IMPACT OF URBANIZATION ON ARABLE LAND IN KOTA - A GEOSPATIAL ANALYSIS

ANKITA P. DADHICH, ROHIT GOYAL, PRAN N. DADHICH

Abstract: With significant economic development in Kota, Rajasthan, the urban land has increasingly expanded and encroached upon arable land in the last 27 years (1989-2016). Spatio-temporal changes in urban growth and arable land were assessed by Landsat data using geospatial techniques. Over the 27 years there is vast increase in built up (291.8 %), however arable land is shrinking (40.3 %) due to large scale land transformation. Four buffer zones with a distance of 2.5 km were created from the center of the Kota city to assess the impact of urbanization on arable land. Results reveal that in 7.5-10 km buffer zone the built-up expanded by 2139.3%, however in 2.5 km buffer area, the urban area increased by 69.5 % only, because no further expansion is possible in that zone however, maximum arable land loss was observed in 2.5 km buffer zone (99.2%) followed by 2.5-5 km (54.4%) buffer zone. The analysis also exhibits the huge land transformation in north-west and north-east direction on very fertile and productive land. This information could be very useful to local government and urban planners for the sustainable development of the city and to protect and conserve the arable land by policy and guidelines.

Keywords: Urban growth, Arable land, Remote Sensing, GIS.

Introduction: Many countries around the world witnessed the losses of arable land [1], [2] with decrease in food production in the last three decades. The shift from an agrarian to commercial/industrial economy abandoned the arable lands and is often converted to human settlements. The urban areas have become the center of all the activities and large-scale land transformation is taking place, leading to loss of arable land [3]. In recent years India is also experiencing rapid urban growth because of increase in population coupled with economic growth (especially after the 1950s) that has resulted in land use/land cover transformations [4]. Urban population across India has been growing consistently from 27.8% in 2001 to 31.2% in 2011 [5]. Over urbanization is the main cause for the reduction of productive arable land which is the backbone of the developing country's economy [6]. Reference [7] reported that the annual average increase in non-agriculture land use was 0.16 million ha (in 1980s) and it rose to 0.21 million ha in most recent decade.

Presently, Kota city is also facing unplanned and uncontrolled settlements on the arable land with the excessive growth in urban population. Though encroachment of arable land cannot possibly be avoided around a growing city, therefore, a bigger pressure is placed on the urban planners and decision makers to acquire detailed and accurate information of urban land transformation for sustainable development of the city. The integration of remote sensing and geographic information system (GIS) is a quite promising approach for detecting and analyzing the spatio-temporal dynamics of land transformation at local scale. Several studies have demonstrated the potential of geospatial techniques for analyzing the spatio-temporal dynamics of land transformation [8], [9], [10]. The present study is aimed to bring out the temporal and spatial change of urban landuse and land transformation in Kota city, further it also try to investigate the impact of these land transformation on city's arable land.

Material and methods : Study area: Kota is located between 24°32' & 25°50 N Latitude and 75°37' & 76°34' E Longitude in the southeast of the state of Rajasthan (Fig 1). The population of the district as per 2011 census is 19,51,014 persons including rural and urban population of 7,74,410 and 11,76,604 respectively. Kota is the third largest city of Rajasthan after Jaipur and Jodhpur. The average elevation of the city is 271 meters. This city has grown up on the banks of Chambal which is the only perennial river of Rajasthan. The city is the trade center for an area in which millet, wheat, rice, pulses, coriander, and oilseeds are grown; industries include cotton and oilseed milling, textile weaving, distilling, dairy, manufacture of metal handcrafts, fertilizers, chemicals and engineering equipment. Kota city is famous for stone and for its coaching institutes, therefore called "Education hub of India".

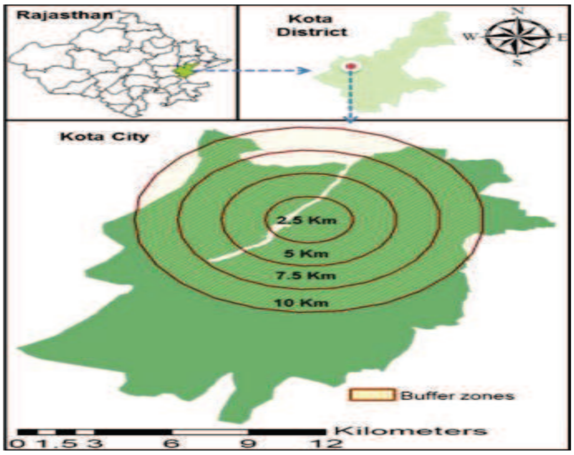

Fig. 1 Location map of Study area

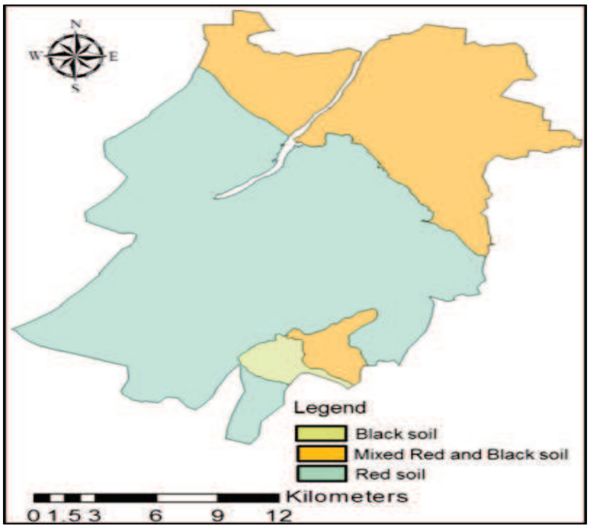

Fig. 2 Soil distribution map of Kota city

Climate of the Kota district is semi-arid type where temperature is high almost throughout the year. January is the coldest month with mean daily maximum temperature at 24.3°C and minimum temperature is 10.6°C. Mean daily maximum temperature during summers is 46.2°C and minimum temperature is 29.7°C. The average annual rainfall is 652.17mm.

Data used: The multi-spectral Landsat TM image with spectral resolution 30 meter for the year 1989 and Landsat 8 multispectral merged panchromatic image with spectral resolution 15 meter for the year 2016 of Kota city area, were downloaded from USGS Earth Explorer to assess the spatio-temporal changes in built-up and arable land. Secondary source data include the city boundary from municipal department of Kota and soil type data from Rajasthan agriculture department.

Data analysis: ArcGIS software has been used to generate various thematic layers, like district boundary map of Kota, Municipal boundary map (Fig 1) and soil map. The major soil types of Kota city are mixed red and black soil, red soil and black soil (Fig 2) which covers 163.33 km², 323.60 km² and 9.77 km² areas respectively. Processing of imagery and image interpretation is done in ERDAS Imagine software for the year 1989 and 2016. Supervised classification was done using maximum likelihood algorithm. For this a set of homogenous pixels were selected and algorithm was trained to classify the data based on 'training sites'. Error of misclassification was rectified by manually re-coding the class after comparison with ground truth data and Google Earth imagery.

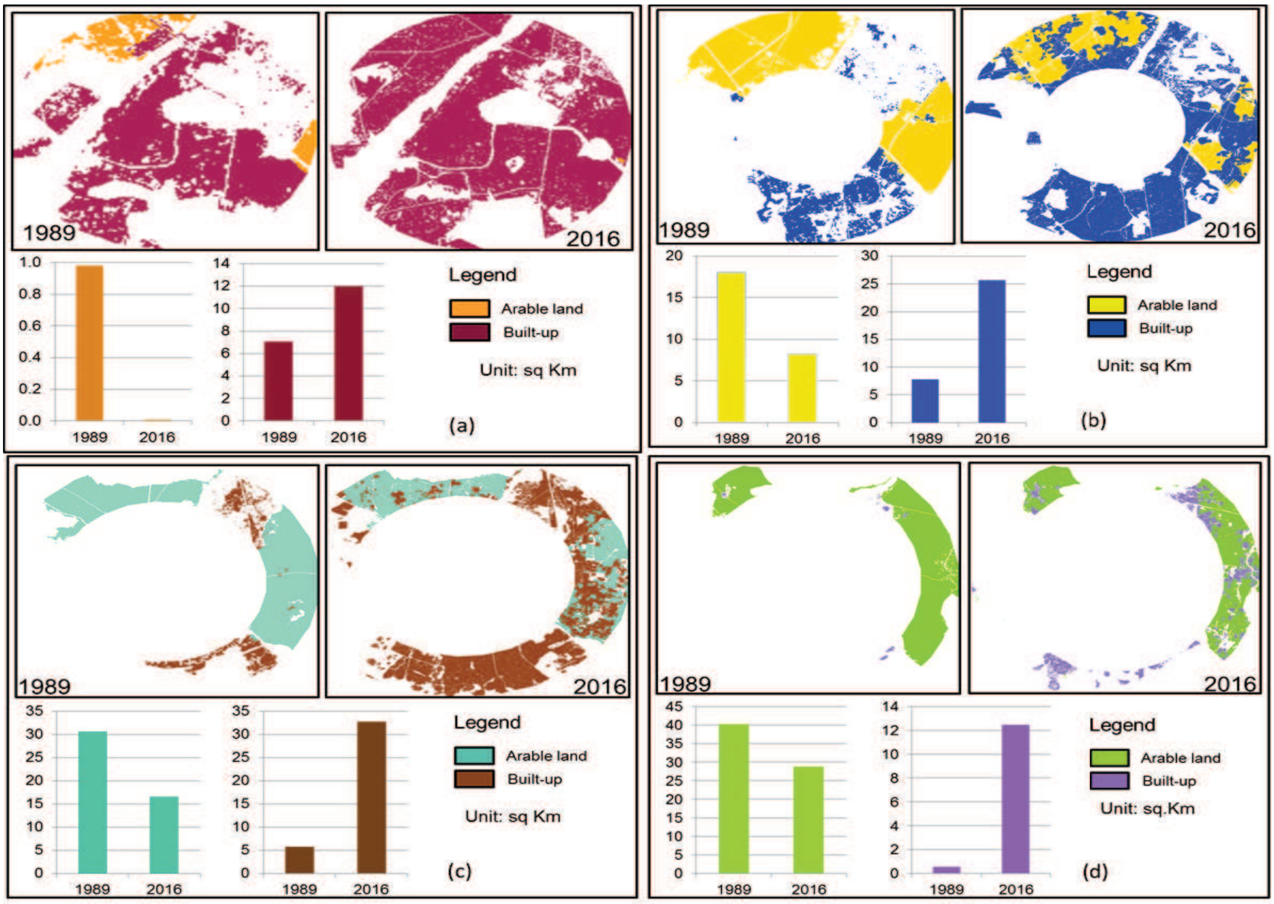

Fig. 3 Arable land loss and built-up area expansion
(a) 2.5 Km buffer zone (b) 2.5-5 Km buffer zone (c) 5-7.5 Km buffer zone (d) 7.5-10 Km buffer zone

Creation of buffer Zones: Four buffer zones with a distance of 2.5 Km were created from the center of the Kota city to assess the extent of land conversion from arable land to built-up(Fig 1). These buffer zone boundaries (i.e. 2.5 km buffer, 2.5-5 km buffer, 5-7.5 km buffer and 7.5-10 km buffer) were overlaid on the classified output of arable land and built-up area to extract the area under each zone during 1989 to 2016.

Results and analysis : Spatial and temporal changes in arable land and built-up: The urban expansion is not only consuming the arable land but also threatening the food security, therefore the concerns have developed over the long term sustainability and environmental consequences of the arable land loss [12]. Figure 3 depicts the spatio-temporal changes in arable land and built-up area of Kota city over a period of 27 years (1989–2016) in four different buffer zones. The increase in built-up area has been clearly seen in the last 27 years in north-west and north-east direction engulfing fertile (mixed red and black soil) and productive land area of the Kota city. Result implies (Fig 3a) that in 2.5 km buffer zone the arable land reduced from 0.98 km^2 to 0.01 km^2 and built-up increased from 7.05 km^2 to 11.96 km^2. Figure 3b indicates that in 2.5-5 km buffer zone the urban area increased 17.81 km^2 with 9.79 km^2 arable land loss. Excessive urban growth (27.06 km^2) was observed in 5-7.5 km buffer zone with high arable land loss of 14.04 km^2 (Fig 3c). In 7.5 -10 km buffer zone (Fig 3d) the arable land reduced from 40.21 km^2 (1989) to 28.82 km^2(2016) and built-up area increased from 0.56 km^2 (1989) to 28.8 km^2 (2016). The spatial and temporal results of Kota urban area reveals that the arable land has contributed to built-up and major land transformation has been taking place in eastern direction due to development of highway and industries.

Urbanization impact on arable land: Figure 4 depicts the change in built-up area and arable land during last 27 years (1989-2016). The analysis implies that arable lands continually dropped in the city during the period while the built-up lands constantly rose. By viewing figure 4a and urban sprawl statistics, it can be concluded that there is considerable increase in built-up area i.e. 291.8% in last 27 years. In 7.5-10 km buffer zone the built-up expanded by 2139.3%, however in 2.5 km buffer area, the urban area increased by 69.5 % only, because no further expansion is possible in 2.5 km buffer zone. The analysis also exhibits the huge growth in city periphery and most of the new built areas are developed near and along the major roads or highways in North-west and eastern direction of the city. Maximum arable land loss was observed (Fig 4b) in 2.5 km buffer zone (99.2%) followed by 2.5-5 km (54.4%), 5-7.5 km (45.8%) and 7.5-10 km buffer zone (28.3%). Over the years (1989-2016), the urban expansion has declined the arable land by 40.3%.

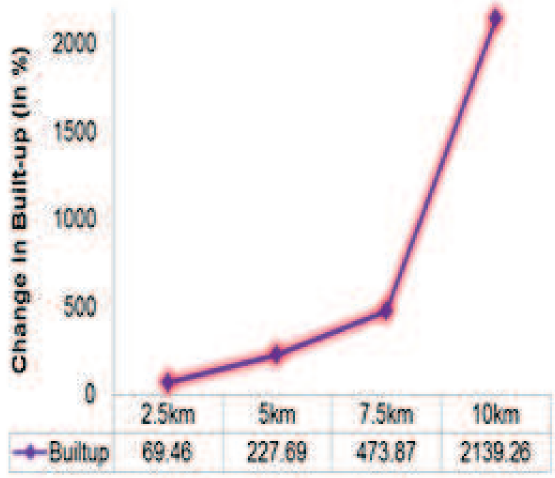

Fig. 4a Change in Built-up land (1989-2016)

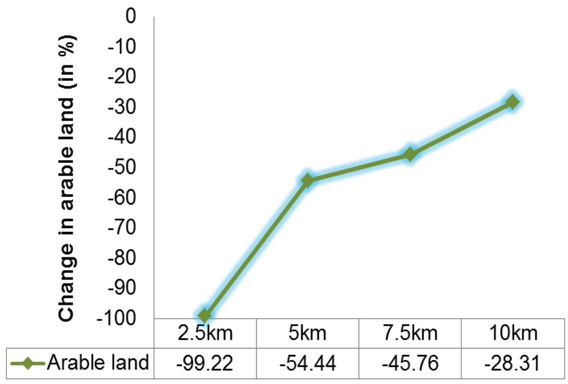

Fig. 4b Change in arable land (1989-2016)

The urban expansion at the cost of arable land reveals that the urban containment policy has been ineffective [13].

Conclusions: In this study, an integrated approach of remote sensing and GIS was used to evaluate the spatial and temporal changes in urban sprawl and loss of arable land. The population growth and urban sprawl has threatened the highly productive arable land in north-east and north-west direction of the Kota city. Results revealed a notable increase in built-up area in last 27 years with excessive pressure on arable land, resulting to import the food from local governments and neighboring states. However urban development cannot be stopped but with proper management and planning it can be directed in a sustainable way to protect and conserve the fertile arable land of the city. Therefore, many measures need to be taken to overcome the productive land scarcity issues. The government and urban planners should ensure the developmental projects in areas other than productive land, and enact policies to reduce the arable land losses.

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