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Loss of arable land due to rapid urbanization: a remote sensing based study on Gujrat District, Pakistan

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Abstract

District Gujrat is a 27th largest district of Punjab, Pakistan which endures high growth rate of population resulting expansion in infrastructure. Gujrat has 91% of its total land area as arable land which is the limited and the most valuable resource. The arable land is being consumed by the process of urbanization. Gradual increase in built-up is directly decreasing arable land and permeable surfaces. The current research was aimed to identify expansion of built-up areas mainly on arable land and to estimate the loss of arable land suing GIS and RS techniques. Remotely sensed data (Landsat TM-1993, ETM$^+$ 2003 and TIRS 2017) was used to evaluate the land use and land cover classification. Secondary data were collected from soil survey of Pakistan. GIS technologies and statistical approach were used to analyze quantitative and spatial attribute data. Results proved that District Gujrat is losing 0.1% arable land annually and if such loss remains continue, then within next 500 years Gujrat will loss all of its arable land. National and local administrative bodies need to formulate policies and legal laws for urban growth directions. By managing urban expansion towards unproductive or barren areas, the loss of arable land can be minimized.

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Introduction

Arable land refers to the land which is capable of producing crops and suitable for farming and plowing. Urbanization is the process of increasing population in the urban area both absolutely and relatively (Beryant, 2004). Urbanization can be considered as; dispersion of suburban areas which causes the reduction in local resources, congestion of traffic and destruction of open areas (agricultural land) by outward expansion of urban areas (Mahboob, 2015; Lean and Goodall, 1977). Like other developing countries, the urban population of Pakistan has been increasing rapidly. According to the World Bank, by the year 2020 half of the country's total population will become urban (Samiullah, 2012). Due to rapid and unplanned growth of infrastructure for housing, commercial, educational and industrial uses, the prime agricultural land is decreasing at a rapid pace (Pandey and Seto, 2014; Yar *et al.,* 2016; Quasem, 2011; Doos, 2002).

In Pakistan the conversion of arable land for urban use is divided into two categories, the unplanned informal settlements and/or planned new expansion areas on either private land or mixed private and state land (Slings by, 1991).

Rapid urban expansion had affected the food production in terms of loss of arable land by various ways; age-old farming land has been altered and also the traditional practice of farming has decreased due to the migration of farmers to urban areas (Kavitha *et al.,* 2015). The rapid urban expansion causes decline in natural vegetation cover, destruction of the ecosystem, noise pollution, air pollution and land pollution. The deforestation into development, rearrangement of land use structure, ecological land use and urban built-up are the main causes of agricultural loss (Wang and Qiu, 2017; Lu *et al.,* 2005). According to Rimal (2012) until 2050, 5.7% arable land will be lost from 2000, but most regions especially those surrounding continent Asia, will be at higher risk.

Satellite remote sensing in combination with geographic information system (GIS) are available to assess and quantify land use and land cover of large areas for spatio-temporal change detection (Lilles and *et al.,* 2015). Urban land can be highly correlated with arable land in spatial distribution by interpreting Landsat Thematic Mapper (TM) imagery (Yan *et al.,* 2009).

Information of land use and maps of land cover are necessary to update for effective management and planning of the resources for sustainable development (Anil *et al.,* 2011). GIS and remote sensing techniques are being widely used as an important tool for detecting agricultural land conversion into built up areas (Abass *et al.,* 2018: Lasisi *et al.,* 2017; Shi *et al.,* 2016; Yar *et al.,* 2016). The main objective of the current research is to perform multi-temporal images analysis to identify the urban land use pattern in and around the district Gujrat and to quantify loss of arable land due to rapidly increasing urban sprawl and increase in built-up area.

Materials and methods

Study area

District Gujrat is the oldest city of the human settlement, situated on +9*32°34′25.67″ north latitude and 74°4′44.18″ east longitude. Gujrat is divided into three tehsils; Gujrat, Kharian and Sarai Alam Gir (Fig. 1), surrounded by two major rivers of Punjab, on northwest by river Jhelum and on southeast by river Chenab. Gujrat has been considered 27th largest city of Punjab with reference to areal expansion having rapidly spreading population. It has also rapidly transforming land from arable to urbanized land. According to district census report 1998, population growth rate had been doubled from 1951 to 1998 with 2.1 average annual growth rates by occupying 27% of the urban area with population of 568,172. The urban area grew at the rate of 2.8% during 1981-1998 but comparative to 1972-1981, it had decreased to about 6.1% (District Census Report, 1998).

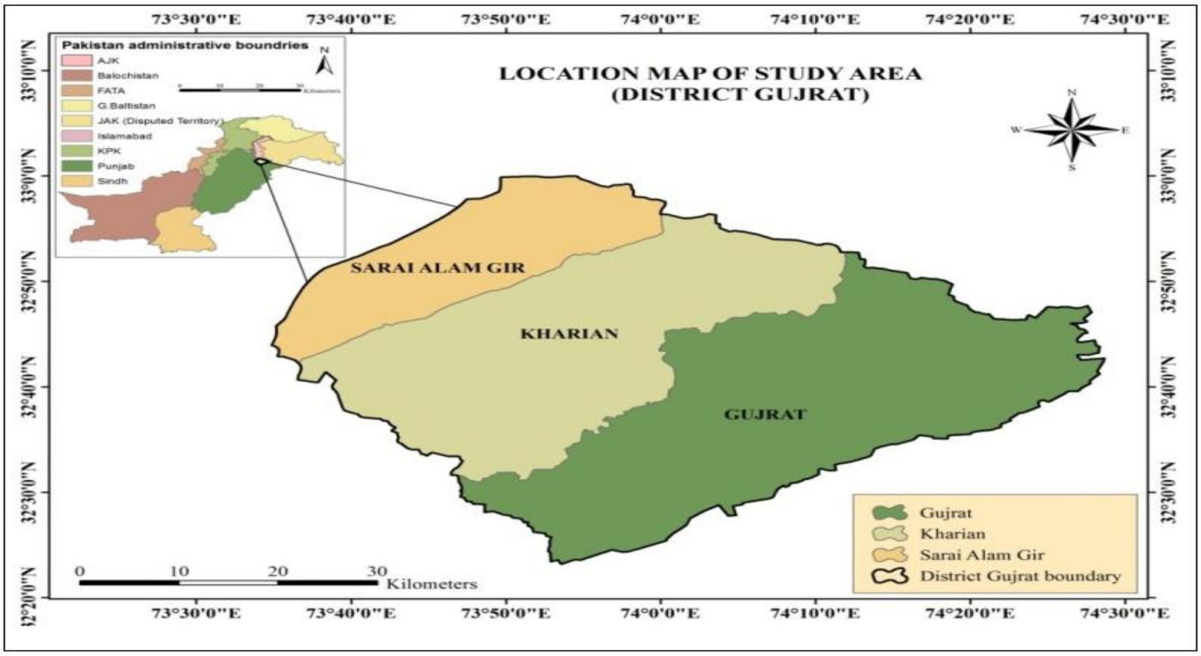

Fig. 1. Map showing spatial location of district Gujrat.

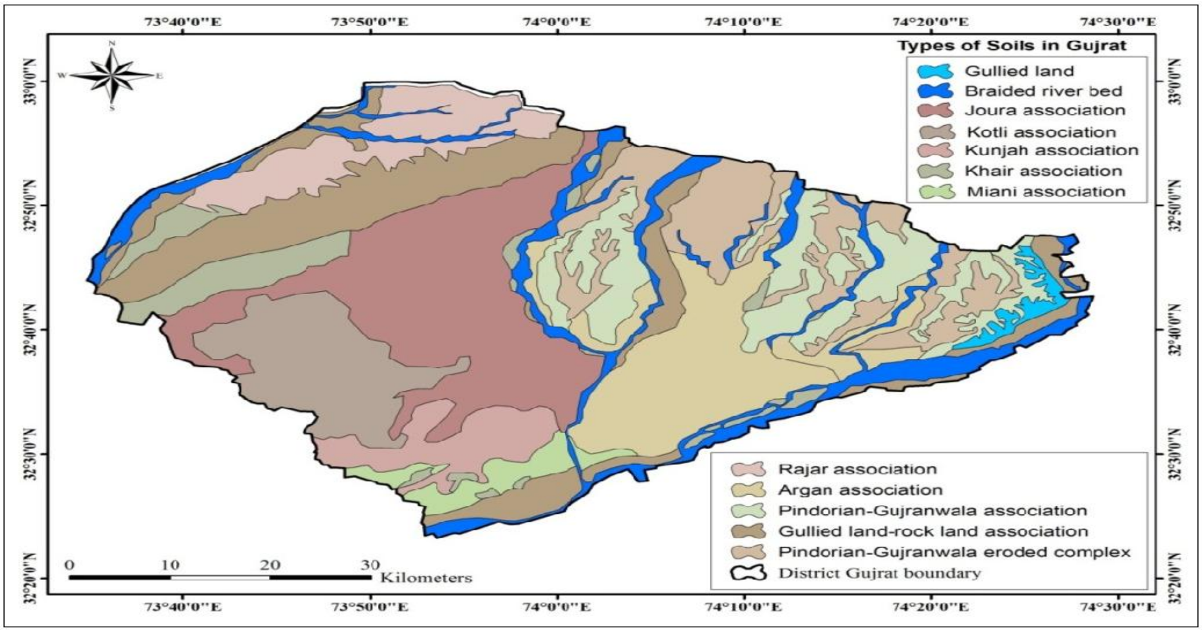

Fig. 2. Map representing various types of soils in district Gujrat.

Remote sensing data

For analysis of land cover classification, satellite LANDSAT imagery of the years 1993, 2003 and 2017 was downloaded from USGS website (https://earthexplorer.usgs.gov) with path 149 and rows 37 and 38 (Table 1). By using tool mosaic in ERDAS imagine 2014, satellite imagery were mosaicked of path 149 and rows 37 and 38 to get whole land cover area of Gujrat. By using the tool of stack, layers were stacked with the band combination RGB as 4:3:2 for land cover classification.

In image subset tool, AOI was extracted from satellite stacked image. To identify built-up areas of Gujrat, supervised classification technique was preferred (Zhang *et al.*, 2014) which was performed by using the maximum likelihood method (Running *et al.*, 1995) in Arc GIS 10.1.

Land cover of Gujrat was classified into eight categories i.e. built-up, crop irrigated, crop rainfed, crop in floodplain, forest – natural trees and mangroves, natural vegetation in wet areas, range land – natural shrubs and herbs and wet areas.

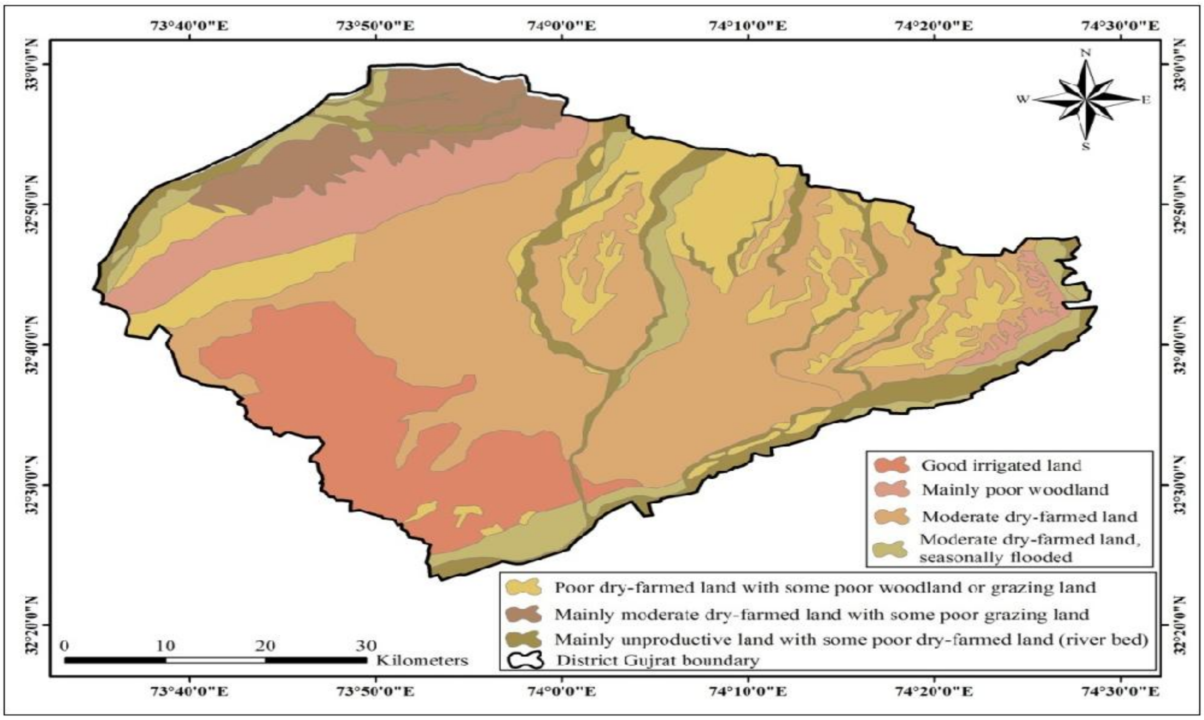

Fig. 3. Map showing land capability classes of district Gujrat.

Secondary data

Soil and land capability maps were obtained from Soil Survey of Pakistan (1978). Firstly, these maps were georeferenced on geographical coordinates WGS84, then shape files were digitized to get different classes of soil and land capability. Later, shape files were converted to projected coordinates at universal transverse Mercator (UTM) zone 43N to calculate area of different classes. Land cover classifications maps and land capability maps were overlaid to identify the areas which have converted to built-up from arable land.

Soil of Gujrat is classified into gullied land (32 Km^2), braided river bed (269 Km^2), Joura association (564 Km^2), Kotli association (261 Km^2), Kunjah association (132 Km^2), Khair association (157 Km^2), Miani association (76 Km^2), Rajar association (201 Km^2), Argan association (391 Km^2), Pindorian-Gujranwala association, gullied land-rock land association and Pindorian-Gujranwala eroded complex (316Km^2) and gullied land-rock land association (475 Km^2) (Fig. 2).

Land capability of the district Gujrat is divided into seven categories; good irrigated land (464 Km^2), mainly poor woodland (293 Km^2), Moderate dry-farm land (1286 Km^2), moderate dry-farmed land, seasonally flooded (211 Km^2), poor dry-farmed land with some poor woodland or grazing land (494 Km^2), mainly moderate dry-farmed land with some poor grazing (199 Km^2) and mainly unproductive land with some poor dry-farmed land, river bed (267 Km^2) (Fig. 3).

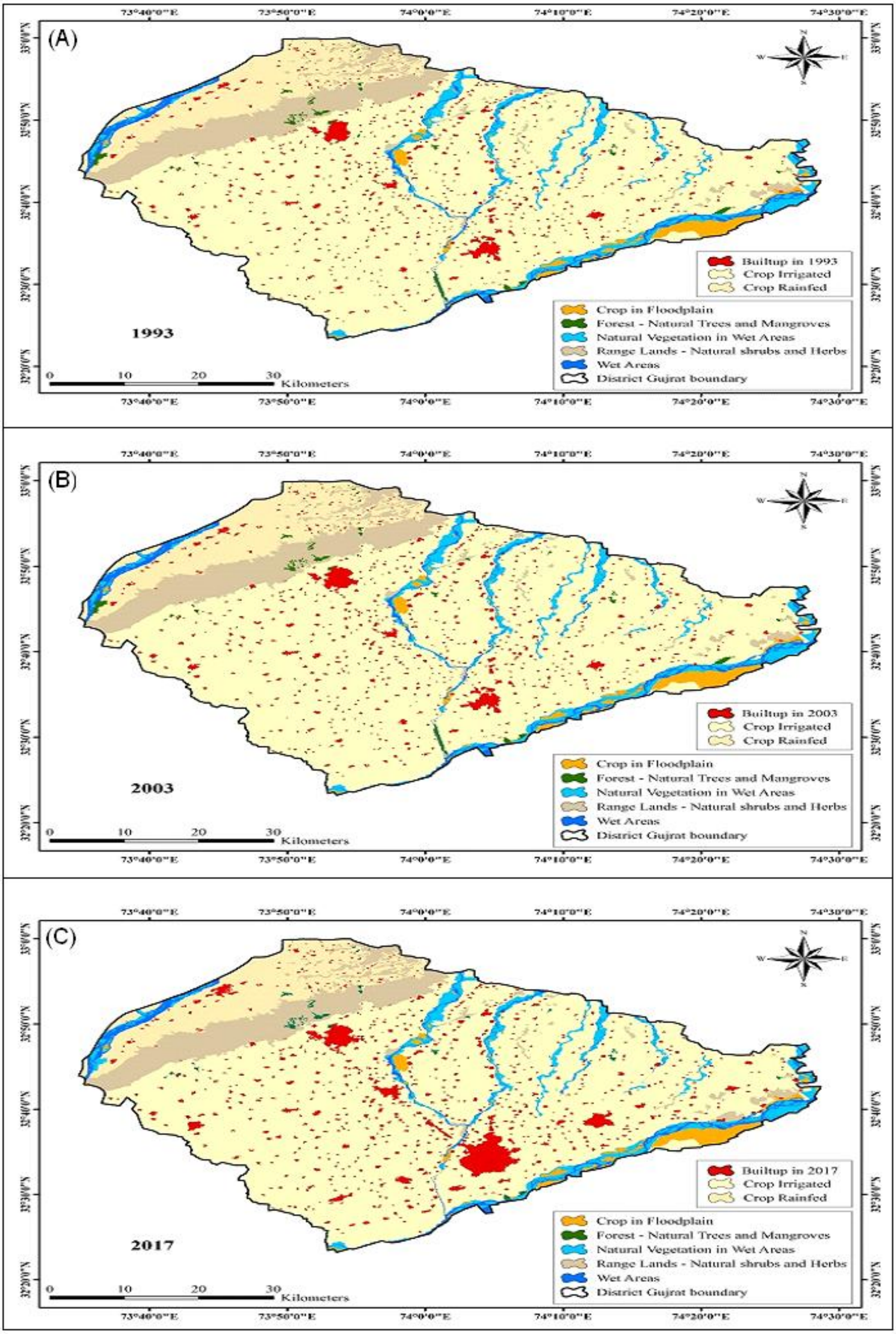

Fig. 4. Classification of land cover pattern in: (A) 1993, (B) 2003 and (C) 2017 in Gujrat.

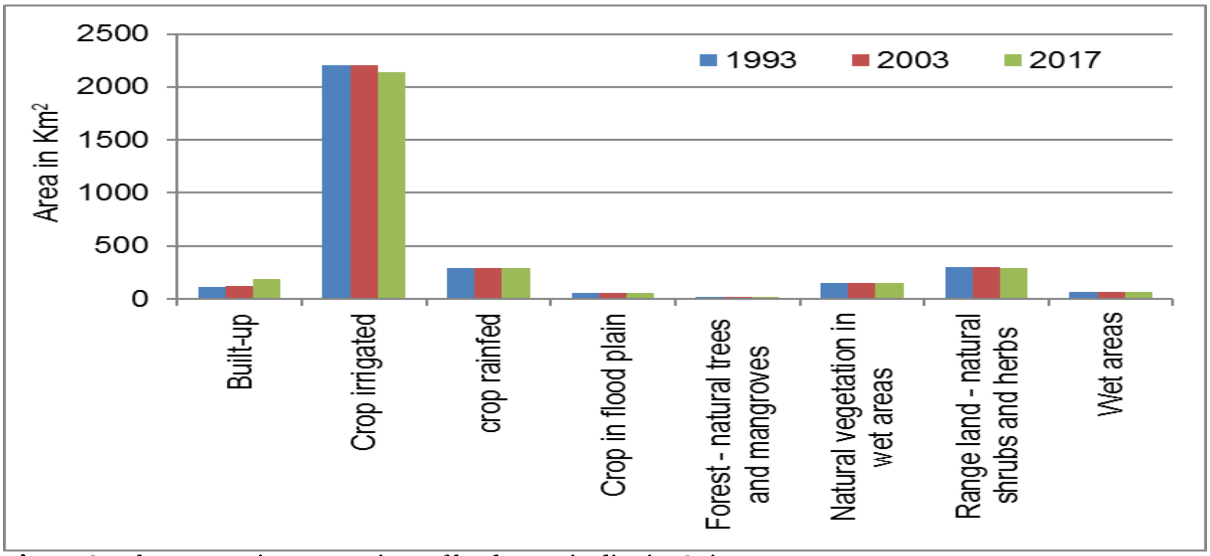

Fig. 5. Graph representing comparison of land cover in district Gujrat.

Results and discussion

The present research was conducted to find out the temporal expansion of built-up area in District Gujrat and its impact on the arable land. The analysis indicates that in the district Gujrat rapid growth in population has caused increased demand for new houses and other infrastructure facilities that cause major land use changes in the district Gujrat.

The change detection maps and visual analysis revealed that most of the arable land in District Gujrat has been consumed by residential, industrial, educational and other infrastructural development.

Classification of Land Cover from 1993 to 2017

Land cover of Gujrat was classified into eight categories as; built-up, crop irrigated, crop rainfed, crop in floodplain, forest–natural trees and mangroves, natural vegetation in wet areas, range land–natural shrubs and herbs and wet areas.

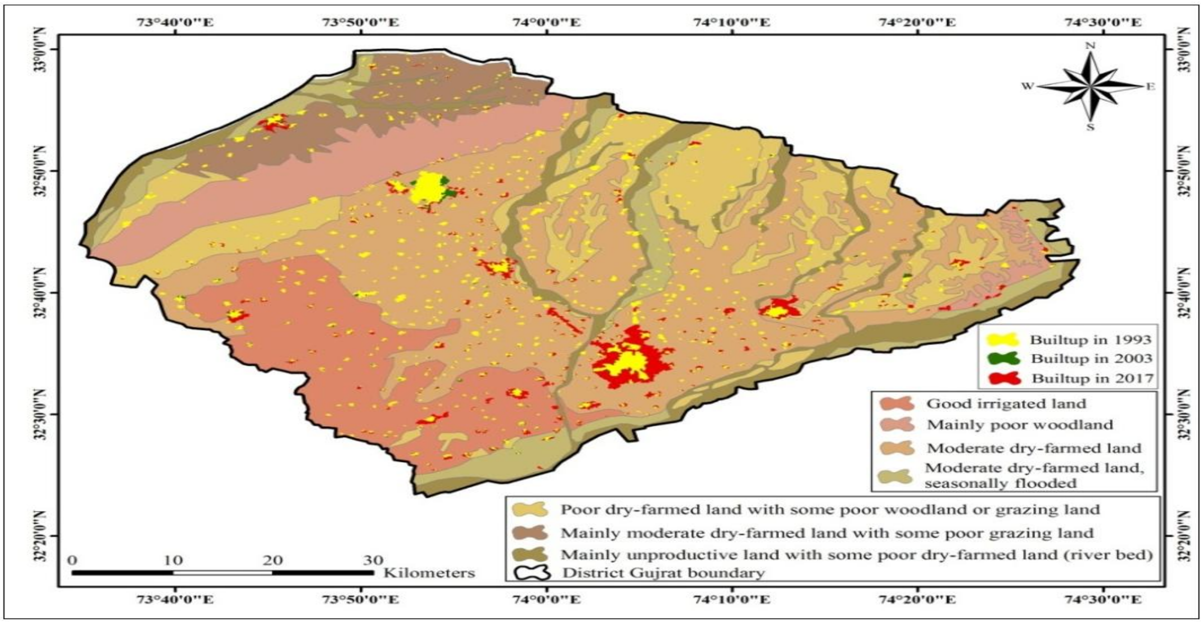

Fig. 6. Map representing comparison of arable land loss due to urbanization in the years 1993, 2003 and 2017.

The results show that built-up growth is random (no specific direction of urban sprawl). There is rapid increase in urban built-up of the district Gujrat from 1993 to 2017 causing reduction in arable land (Figs. 4 A, B, C). Urban expansion during 2003 to 2017 is more rapid in comparison to, from 1993 to 2003 (Table 2 and Fig. 5).

Estimated Loss of arable land

The comparison between distribution of arable land and temporal increase in built-up area in the years 1993, 2003 and 2017 indicate that there is a marked loss of arable land due to rapid urbanization. In 1993 built-up area was 118.12 Km² which increased to 123.09 Km² in 2003. In 2017 the built-up area further increased to 188.09 Km² (Table 2).

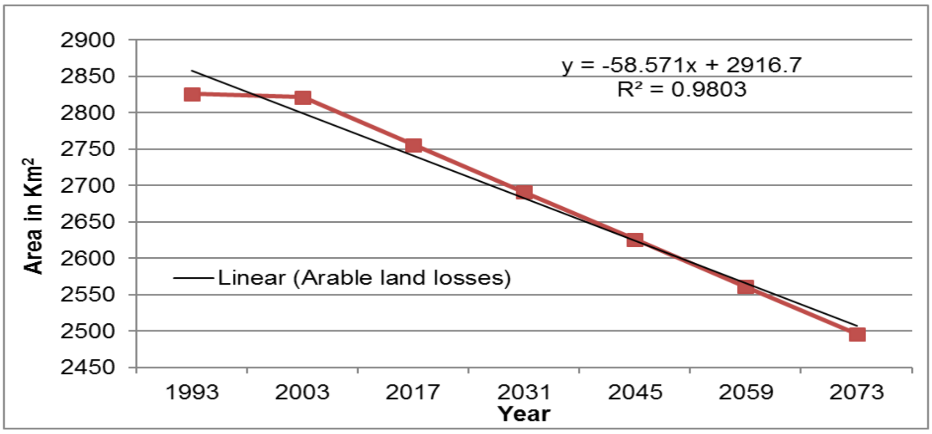

Fig. 7. Forecasting about loss of arable land in district Gujrat.

In 1993 total arable land was 2826 Km² which reduced to 2821 Km² in 2003. In 2017 the arable land further reduced to 2756 Km² (Table 3).

Forecasting about loss of arable land

Due to rapid growth of urbanization in the district Gujrat, arable land is decreasing rapidly. For planning about development, loss of arable land should be under consideration, about which predictions can be made by forecasting of satellite imagery. Predictions used for current analysis were based on a hypothesis considering loss of arable land is constant, non-stoppable.

Table 1. Description of Landsat images used for land cover classification of the study area.

Satellite	Year	Date	Sensor	Spectral Resolution	Spatial Resolution
Landsat5	1993	05-12-1993	TM	7	30m
Landsat7	2003	03-12-2003	ETM+	8	15(PAN), 30 (MS)
Landsat8	2017	07-12-2017	TIRS	11	30m

Table 2. Comparison of land covers of Gujrat from the year 1993 to 2017.

Type of Land Cover	Area in 1993 (Km²)	Area in 2003 (Km²)	Area in 2017 (Km²)	Change in area from 1993-2003 (Km²)	Change in area from 2003-2017 (Km²)	Change in area from 1993-2017 (Km²)
Built-up	118.12	123.09	188.09	4.97	65.00	69.97
Crop irrigated	2206.6	2202.7	2142.18	3.90	60.52	64.42
Crop rainfed	294.8	293.97	293.23	0.83	0.74	1.57
Crop in flood plain	58.19	58.31	58.31	0.12	0.00	0.12
Forest-natural trees and mangroves	18.1	17.98	16.29	0.12	1.69	1.81
Natural vegetation in wet Areas	150.13	150.13	150.13	0.00	0.00	0.00

Range land-natural shrubs and herbs	297.03	296.73	294.68	0.30	2.05	2.35
Wet areas	71.03	71.09	71.09	0.06	0.00	0.06

Increase in urbanization and no legal laws will be followed by such loss. From 1993 to 2017, loss of arable land was about 2.5% (Table 3), in next 50 year it will become approximately 10% till 2073 (Fig.7) and in upcoming 500 years there will be no more arable land for agricultural activities in district Gujrat.

Table 3. Losses of arable land in Gujrat from 1993 to 2017.

Year	Area of arable land (Km^2)	Years	Decrease in arable land area (Km^2)	Percentage decrease in arable land area (%)
1993	2826	-		-
2003	2821	1993 to 2003	5	0.18
2017	2756	2003 to 2017	65	2.30
		1993 to 2017	70	2.50

Conclusion

The remote sensing and GIS based temporal analysis of Landsat images proved to be an effective tool in analyzing land use changes. The present study showed that district Gujrat has underwent a rapid urban growth during 1993-2017. The built-up area has expanded in all directions from 118.12 Km^2 in 1993 to 188.09 Km^2 in 2017, over peri-urban arable land. Increased housing demand, improved transport systems and increasing land value was the main factors liable for the conversion of arable land into Built-up environment. If increase of built-up could not manage properly, it will insert a high pressure on food production and pollution will be increased. By formulating legal policies and specific direction of expansion toward those areas which are not suitable for cultivation on the barren land, loss of arable can be minimized. Government needs to promote agriculture by formulating sustainable land use policies to protect arable land. Furthermore, the urban authorities may develop alternate sites for construction and development mainly on unproductive areas. The vertical growth of buildings (for housing, commercial plazas) rather than horizontal development, may be encouraged.

References

Abass K, Adanu SK, Agyemang S. 2018.Peri-urbanisation and loss of arable land in Kumasi Metropolis in three decades: Evidence from remote sensing image analysis. Land Use Policy **72**, 470-479. http://dx.doi.org/10.1016/j.landusepol.2018.01.013

Anil NC, Sankar GJ, Rao MJ, Prasad IVRKV, Sailaja U. 2011. Studies on land use/land cover and change detection from parts of South West Godavari District, A.P-using remote sensing and GIS techniques.Techniques. Journal of Indian Geophysical Union **15(4),**187-194.

Beryant C. 2004. The impact of urbanization on rural land use, in the role of food, agriculture, forestry and fisheries in human nutrition, [Ed. Victor R. Squires], in Encyclopedia of Life Support Systems (EOLSS), Developed under the auspitious of UNESCO, Eolss Publishers, Oxford, UK.

Dewan AM, Yamaguchi Y. 2009. Land use and land cover change in Greater Dhaka, Bangladesh: using remote sensing to promote sustainable urbanization. Applied Geography **29(3),** 390-401. http://dx.doi.org/10.1016/j.apgeog.2008.12.005

District Census Report of Gujrat. 1998. Population Census Organization Statistics Division, Islamabad, Government of Pakistan.

Doos RB. 2002. Population growth and loss of arable land. Global Environmental Change **12(4),** 303-311.

Kavitha A, Somashekar RK, Nagaraja BC.2015. Urban expansion and loss of agriculture land - a case of Bengaluru city. International Journal of Geomatics and Geosciences **5(3),** 492-498.

Lasisi M, Popoola A, Adediji A, Adedeji O, Babalola K. 2017. City expansion and agricultural land loss within the peri-urban area of Osun State, Nigeria. Ghana Journal of Geography **9(3),** 132-163.

Lean W, Goodall B. 1977. Aspects of Land Economics. The Estate Gazette Limited, London.

Lillesand T, Kiefer RW, Chipman J. 2015. Remote sensing and image interpretation 7th Ed. p. 736.

Lu Q, Soderlund L, Peilin W, Juan L. 2005. Cultivated land loss arising from the rapid urbanization in China. MTT Agrifood Research Reports **68,** 313-327.

Mahboob MA. 2011. Assessment of urban sprawl of Lahore, Punjab, Pakistan using multi-stage remote sensing data. Science International **6,** 6219-6224.

Mohsin M, Bhalli MN.2015. Rapid urban growth and change in urban and municipal limits of Bahawalpur City, Pakistan: A spatio-periodical discourse. Journal of Basic and Applied Sciences **11,** 528-538.

Pandey B, Seto KC. 2014. Urbanization and agricultural land loss in India: comparing satellite estimates with census data. Journal of Environmental Management **53,** 53-66. http://dx.doi.org/10.1016/j.jenvman.2014.05.

Quasem M. 2011. Conversion of agricultural land to non-agricultural uses in Bangladesh: Extent and determinants. Bangladesh Development Studies **34,** 59-85.

Rimal B. 2012.Urbanization and the decline of agricultural land in Pokhara Sub-metropolitan City, Nepal. Journal of Agriculture Science **5(1),** 54-65.

Running SW, Loveland RT, Pierce LL, Nemani RR, Hunt ER.1995. A remote sensing based vegetation classification logic for global land cover analysis. Remote Sensing of Environment **51(1),** 39-48.

Samiullah. 2012. Expansion of built up area and its impact on urban agriculture in Peshawar Pakistan. PhD thesis submitted to Department of Geography, University of Peshawar, Pakistan.

Shi K, Chen Y, Yu B, Xu T, Li L, Huang C, Liu R, Chen Z, Wu J. 2016. Urban expansion and agricultural land loss in China: a multiscale perspective sustainability **8**, 1-16. http://dx.doi.org/10.3390/su8080790

Slingsby AE. 1991. Shelter for low income communities first interim report Punjab, Centre for Development and Environmental Planning. Oxford, UK.

Soil Survey of Pakistan Lahore. 1978. Reconnaissance soil survey report Gujrat area.

Wang H, Qiu F. 2017.Investigating the impact of agricultural land losses on deforestation: Evidence from a peri-urban area in Canada. Ecological Economics **139,** 9-18. http://dx.doi.org/10.1016/j.ecolecon.2017.04.002

Yan H, Liu J, Huang HQ, Tao T, Cao M. 2009. Assessing the consequence of land use change on agricultural productivity in China. Global and Planetry Change **67(1-2),** 13-19. http://dx.doi.org/10.1016/j.gloplacha.2008.12.012

Yar P, Rahman A, Khan MA, Samiullah S, Shah AA. 2016. Spatio-temporal analysis of urban expansion on farmland and its impact on the agricultural land use of Mardan City, Pakistan. Proceedings of the Pakistan Academy of Sciences: B. Life and Environmental Sciences **53(1)**, 35-46.

Zhang J, Li P, Wang J. 2014. Urban built-up area extraction from Landsat TM/ETM+ images using spectral information and multivariate texture. Remote Sensing **6(8),** 7339-7359.
http://dx.doi.org/10.3390/rs6087339