	Area (ha)	Area (%)	Area (ha)	Area (%)
Agricultural land to Built-up area	216.54	79.9	143.37	24.1	359.91	41.6
Water area to Built-up area	3.33	1.2	12.51	2.1	15.84	1.8
Bare Land to Built-up area	51.12	18.9	439.02	73.8	490.14	56.6
Total	270.99	100	594.9	100	865.89	100

Moreover, during the second period of study which is 2010-2017 maximum bare land area of 439.02 hectare, 73.8% has been converted into built-up and 143.37 hectare, 24.1% area of agriculture land has been changed in to built-up furthermore, during 2003-2017 there has been noticed that much of the agricultural land area 359.91 hectare, 41.6% has been converted into built-up whereas 490.14 hectare, 56.6% bare land area has been replaced by built-up land (Table 3 & Figure 6).

Accuracy Assessment

This research represents that supervised land use classification a better choice for multi-temporal land use change assessment. Kappa statistics is a measurement between users identified classification data and referenced data. Accuracy in classification is tested with Kappa value (0.81–1.00) indicate approximately perfect/perfect match among the classified and referenced data (van Vliet, Bregt, and Hagen-Zanker, 2011). Classification accuracy for the year 2003, 2010 and 2017 with the overall classification accuracy was 89.11%, 88.75% and 91.11% respectively while the overall Kappa statistics was 0.8300, 0.85 and 0.88 respectively for the three years' supervised classification maps against the 103 random sample points.

Population Growth

Population growth has been considered among the major issues in Faisalabad city. As it was mentioned that the Faisalabad city is the 3rd largest city of Pakistan as well as is an economic hub especially in textile industry. People migrate from other cities to the Faisalabad and due to high migration rate; population of this area was increasing day by day.

Table 4. Population growth of Faisalabad city from 2003 to 2017.

Years	Population in Millions	Annual Growth %
2003	2.26	2.57
2004	2.32	2.57
2005	2.38	2.6
2006	2.44	2.55
2007	2.5	2.58
2008	2.56	2.57
2009	2.63	2.55
2010	2.7	2.58
2011	2.77	2.56
2012	2.84	2.54
2013	2.91	2.61
2014	2.99	2.54
2015	3.06	2.56
2016	3.14	2.57
2017	3.22	2.57

Source: UN, 2019

The annual population increased by 2.6% in 2005 as compared to the year 2004. The population growth pattern remained similar with annual average of 2.5% except 2.61% in 2013 in comparison with previous year 2012 and 2.59% in 2017 respectively.

Table 5 Intercensal population change and Annual growth rate of Faisalabad city.

Years	Population in Million	Annual Growth rate %	
1981	1.1	1972-1981	3.52
1998	2.01	1981-1998	3.21
2017	3.2	1998-2017	2.57

Estimated population of the city in 1998 was 2.1 million, which reached up to 2.3% in 2003 and the process continue to increase resulted in 2.7 million in 2010 and within seven years' period the urban population reached up to 3.2 million (Table 4). Moreover, increase in population of annual growth rate of Faisalabad city has been given in Table 5. Population during 1981 census was 1.1 million which increased to 2.1 million in 1998 and reached 3.2 million in 2017 with double the numbers of people during each census time period. While during the 1981-1998 census the annual growth was 3.6% while during the other census period of 1998-2017 the growth rate percentage was 2.57%.

Conclusion

The current research concluded the extent of urban expansion and population change with annual growth rate change from 2003 to 2017, with the integration of RS & GIS techniques for land use change detection. Thus, incorporating demographic data beside temporal change pattern has given a significant reasoning for land use change and urban expansion evaluation. Consequently, it has been noted that maximum increase of built-up land was from 30% in 2003 to 50% in 2017 whereas the maximum decrease in agriculture land class has been observed from 36% in 2003 to 10% in 2017. Urban population in city has increased from 2 million in 1998 to 2.7 million in 2010, which reached 3.2 million in 2017. It has been concluded that during 2003-2017 total agricultural land area of 359.91 hectares, 41.6% has been converted into built-up whereas 490.14 hectares (56.6%) bare land area has been substituted by built-up land. Thus, Faisalabad city is facing many problems due to growing urbanization due to increase in migration rate due to economic growth. Moreover, the land use change analysis facilitates local government, urban planners for better management of future urban settlements and reduces the negative consequences.

References

Abebe, G. A. (2013). Quantifying urban growth pattern in developing countries using remote sensing and spatial metrics: A case study in Kampala, Uganda. Enschede: University of Twente Faculty of Geo-Information and Earth Observation (ITC).

Ahmad, F. (2012). Detection of change in vegetation cover using multi-spectral and multi-temporal information for district Sargodha. *Pakistan Sociedade and Natureza*, **24** (3), 557-571.

Mughees, A. (2010). E-Governance in Pakistan, A case study of city district government Faisalabad. In: Government College University Faisalabad.

Akar, A., Gokalp, E., Akar, O.,Yılmaz, V. (2017). Improving classification accuracy of spectrally similar land covers in the rangeland and plateau areas with a combination of WorldView-2 and UAV images. *Geocarto International*, **32** (9) 990-1003.

Arshad, A., Zhang, W., Zaman, M. A., Dilawar, A., Sajid, Z. (2019). Monitoring the impacts of spatio-temporal land-use changes on the regional climate of city Faisalabad, *Pakistan Annals of GIS*, **25** (1) 57-70.

Bagan, H., Yamagata, Y. (2012). Landsat analysis of urban growth: How Tokyo became the world's largest megacity during the last 40 years. *Remote Sensing of Environment*, **127,** 210-222.

Bhalli, M. N., Ghaffar, A., Shirazi, S. A. (2012) Spatio-temporal Patterns of Urban Growth in Faisalabad-Pakistan: A GIS Perspective. *Journal of Research Society of Pakistan*, **49** (1), 115-134.

Bhalli, M. N., Abdul Ghaffar**,** A. (2015). Use of Geospatial Techniques in Monitoring Urban Expansion and Land Use Change Analysis: A Case of Lahore, Pakistan. *Journal of Basic & Applied Sciences*, **11**, 265-273.

Bhatta, B. (2009). Analysis of urban growth pattern using remote sensing and GIS: a case study of Kolkata, India. I*nternational Journal of Remote Sensing*, **30** (18) 4733-4746.

Butt, A., Shabbir, R., Ahmad, S. S., Aziz, N. (2015). Land use change mapping and analysis using Remote Sensing and GIS: A case study of Simly watershed, Islamabad, Pakistan. *Egyptian Journal of Remote Sensing and Space Science*, **18** (2) 251-259.

Carlson, T. N., Traci, A. S. (2000). The impact of land use - land cover changes due to urbanization on surface microclimate and hydrology: a satellite perspective. *Global and Planetary Change*, **25**, 49-65.

Chen, G., Knibbs, L. D., Zhang, W., Li, S., Cao, W., Guo, J., Ren, H., Guo, Y. (2018). Estimating spatiotemporal distribution of PM1 concentrations in China with satellite remote sensing, meteorology, and land use information. *Environmental Pollution*, **233**, 1086-1094.

Chen, X. L., Zhao, H. M., Li, P. X., Yin, Z. Y. (2006). Remote sensing image-based analysis of the relationship between urban heat island and land use/cover changes. *Remote Sensing of Environment*, **104** (2), 133-146.

Coban, H. O., Koc, A., Eker, M. (2010). Investigation on changes in complex vegetation coverage using multi-temporal landsat data of Western Black sea region - A case study. *Journal of Environmental Biology,* **31**, 169-178.

Dadras, M., Shafri, H. Z. M., Ahmad, N., Pradhan, B., Shafri, H. Z. M., Dadras, M., Safarpour, S. (2015). Spatio-temporal analysis of urban growth from remote sensing data in Bandar Abbas city, Iran. *Egyptian Journal of Remote Sensing and Space Science,* **18**(1), 35-52.

Drummond, M. A., Loveland, T. R. (2010). Land-use Pressure and a Transition to Forest-cover Loss in the Eastern United States. *Bioscience,* **60** (4), 286-298.

Ettehadi, O. P., Kaya, S. (2017). Analysis of land cover/use changes using Landsat 5 TM data and indices. *Environmental Monitoring and Assessment*, **189** (4), 1-11.

Fan, Q., Ding, S. (2016). Landscape pattern changes at a county scale: A case study in Fengqiu, Henan Province, China from 1990 to 2013. *Catena*, **137**, 152-160.

Fonji, S. F., Taff, G. N. (2014). Using satellite data to monitor land-use land-cover change in North-eastern Latvia. *Springerplus*, **3** (1), 1-15.

Gazioglu, C., Aipar, B., Yucel, Z. Y., Muftuoglu, A. E., Guneysu, C., Ertek, T. A., Demir, V., Kaya, H. (2014). Morphologic Features of Kapıdağ Peninsula and its Coasts (NW-Turkey) using by Remote Sensing and DTM. *International Journal of Environment and Geoinformatics,* **1** (1), 48-63.

GoP. (2017). *Provisional summary of population census*, Population Census Organization, Statistics Division. Govt. of Pakistan.

Giuliani, G., Dao, H., De, B. A., Chatenoux, B., Allenbach, K., De, L. P., Rodila, D., Peduzzi, P. (2017). Live Monitoring of Earth Surface (LiMES): A framework for monitoring environmental changes from Earth Observations. *Remote Sensing of Environment*, **202**, 222-233.

Latifovic, R., Trishchenko, A. P., Chen, J., Park, W. B., Khlopenkov, K. V., Fernandes, R., Pouliot, D., Cihlar, J. (2005). Generating historical AVHRR 1 km baseline satellite data records over Canada suitable for climate change studies. *Canadian Journal of Remote Sensing*, **31** (5), 324-346.

Lewis, A., Lymburner, L., Purss, M. B. J., Brooke, B., Evans, B., Ip, A., Dekker, A. G., Wyborn, L. (2016). Rapid, high-resolution detection of environmental change over continental scales from satellite data – the Earth Observation Data Cube. International Journal of Digital Earth, **9** (1), 106-111.

Li, S., Yang, S., Liu, X., Shi, M., Li, S., Yang, S., Shi, M., Liu, Y. (2015). NDVI-based analysis on the influence of climate change and human activities on vegetation restoration in the shaanxi-gansu-ningxia region, central China. *Remote Sensing*, **7** (9), 11163-11182.

Minallah, M. N., Rafique M., Anwar, M. M., Mohsin, M. (2016). Assessing the Urban Growth and Morphological Patterns of Gojra City, Pakistan. *Sindh University Research Journal*, **48** (2), 393-398.

Nasar-u-Minallah, M. (2018). Spatial and Temporal Change Assessment in Land Surface Temperature of Lahore using GIS and Remote Sensing Techniques. *Proceedings of the Pakistan Academy of Sciences*: *A. Physical and Computational Sciences,* **55** (3), 67–75.

Riaz, O. Munawar, H., Nasar-u-Minallah M., Hameed, K. and Khalid, M. (2017). Geospatial Analysis of Urbanization and its Impact on Land Use Changes in Sargodha, Pakistan. *Journal of Basic & Applied Sciences*, **13**, 226-233. https://doi.org/10.6000/1927-5129.2017.13.39.

Rawat, J. S., Biswas, V., Kumar, M. (2013). Changes in land use/cover using geospatial techniques: A case study of Ramnagar town area, district Nainital, Uttarakhand, India. *The Egyptian Journal of Remote Sensing and Space Science*, **16** (1), 111-117.

Seif, A., and Mokarram. M. (2012). Change detection of Gil Playa in the Northeast of Fars Province. *Iran Am. J. Sci. Res,* **86,** 122-30.

Shao, Y., Lunetta, R. S., Wheeler, B., Iiames, J. S., & Campbell, J. B. (2016). An evaluation of time-series smoothing algorithms for land-cover classifications using MODIS-NDVI multi-temporal data. *Remote Sensing of Environment*, **174**, 258-265.

Marien, T. (2018). "Mapping land use and landcover change in Kalmar,(Sweden) using object-based change detection." University of Salzburg.

UN. (2019). *United Nations-World Population Prospects*, *2019*, retrieved from https://www.macrotrends.net/cities/22038/faisalabad/population.

Van, V. J., Bregt, A. K., & Hagen-Zanker, A. (2011). Revisiting Kappa to account for change in the accuracy assessment of land-use change models. Ecological Modelling, **222** (8), 1367-1375.

Zaharaddeen, Isa, Z., Baba, I. and Zachariah. A. (2016) Estimation of land surface temperature of Kaduna metropolis, Nigeria using landsat images. Science World Journal, **11** (3):36-42.