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Applications of Geospatial Techniques to Identify Landscape Changes and Urban Expansion of Dera Ghazi Khan City, South Punjab-Pakistan

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Abstract: A temporal analysis of landscape change patterns and consequent evaluation of urban expansion has been studied for the Dera Ghazi Khan city which is developing fast since 2000 as an emerging metropolis of South Punjab. The geospatial techniques particularly remote sensing augmented with GIS are vital tools and are mostly used in studying landscape changes and decision making for sustainable urban development. Four Landsat images (1991, 2001, 2011 and 2021) obtained from the free web of GLFC have been analysed. A supervised classification algorithm was applied to all images and results have been presented in both tabular and graphic forms. Present study, focuses upon two land-use classes i.e. built up and open areas, which will be monitored by land-use patterns of Dera Ghazi Khan city during 1991 to 2021 using satellite images. The graphical depiction of all the landscape changes, which have taken place in D. G. Khan city in the form of tables and maps provides detailed information about the degree and ratio of urban expansion and the changes in land use that occurred during the stipulated period.The classification was based on four categories i.e., urban land, bare soil, vegetation, and water; while maps were prepared to present the temporal changes in D. G. Khan city. A total of 52 sq./kms areas was selected for this study designated as the Dera Ghazi Khan city. According to the results, 33% of the urban area has been expanded in Dera Ghazi Khan from 1991 to 2021 and 19% vegetation cover has been reduced. It is a very alarming situation that agricultural land is decreasing because of urban expansion. The results revealed the significance of remote sensing and GIS in evaluating landscape changes.

Keywords: Geospatial, landscape changes, Landsat, urban expansion, D.G.Khan.

Introduction

The urban expansion involves the conversion of rural land into commercial and residential areas at the boundary of the urban fringe. It is among the basic reforming processes, which affect natural as well as man-made environments through several ecological and socio-economic processes (Mandelas et al., 2007; Ghurah et al., 2018). However, the massive movement of rural population to urban areas and improved infrastructure development in cities are key factors for accelerated urban growth (Mohammady and Delavar, 2016). Therefore, unplanned urban growth is associated with several negative effects on the urban environment. For example, urban growth involves social changes and is linked with various environmental risks such as deterioration of air and water quality, loss of agricultural land, and forestand economic inequalities (Chadchan and Shankar, 2012; Gasim et al., 2013; Ghurah et al., 2018). Moreover, changes in temperature and rainfall patterns are also linked with unplanned urban growth. Several researchers have studied the trends of temperature and rainfall in major urban areas of Pakistan and found increased temperature and rainfall particularly in Punjab (Zahid and Rasul, 2011). Modification in forest cover due to urban growth causes higher net carbon flux in the atmosphere, which led to global climate change (Houghton and Skole, 1990; Houghton et al., 1999; Dewan et al., 2012). Urban growth also exhibits significant effects on energy flow, biogeochemical cycles, and biodiversity at local and regional levels (Baker et al., 2001; McDonnell et al., 2008; Dewan et al., 2012). Additionally, urban growth involves a significant decrease in arable land, habitat loss, species extinction, lowered net primary productivity coupled with landscape degradation through environmental changes (Herold et al., 2002; Xian et al., 2007). Although urban expansion is considered among the important indicators of socio-economic development. This development is at the cost of loss of agricultural land which results in land use land cover changes within and outside the urban centres (Badlani et al., 2017).

Land use land cover (LULC) are two distinct terms that are used interchangeably especially concerning urban expansion/urbanization (Rawat and Kumar, 2015). The land cover indicates the biophysical features of the earth's surface, for example, vegetation, soil, water, and urban infrastructure. Whereas, land use is linked with how human beings use the land with an emphasis on the role of land in economic activities (Arsanjani, 2011). Urbanization involves the transformation of agricultural or forest land into urban areas, utilization of land for mining activities to fulfil human's demand which directly leads to land use land cover changes (Li et al., 2016; Basommi et al., 2016). Land use land cover (LULC) change involves qualitative changes in the structure and function of land along with quantitative changes in terms of area extent. LULC changes refer to the conversion of various types of land use and involve complex interactions between humans and the physical environment (Pielke et al., 2011).

Materials and Methods

Dera Ghazi Khan city (Area 2.79 sq./kms.) is located in the southwestern part of Punjab. This city lies between 29°-34' to 31°-20' north latitudes and 69°-53' to 70°-74' east longitudes. It is part of the Dera Ghazi Khan district along with three tehsils: namely Taunsa Sharif, Kot Chutta and Koh-e-Sulaiman (GoP 2017). According to the 2017 Census of Pakistan, Dera Ghazi Khan has a population of 399,064 and is ranked at number 19th in Pakistan.The city is growing at a steady pace due to the influx of rural population to the city in search of better job opportunities and other civic amenities. Owing to the regional inequality in Punjab, a high development priority has been assigned to D.G. Khan-southern Punjab by the present and former governments. Therefore, the government has taken many comprehensive development initiatives, which foster regional and city planning. As stated earlier that Dera Ghazi Khan is one of the fast-growing cities of Punjab, and has become a major urban centre of South Punjab. Keeping this fact in view, the present research has been carried out to analyze urban growth rate and trends through landscape change detection and analysis in D.G. Khan city from 1991 to 2021 using Landsat data and to highlight the relationship between urban expansion and landscape changes and their effects on D.G. Khan City (Fig.1).

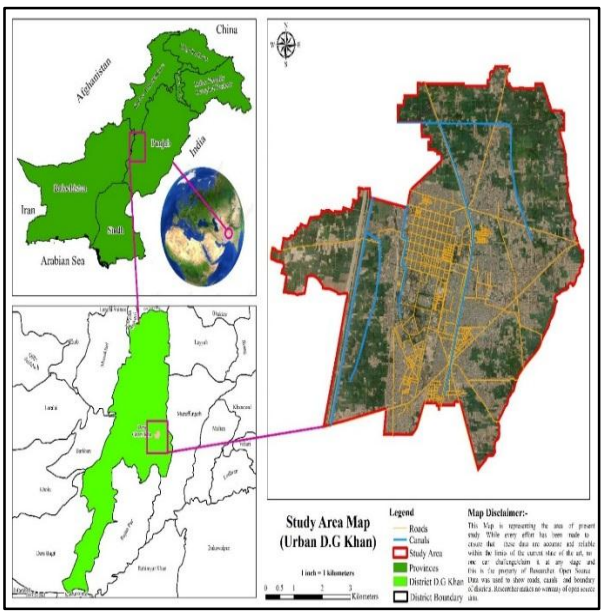


Fig. 1 Dera Ghazi Khan city-the study area.

Remote sensing is an essential and useful technique for the detection and monitoring of land-use changes during the last decades. At present, it is very easy to find out sources of remotely sensed data, and its acquisition from different sources. In this study, three sets of remotely sensed data were used for the investigation of change detection in the study area. To find out LU changes in D.G. Khan city, four Landsat images i.e., from 1991, 2001, 2021, and 2021 with the time interval of 10 years were acquired. All the images were obtained from USGS (Free-web of United State Geological Survey) which is an earth observatory website. It provides expert, well-timed, related and beneficial information about the Earth. All the acquired images were used as basic data sources for change maps and classification.

Image processing techniques were adopted to extract information from remotely sensed data. Image processing involves some action to improve image form and gather information from the image that has two types, digital and analogue image processing. In this study, digital image processing was used which is useful for change detection using computers. The steps involved in image processing are pre-processing, enhancement, display, and information extraction. Image classification is also of two types i.e. supervised and unsupervised. In this study, supervised classification was carried out which is considered more trustworthy and reliable compared to the unsupervised classification of images.

Results and Discussion

The landscape is distributed in four classes, namely; urban, agricultural, bare, and water landuse. Each map is prepared based on these classes.The urban area of D.G. Khan city expanded from 9.89 sq./km to 27.55 sq./km during 30 years (1991 to 2021) which is now 52.11% of the total study area, and agricultural land is decreased from 64.8% to 45%.. In terms of linear regression and temporal study, D.G. Khan is expanding towards the East side along with the Multan road and Bypass road.

Over the past 30 years, the process of urban growth in D.G. Khan city is steady and fast. The urban area of D.G. Khan in 1991 was just 18.7% of the total selected area surrounding the city. It is the total municipal area of D.G. Khan city which is covered (Fig.1) by a total of 52 sq./km land surrounding the DG Khan city. In 2001, it was 25.93% of the total area with a 7% increase in 10 years whereas, in 2011, the urban area was 38.85% which is almost 13 % expandation during the last 10 years. In 2021, the urban area of D.G Khan city is 52.11% of the total selected area surrounding the D. G. Khan city. From 2011 to 2021, the urban area of D.G. Khan city is expanded by almost 14% which is double of 1991.Urban expansion affects the agricultural land of the study area. In 1991 total agricultural area was 64.8 % and now in 2021 total area of agricultural land is 45% with a decrease of 19%. Bare soil in the study area also decreased from 15.7% to 3.28% during 1991-2021. The urban area is expanding very rapidly due to socio-economic development. People from the west of the city area are migrating from their homelands towards the D.G. Khan city due to good living facilities since the city is considered as a tribal area and has a very rough topography, which is not suitable for living (Fig. 2).

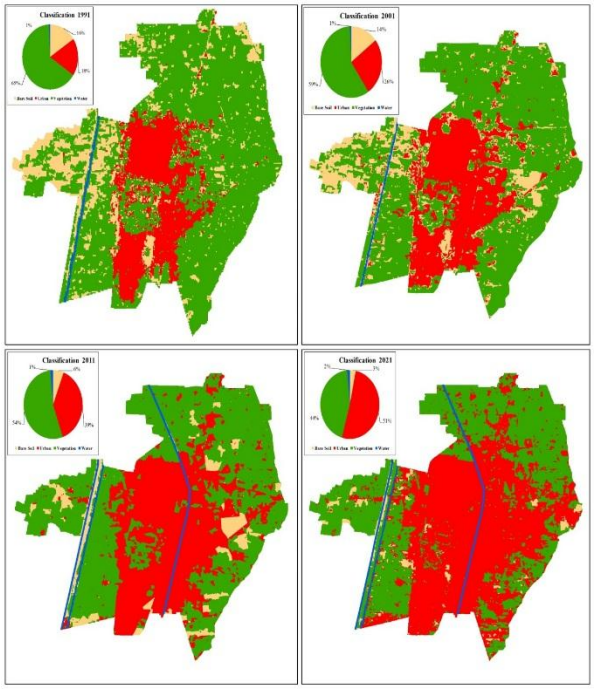
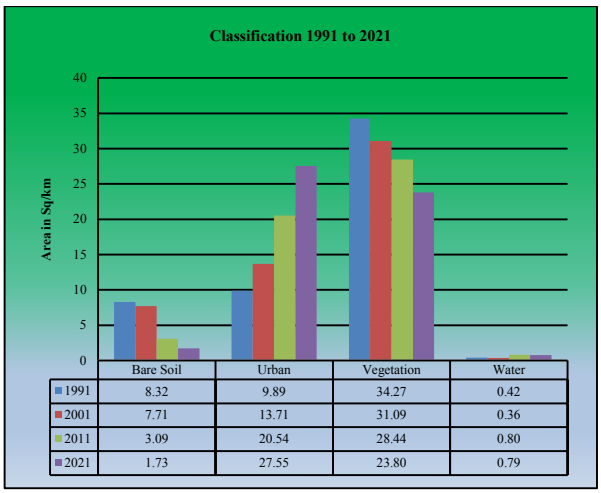
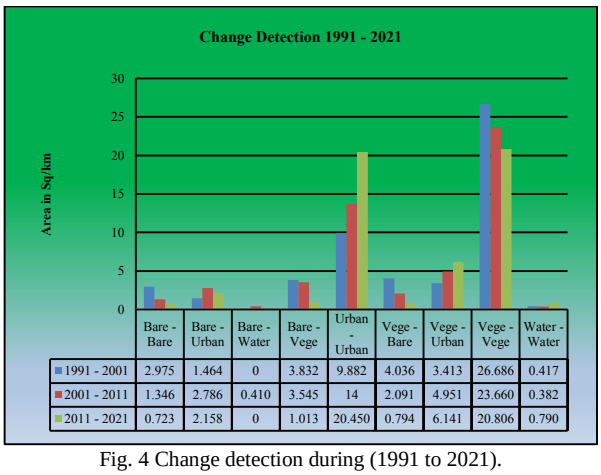


Fig. 2 Supervised classification results during (1991 to 2021).



	Bare Soil	Urban	Vegetation	Water
1991	8.32	9.89	34.27	0.42
2001	7.71	13.71	31.09	0.36
2011	3.09	20.54	28.44	0.80
2021	1.73	27.55	23.80	0.79

Fig. 3 Classification results (1991 to 2021) in sq./km.



	Bare - Bare	Bare - Urban	Bare - Water	Bare - Vege	Urban - Urban	Vege - Bare	Vege - Urban	Vege - Vege	Water - Water
1991 - 2001	2.975	1.464	0	3.832	9.882	4.036	3.413	26.686	0.417
2001 - 2011	1.346	2.786	0.410	3.545	14	2.091	4.951	23.660	0.382
2011 - 2021	0.723	2.158	0	1.013	20.450	0.794	6.141	20.806	0.790

Fig. 4 Change detection during (1991 to 2021).

To evaluate, four images of Landsat were used to detect landscape (land use/land cover change) due to urban expansion in the last 30 years. The aforementioned maps are showing the change in the landscape of D.G. Khan between of 1991 to 2021. To assess accuracy of the classifications, an accuracy assessment tool was used to assess the accuracy which is a total of 90% and also Google earth high-resolution image was used to assess the accuracy of classifications 2011 and 2021 which is almost 95% accurate with a high-quality image (Figs. 2,3, 4).

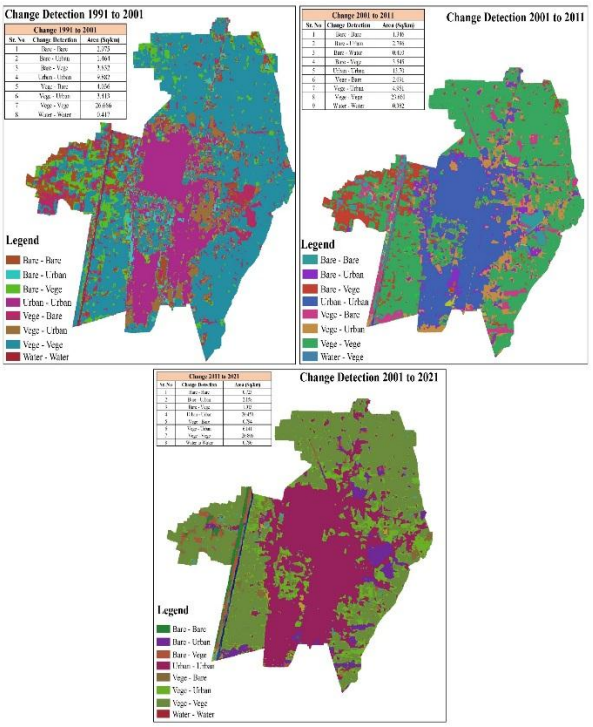


Fig. 5 Maps of change detection during (1991 to 2021).

Comparison of four raster images demonstrated in Figure 3, land use land cover/landscape changes can be seen very clearly, and growth of urban area towards Multan and bypass roads is quite clear, while agricultural land decreased due to growth of urbanization. Through overlay analysis/change detection analysis landscape change matrix was produced from 1991 to 2021 (Fig. 5). Most urban areas have encroached on agricultural land and bare soil due to public demand and new housing schemes for higher living standards and socio-economic growth. The water area increased after 2005 because of the construction of a new canal for agricultural activity, and to meet water demand in the study area. To compare two raster images, overlay analysis was used to calculate the year-wise changes related to each class. After overlay analysis, it can be seen that in the year 1991 to 2001, bare soil decreased to 64%, and vegetation reduced to 21%, whereas the water available remained the same as in previous year while urban area increased by 2%. During 2001 to 2011, bare soil decreased by 83%, vegetation also reduced by 22%, water increased by 50% and urban area increased by 50%. During 2011 to 2021 bare soil decreased by 81%, vegetation also decreased by 25%. However, the water quantity available remained the same and urban area increased to 77% of the total study area.

Conclusion

It is concluded that the urban landscape has engulfed agricultural lands and bare soil due to population growth, socio-economic development, and consequent demand for new housing schemes for improved living standard. The water area has increased marginally after 2005 because of the construction of a new canal for irrigation purpose and more water demand in the newly developed residential neighborhoods. The findings of this research revealed that GIS analysis augmented by digital data from different sources are essential to identify urban attributes, change detection, and a regional database development.

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