P: ISSN No. 2231-0045 RNI No. UPBIL/2012/55438 VOL.-IV, ISSUE-II, November-2015
E: ISSN No. 2349-9435 Periodic Research

Impact Assessment of Land Use/Land Cover Change on Population and Settlement in Bikaner District (Rajasthan) Using Geospatial Techniques

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Abstract

Land is becoming a scarce resource due to immense demographic pressure. Hence, information on land use/land cover and possibilities for their optimal use is essential for the planning and implementation of land use schemes to meet the increasing demands for basic human needs and welfare. This information also assists in monitoring the dynamics of land use resulting out of changing demands of increasing population. Any change in land use/land cover of any area is reflected in economy and livelihood of the inhabitants. Remote sensing and GIS techniques play an important role when applied in identifying and delineating the parts of land under different uses and covers, which leads to better management and development of land resources in terms of time and cost.

Keywords: Scarce Resource, Demographic Pressure, Land Use and Land Cover Change.

Introduction

The fact that human beings are the major contributors to land cover changes and are the ones experiencing the consequences of these changes, it will be of paramount importance to understand the interaction among human beings and their environment (Jaiswal J.K. and Verma N., 2013). This need becomes more imperative as changes in land use become more rapid affecting the livelihoods of societies. The alterations of ecosystem, due to changes in land use/land cover (LULC), negatively affect the ability of the biological systems to support the human needs. These changes also determine, in part, the vulnerability of places and people to climatic, economic or socio-political perturbations (Singh A., 1989). Therefore, thinking about the driving forces behind land use changes and developing appropriate measures to control, or at least, minimize the effects will then be very important.

The geospatial techniques are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analysis of the earth's patterns and changes at local, regional and global levels over time. These data also provide an important link between intensive research and management of biodiversity (Pandey A.C. and Nathawat M.S., 2006).

Objectives of the Study

1. To analyze the trends of LULC changes in the study area; and
2. To evaluate the effect of LULC changes on population and settlement in pattern in the study area.

Hypotheses

1. The amount of rainfall and irrigation have positive correlation with land use/land cover.
2. The expansion of irrigation facilities and area under cultivation have accelerated the population and settlement in Bikaner district.

Methodology

The secondary data have been collected from different sources such as- Internet, Department of Land Records and Agriculture, Bikaner; District Statistical Outline, Bikaner; Animal Husbandry Department, Jaipur; Indian Meteorological Department, Bikaner; and Office of the Registrar General and Census Commissioner, Govt. of India (Census of India, 1981; 1991;

2001; 2011). For primary data, mainly toposheets, survey data and satellite images have been used.

The satellite images have been downloaded from the website glcf.umd.edu and these have been masked according to study area. Generation of FCC (False Color Composite) - Downloading site is used to obtain seven separated band image of Landsat using the layer stacking function and the multi-spectral (multi-band) composite image has been made. From this, 4^{th}, 3^{rd} and 2^{nd} bands are used for formation of a standard FCC, and this was, again used for extracting the LULC classes. Similarly, different band combinations are used for formation of various FCCs. In the end, the total area of different classes have been calculated, and the pattern of LULC at different points of time is studied and LULC maps have been created with the help of above procedure.

Study Area

Bikaner is one of the desert districts, situated in the Thar Desert towards north-west of Rajasthan. It extends from $27^0$11' to $29^0$3' north latitudes and $71^0$54' to $74^0$12' east longitudes. It is bounded by Sriganganagar district in the north; Jaisalmer district and Pakistan in the west; Churu in the east and Nagaur and Jodhpur districts in the south and south-west. It has a geographical area of 30289.62 sq km which is around 8.8 per cent of the total area of the State and stands at second place in area. There are five sub-divisions and eight revenue tehsils in the district.

The district has a dry climate, with large variation of temperature and scanty rainfall. Hot winds blow in summer, sweeping away and creating new sand-dunes. The highest temperature may go up to 48^0C during summer and lowest up to freezing point during winter season. The mean annual rainfall in the district is 26.3 cm, mean relative humidity remains below 50 per cent, while the mean annual maximum temperature is found to be above 30^0C and minimum temperature below 20^0C (Sharma, H. S. and Sharma, M. L., 2010). The wind velocity ranges between 6.1 km/hr to 9.4 km/hr.

Factors Influencing LULC

It is found that there are three categories of land use and land cover in the study area: (i) Crop cover, (ii) Bare land, and (iii) Grazing land. The following are factors influencing LULC directly -

Rainfall

The following conclusions are based on the data during the year 1973 to 2014:

1. Getting decadal mean of rainfall since 1973, it is found that in the first decade; mean rainfall was highest 30.53 cm (table 1). It is seen to fall down after 1973. From the third decade it increased from 27.93 cm to 28.99 cm in the fourth decade (2003-2012).
2. From the study of rainfall, it is found that in the years 1984, 1985, 1987, 1991, 1999, 2002, 2004 and 2006 the rainfall was less than 20 cm; while in the year 2002 it was the lowest at 6.62 cm.
3. After the year 2012, the annual rainfall is more than 30 cm; that is; in 30.62 cm in 2013 and 30.51 cm in 2014.
4. The lowest rainfall years have least Kharif cultivated area and the lowest cultivated years are 1976, 1984, 1985, 1987, 1990 and 2000.

The most kharif cultivated years in ascending order are 2001, 2003, 2010, 2011, 2012 and 2014; the annual rainfall is also high as we can see in table1.

Table 1
Bikaner District - Annual Rainfall

Year	Rainfall (cm)	Year	Rainfall (cm)	Year	Rainfall (cm)	Year	Rainfall (cm)
1973	26.36	1983	51.31	1993	21.55	2003	30.06
1974	23.75	1984	17.79	1994	29.67	2004	15.79
1975	38.09	1985	13.27	1995	31.97	2005	29.67
1976	33.25	1986	23.54	1996	44.60	2006	19.26
1977	39.64	1987	17.40	1997	42.01	2007	28.99
1978	42.22	1988	22.67	1998	32.07	2008	34.64
1979	24.48	1989	27.32	1999	19.90	2009	20.87
1980	19.17	1990	29.31	2000	23.63	2010	42.67
1981	21.59	1991	11.68	2001	27.29	2011	34.06
1982	36.77	1992	38.72	2002	6.63	2012	33.96
Mean Decadal	**30.53**	**25.30**		**27.93**		**29.10**	

Source: Meteorological Department, Bikaner

Irrigation

Bikaner district is mainly irrigated by IGNP (64.03 per cent) and tube-wells (33.61 per cent). Under the lift irrigation scheme, 41 villages of Lunkaransar tehsil, with an area of 2.59 lac acres, and 35 villages of Bikaner tehsil (3.93 lac acres) are being benefitted (table 2).

Table 2
Bikaner District - Sources of Irrigation (2007 -08)

Tehsil	Source (per cent)			Irrigated Area (Ha)
	Wells	Tube-wells	Canals	
Bikaner	0.00	73.60	26.39	38928
Lunkaransar	0.03	19.14	80.81	39326
Nokha	1.54	98.45	0.00	33178
Kolayat	0.01	13.12	86.86	75329
Pugal	0.00	0.00	100.0	36100
Khajuwala	0.00	0.00	100.0	61673
Chhatargarh	1.18	0.00	98.81	35478
Dungargarh	14.35	85.64	0.00	55279
Total District	2.36	33.61	64.03	375291

Source: Economic and Statistical Department, Bikaner.

The above given details clearly reflect the lack of irrigation facilities and ground water in Bikaner district. A number of tube-wells have been dug out in Bikaner, Nokha, Dungargarh and Kolayat Tehsils that have changed the agricultural system in the area.

1. Irrigated area has been more than 10,000 sq km since 2000, except 2002. In 2002; the reason behind the less irrigation was draught.
2. After 2000, expansion in irrigation was due to tube-well irrigation in Nokha, Dungargarh and Bikaner tehsils. Owing to this, the crop cover is also found to be greater than before.
3. Expansion of the tube-well irrigation after 2010 was due to pump-sets that are run by solar energy.
4. High variation in irrigated area can be attributed to high fluctuation in water running in the Indira Gandhi Canal System, which itself varies with amount of rainfall.
5. Karl Pearson correlation coefficient between annual rainfall and Kharif cropped area was calculated, and was found to be 0.59. This medium positive correlation indicates towards dependence of Kharif cropped area on rainfall, despite the development of vast canal infrastructure.

Table 3
Bikaner District - Land use/Land Cover

Type of LULC	Area (km^2)			
	1976	1992	2000	2009
Crop Land	6159.72	10309.38	9973.91	10078.49
Range / Grazing Land	9769.38	11048.91	11965.49	10897.38
Bare Land	14264	9697.02	9058.47	9480.96
Settlements	92.04	216.69	272.30	318.87
Water-bodies	4.01	17.62	19.45	13.92
Canal Length (km)	1018.36	1642.68	1862.88	1988.86

Source: Data calculated with help of Satellite Imagery

Crop Cover

During 1976-1992 there was a growth of 67.37 per cent in crop cover, that is, the highest for the study area and will, perhaps, remain so. This phenomenal growth is attributable to the Green Revolution facilitated initially by IGNP (table 3 & figure1).

Impact of LULCC on Population and Settlement

Population

The population share of Bikaner district out of the total population of Rajasthan State has been continuously growing from 2.84 per cent to 3.44 per cent during 1981- 2011. The population growth rate of Bikaner was high up to the year 2001 due to migration towards Bikaner and higher natural growth; while reduction in the above factors led to decrement in the subsequent Census 2011. This reduction was caused by the factors such as lack of water in the canal system (IGNP), increment in literacy rate and per capita income. Growth rate of population has remained higher in Bikaner district than the State (table 4).

Table 4
Bikaner District and Rajasthan - Population (1981-2011)

Year	Bikaner		Rajasthan	
	Population	Decadal Growth Rate (per cent)	Population	Decadal Growth Rate (per cent)
1981	973800	-	34261862	-
1991	1270797	30.49	44005990	28.44
2001	1902110	49.67	56507188	28.40
2011	2363937	24.27	68548437	21.30

Source: Census of India, 1981 to 2011

P: ISSN No. 2231-0045 RNI No. UPBIL/2012/55438 VOL.-IV, ISSUE-II, November-2015
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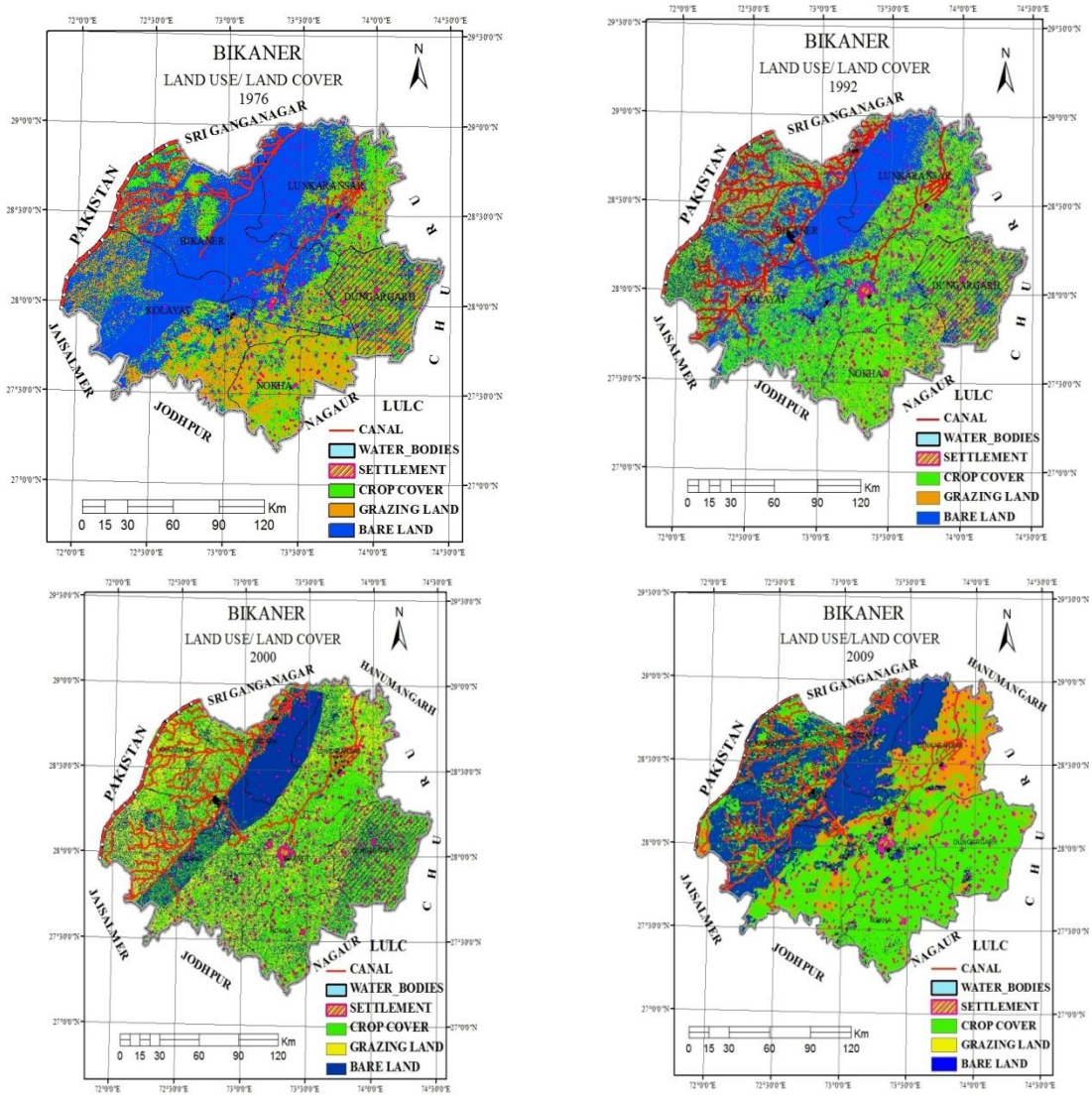
Fig 1 : Bikaner District - LULC Pattern (1976 - 2009)



Source: Prepared with help of Satellite Imagery

The fast pace of urbanization and expansion of canal system has spiked population density and growth rate of Bikaner tehsil. The high growth in agriculture sector accounts for high density and growth rate in Lunkaransar tehsil. The limitation of the canal system has led to gradual increment in Nokha, Kolayat and Dungargarh tehsils. The population distribution in Bikaner district is not uniform as Bikaner tehsil, occupying 31 per cent area of total land, contains 50 per cent of total population, while remaining tehsils occupying 69 per cent of total land account for rest of 50 per cent of total population (table 5).

Table 5
Bikaner District - Population and Density

Tehsil	Density		2001		2011	
	1981	1991	Population	Density	Population	Density
Bikaner	49	69	725810	227	919706	288
Lunkaransar	18	25	174293	35	213627	42
Nokha	47	54	329031	87	436876	115
Kolayat	12	17	207749	26	261028	33
Pugal*	NA	NA	73935	23	67163	21
Khajuwala*	NA	NA	91771	45	88730	44
Chhatargarh*	NA	NA	71682	33	82488	38
Dungargarh	41	44	227839	75	294319	97
Total District	32	42	1902110	63	2363937	78

Source: District Outline, Bikaner * These tehsil came into existence after 1991.

This phenomenon is caused by lack of resources and urban centres in rest of the tehsils. The comparative low population growth rate is recorded in Nokha and Dungargarh tehsils, due to absence of irrigation channels. The high growth in agriculture sector accounts higher population density and growth rate in Dungargarh, Nokha and Bikaner tehsils. Tube-well irrigation system is responsible for the above phenomenon. Lack of water in the canal system, and boom in land cost, leading to change in land ownership; are responsible for the negative growth rate in Pugal and Khajuwala tehsils. Higher growth rates reflect increment in the population of Bikaner and Nokha tehsils, while negative growth rates in case of Pugal and Khajuwala indicate absolute decrease of population during 2001-2011. These tehsils even show decrease in population density for the aforesaid period.

This phenomenon is caused due to lack of resources and urban centres in rest of the tehsils. The comparative low population growth rate is recorded in Nokha and Dungargarh, because of absence of irrigation channels, has caused decrement in their share in district population. The high growth in agriculture sector accounts higher population density and growth rate in Dungargarh, Nokha and Bikaner tehsils. Tube-well irrigation system is responsible for the above phenomenon. Lack of water in the canal system, and boom in land cost, leading to change in land ownership; are responsible for the negative growth rate in Pugal and Khajuwala tehsils. Higher growth rates reflect increment in the population of Bikaner and Nokha tehsils, while negative growth rates in case of Pugal and Khajuwala indicate absolute decrease of population during 2001-2011. These tehsils even show decrease in population density for the same period.

Settlement

In 1976, the rural settlements were dense in eastern half of the district, and scattered in middle and western parts. Rural settlements increased both in number and area in 1992, especially in north-western irrigated region, comprising modern Pugal, Chhatargarh and Kolayat tehsils. The data for 2009 shows a stagnant growth of rural settlements, while the Bikaner City area shows a growing trend. The growth in rural settlement area seems to be getting slower because of increasing culture of single on-farm dwellings.

The change in area or growth of settlement in Bikaner district for the period 1976-2009, and for various point of time, i.e., 1976, 1992, 2000 and 2009 has been discussed above. Due to small scale of the settlement map, the areal change is not so visibly obvious. So, the areal growth analysis and mapping of Bikaner City for the same period has been performed, as a sample, in order to clearly bring out the spatial growth trends on a map of large scale.

The spatial growth of built up area of the City has showed a very high annual growth rate of 9.40 per cent during the period 1976-1992. This period saw a fast expansion of canal system. The establishment of institutional and residential area under IGNP, expansion of business and economy due to increased agricultural production, growth of educational centres and transportation have led to high rate of areal expansion of the city during this period (figure 2).

This expansion of Bikaner City has led to merger of suburbs and villages like Gangashahar, Bhinasar, Bichhwal and Karmisar within the City area. The spatial growth of the City declined to a low of 1.73 per cent per annum during 1992-2000, indicating stagnation in the canal-based agro-economy of the district (table 6).

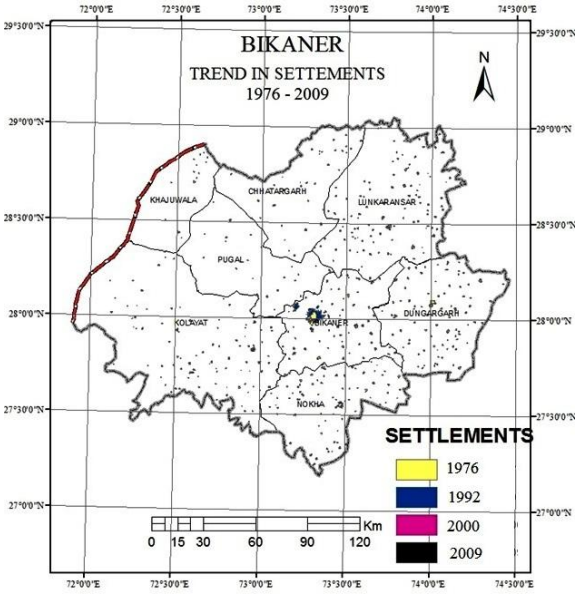
The City again, revived its spatial growth rate and rose to an average of 5.66 per cent per annum between 2000 and 2009. Fast growth of tube-well irrigation, dairying, number of educational/coaching institutions and connectivity of transportation and communication this period are some of the reasons for the observed trends.

Table 6
Bikaner City - Urban Area (1976 - 2009)

Year	Area (km^2)	Areal Growth (km^2)	Annual Growth Rate (per cent)
1976	20.34	-	-
1992	50.93	30.59	9.40
2000	57.97	7.04	1.73
2009	87.52	29.55	5.66

Source: Calculated with help of Landsat Imagery

Fig 2: Bikaner District - Expansion in Settlement (1976 - 2009)



Source: Prepared with help of Satellite Imagery

Suggestions

1. The population of Bikaner district has extended into new parts of the study area with development of irrigation. However, these areas too exhibit a downfall in population due to reduction in crop cover, affected by reduced availability of irrigation water. It happened in Pugal and Khajuwala tehsils between 2001 and 2011. The reason behind reduction in crop cover and population may also be attributed to traditional farming. If the horticulture is encouraged in this area then this sort of problem could be avoided. Horticulture would ensure that there is no sudden decline in crop cover. Besides, need for irrigation water would also be lower, as compared to traditional

cropping.

2. Traditional method of flood irrigation is being practiced by the farmer as they consider it cheaper method of irrigation. While adoption of drip and sprinkler irrigation system can ensure both increase in the irrigated area and the yield as well. Solution for lack of electricity may be searched in solar energy based pumps. By using these, ground-water resources can also be utilized.
3. The study area has been traditionally suitable for animal-rearing. So, animal-based industries should be encouraged here. This will not only provide conservation to natural ruminants like sheep, which can survive in conditions of low rainfall, but also provide additional income to the farmers.
4. In order to check the decline of crop cover during the years of low rainfall, dry farming methods should be employed in the study area. These include deep ploughing before rains, use of drought-resistant varieties of crops etc. This will not only ensure crop yield but also requiring low levels of irrigation should be raised. This will also enable to provide surplus water to other sectors.
5. Growth and extension of population in the study area is much affected by crop production and crop cover. In order to reduce this dependence, secondary and tertiary economic activities need to be developed. When more people are absorbed in manufacturing, commercial activities and services, the dependence of population upon agriculture will decline. There are sufficient mineral and livestock resources in the study area to develop mineral and animal-based industries for achieving this.
6. In recent years, irrigation water availability has declined because of the need of water for domestic use. Possibilities of reuse and recycling of waste water, emanating from urban and rural areas, need to be explored in order to fulfill a part of the demand. Treated waste water can also be used to irrigate crops.

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