

*Full Length Research Paper*

# **Analysis of the impact of urban sprawl in altering the land-use, land-cover pattern of Raichur City, India, using geospatial technologies**

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**In this paper, an attempt was made to study the implications of urban sprawl on the land-use and land-cover pattern of a typical rural region, located in the State of Karnataka, India. Raichur quickly emerged as a city with the typical promises of an urban image. The GIS and remote sensing based assessment of the study area reveals that the city is still juvenile and there is some chance to save it from the adverse impact of urbanization, popularly described as sprawl.**

**Key words:** Land-use, land-cover, urbanization, GIS, remote sensing, urban sprawl.

## **INTRODUCTION**

As population increases, so does the need for new housing, schools, transportation and other civic amenities increases. This had been earlier considered as urbanization, a development that was considered as advancement, but soon the burgeoning population and industrial growth imposed such huge demands for infrastructure that it changed the very face of urbanization to that of urban sprawl.

Sprawl has been criticized for eliminating agricultural lands, spoiling water quality, and causing air pollution (Allen and Lu, 2003). Symmetrical growth of urban centres consumes agricultural land adjacent to these, resulting in lower agricultural productivity. Besides taxing the groundwater resources available for an urban centre, an increase in the paved area severely reduces the groundwater recharge potential, leading to situations which may truly be potential catastrophes (Farooq and Ahmed, 2008).

In recent years, understanding the dynamics of sprawl, quantifying them and subsequently predicting the same for a future period has attracted significant interest of

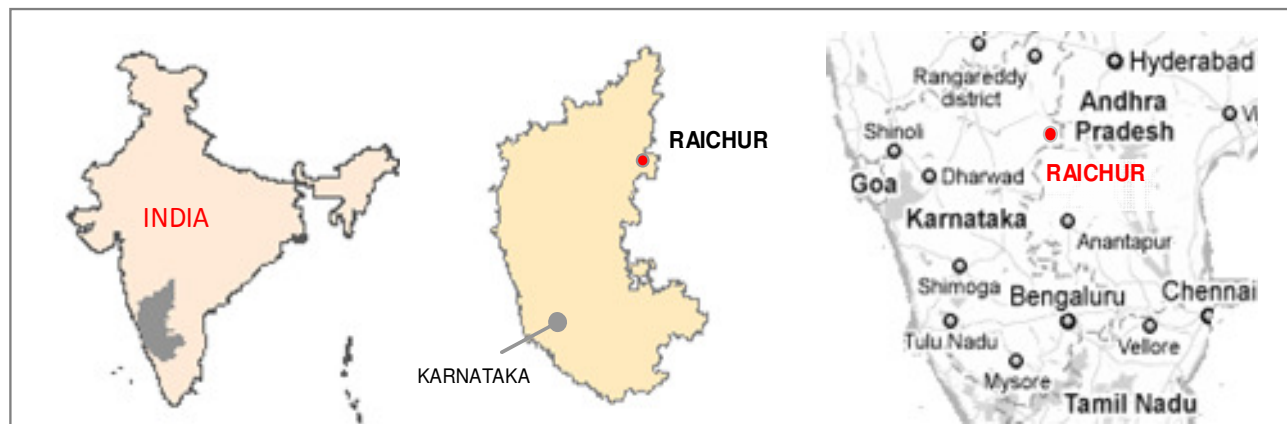
researchers. Measurement of these traits and additional attributes are used to develop standardized indices of sprawl development. Some researchers have employed an array of indicators, including land-use conversion, population change, traffic and vehicles, miles travelled, energy consumption, and fiscal measures (Nelson, 1999). Other researchers focused on measuring sprawl through the use of population data and detailed land-use and land-cover pattern (Eryilmaz et al., 2008; Sudhira et al., 2003). The physical expressions and patterns of sprawl on landscapes can be detected, mapped and analyzed using remote sensing and GIS (Geographical Information System) technologies (Gadal et al., 2009; Hasse, 2007; Kumar et al., 2008; Pilouk and Abdul-Rahman, 2007; Rashed, 2007; Yang, 2007; Zhu and Hu, 2010; Hurd et al., 2001; Yeh and Li, 2001). Also, there are dedicated software programs developed for simulating urban sprawl, such as NAUTILUS (2001) and EMPACT (USEPA, 2002).

In the present study, an attempt has been made to study the impact of growing urbanization on the land-use and land-cover pattern of Raichur city. This city is still young but there are already indicators which are pointing towards the rampant and uncontrolled growth. In view of this, the present study assumes significance in understanding the growth pattern of the city and cause the

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**Table 1.** Satellite imagery procured from national remote sensing centre.

Satellite	Sensor	Path and row	Date of acquisition	Spatial resolution (m)
IRS 1C	LISS 3	099-061	17 March, 1998	23.5
IRS 1D	LISS-3	099-061	16 February, 2003	23.5
IRS-P6	LISS-4	102-076	07 March, 2009	5.8

**Figure 1.** Location map of Raichur city.

56 H/7/SW	56 H/7/SE
56 H/8/NW	56 H/8/NE

**Figure 2.** Incidence of Raichur City on the survey of India topomaps of 1:25000.

impetus required for curbing the sprawl.

## THE STUDY AREA

Raichur city is located at 16° 10' and 16° 14' N latitude and 77° 19' and 77° 23' E longitude, between two major

ivers: Krishna and Tungabhadra (Figure 1). The general slope of the region is from the north-west towards the south-east, its average height above the mean sea-level being 382 m.

The climate of Raichur is characterised by mild winters and hot summers. December is the coldest month with a daily minimum mean of 17.7°C, while May is the hottest month with mean daily maximum temperature of 39.8°C. The day temperature in May often touches 45.0°C. Raichur is drought prone, and it falls in the northeast dry agro climatic zone. The normal annual rainfall of the district is 621 mm. The annual number of rainy days is about 49 days. Nearly 67% of the rain is received during the southwest monsoon period (June to September). The northeast monsoon contributes about 24%, during the post monsoon period (CGWB, 2008).

## DATASETS AND METHODS

For studying the temporal changes in land-use and land-cover pattern of Raichur city, a survey of India (SOI) toposheets (Figure 2) and satellite imagery (Table 1) was acquired from different periods of time. The following SOI toposheets on 1:25000 scale were used as base maps. The Raichur city municipal limits are covered within the extents of toposheet No: 56 H/8/NW.

The satellite imagery was processed using image processing software - *ERDAS Imagine 8.6*. The LISS -III and IV satellite imagery were imported and saved as a combination of 2 (red), 3 (blue) and 4 (green) bands. The imagery was geo-referenced based on the features of SOI topomap.

Automated and supervised (software-based) classification had

disadvantages considering the wide range of spectral signatures overlapping diverse land use categories of scrubs, plantations, rock outcrops, stony waste and settlements. Hence, the imagery was classified by means of visual interpretation and extensive ground truthing.

The land-use, land-cover mapping and statistical analyses were done using an add-on ArcGIS extension suite – Graphics and Shapes graphics (Jenness, 2010). This extension includes a large suite of tools for calculating geometric attributes of vector features and for selection and naming. MS Excel 2000 was used to prepare the graph charts.

## RESULTS AND DISCUSSION

Land-use and land-cover pattern during the year 2009 indicates agriculture as the major land-use type with 115.5 sq km (46%) of the total land-use. Stony waste, stone quarries and the dried-up water resources span about 73 sq km (29%), while settlements occupied 19 sq km (7.7%) of the land-use and land-cover (Figure 3).

The Raichur municipal limit spans 61.34 sq km, with residential settlements (19.33 sq km) as predominant land-use, followed by transportation (9.13 sq km) and industrial use (6.5 sq km) (Figure 4).

### Temporal change analysis

#### Settlements

The core of Raichur city, which is the densest built-up area, is spread within a radius of 3 km (Figure 3). The remaining settlements are strewn sporadically around this core up to a distance of 10 km.

Interestingly, no new patches of settlements were observed since 1982. The city had been sprawling outwards from the core area and the peripheral nuclear patches of the settlements. Between 1982 and 1998, there was three times increase in the core and fringe areas. Between 1998 and 2002, the growth at the core remained stable, while the fringes spread by 20% more. During the period, 2002 and 2009, the core as well as fringes saw a growth of 1.5 times (Figures 5 and 6).

To estimate the likely growth of the built-up area by 2021, a simple one-variable linear regression analysis was done with the total population (TPop) as regressor (Table 2). The linear regression equation calculated by the method of least squares is:

$$\text{Built-up area} = - 7.8240 + (0.0001 \times \text{TPop}) \dots\dots\dots(1)$$

From Equation 1, the built-up area by 2021 would be 27.33 sq km, an increase of nearly 52% when compared to the year 2001.

The demographic profile of Raichur indicates that the decadal growth rate had been decreasing sharply. Between 1981 and 1992, there has been a decrease of 20% population growth rate, and during 1992 to 2002, a

decrease of 16% population growth rate was observed (Figure 7). In spite of the decrease in the decadal population growth rate, the built-up area had been increasing steadily at the rate of 30% per decade. This indicates that the city is growing horizontally, where the land is consumed at an excessive rate.

#### Water resources

The water resources are heavily dependent on the rainfall and water supply from the two rivers (Krishna and Tungabhadra), and in turn, the agriculture extents are directly correlated with the water resources. Thus, 2002 had better water resources spread than any other year.

#### Plantations

There was no significant change in the area spread of plantations during 1982, 1998 and 2002. In 2009, an increase of 2.5% was noticed. The lack of good rains could have caused less agriculture practice. The dried-up water bodies and some agriculture fields were converted to plantations and hence a marginal increase was seen in plantations during 2009.

#### Scrubs

During the year 1982 and 1998 (Figure 6), there was 6 times increase in the spread of scrubs, while it reduced by half in 2002. During the year 2002 and 2009, there was no significant change in the total area occupied by scrubs.

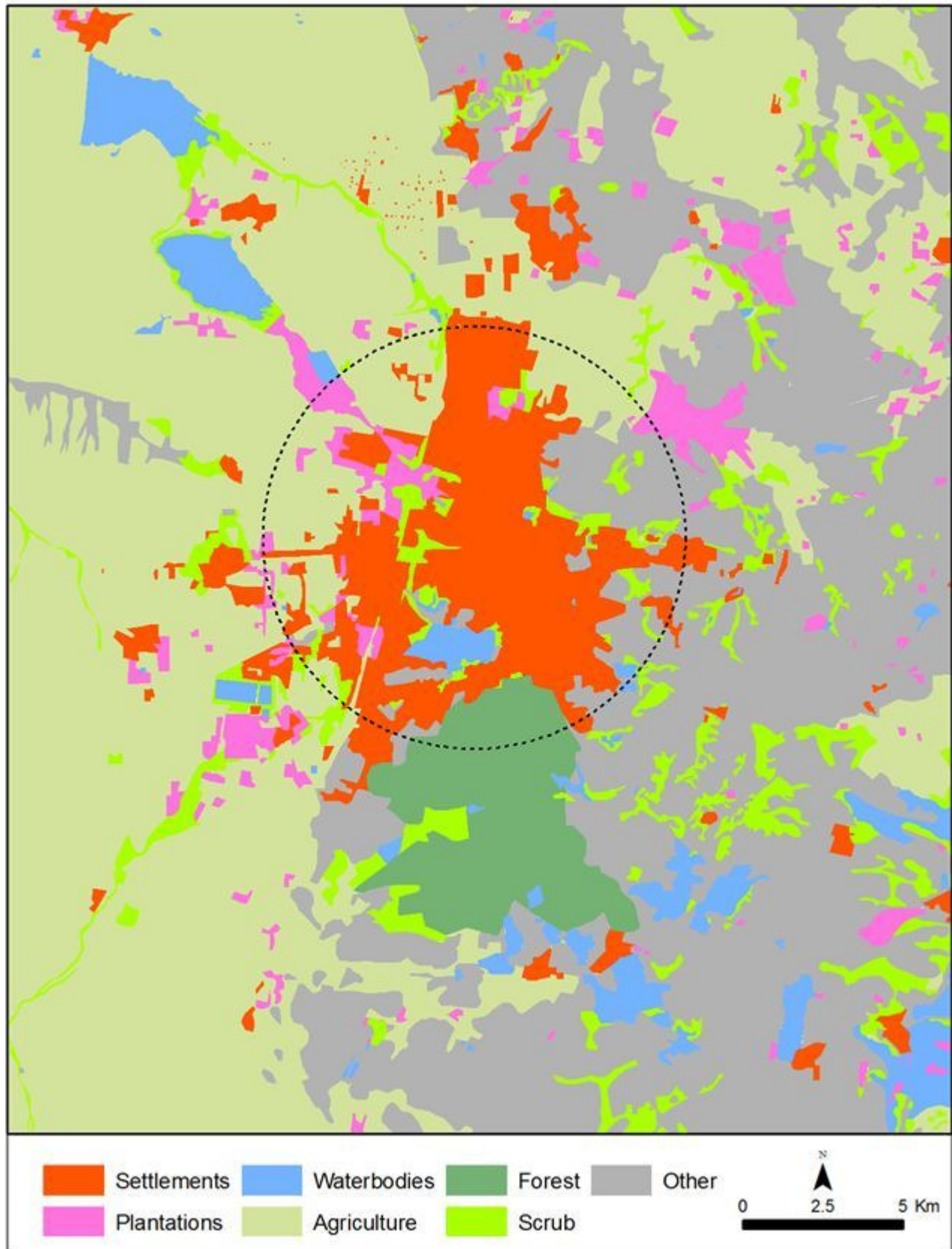
#### Agriculture

As mentioned earlier, agriculture is directly dependent on the extent of water resources spread. In Raichur, 47% of the agricultural land is irrigated by means of canals, tanks and lift irrigation (Figure 8), while the remaining 53% is irrigated by means of bore wells and dug wells.

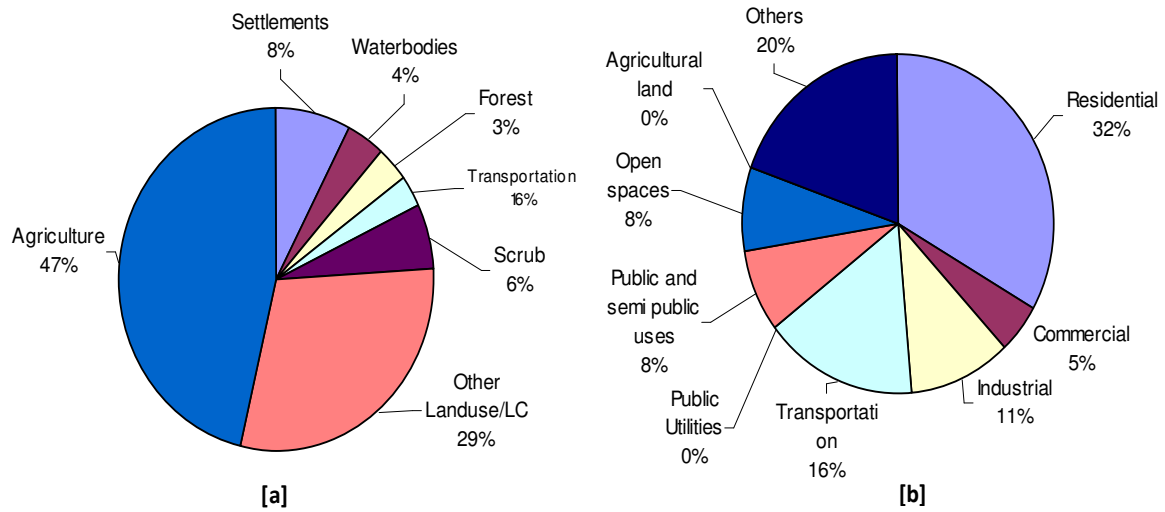
Earlier, oil seed crop was the main crop grown by farmers. Two decades ago, they switched to growing *Sona Masoori variety* of rice as the main crop. Also, cotton was grown in the areas where little or no irrigation was available. Linear regression analysis indicates that by 2021, nearly 27% of the agricultural land would be converted to settlements. Thus, agriculture and settlements would share almost an equal area.

#### Forest

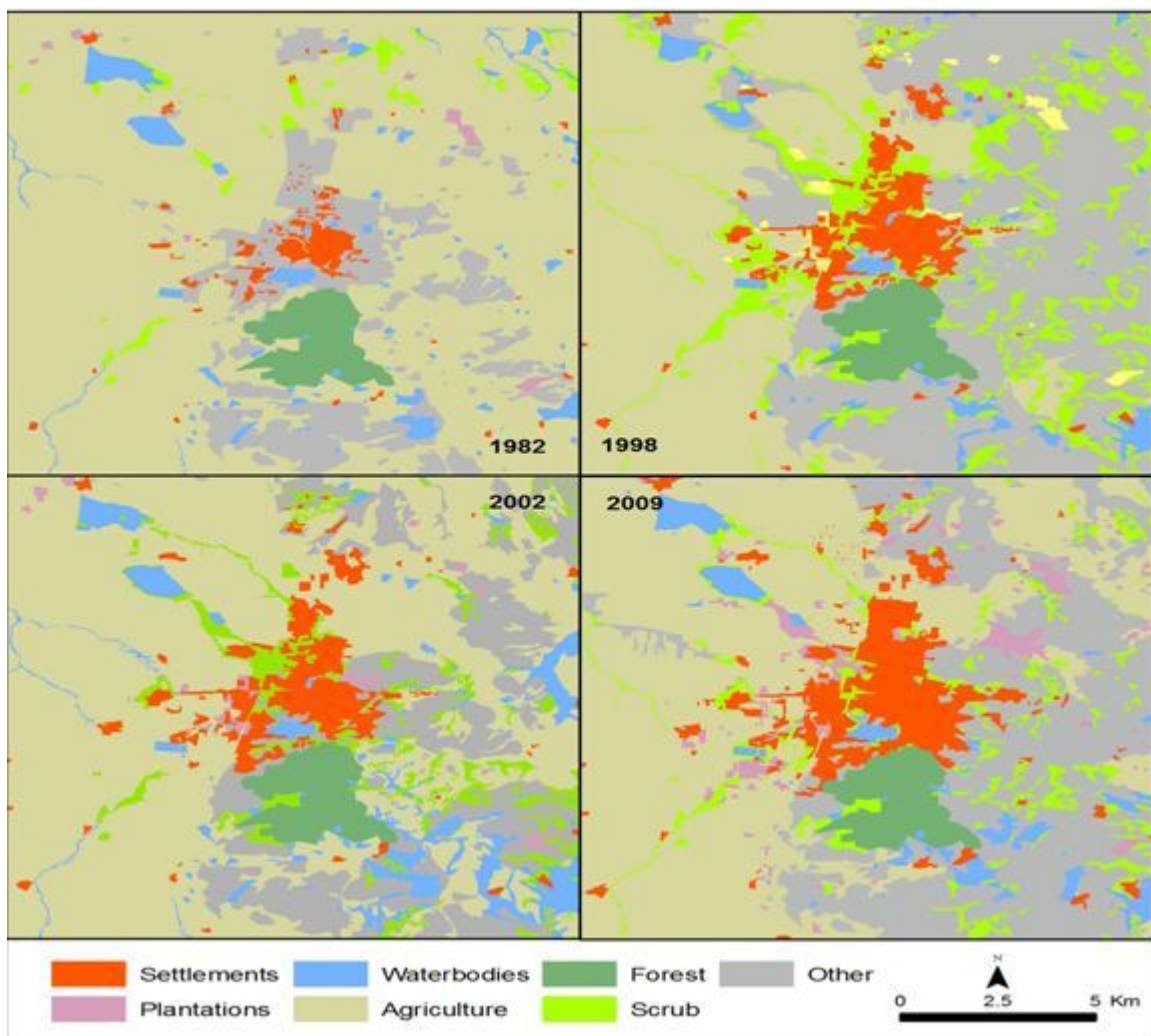
There is only one patch of the forest measuring 8.2 km<sup>2</sup>



**Figure 3.** Land-use and land-cover map of Raichur city, 2009. The dotted circle represents the core of Raichur City, which is the densest built-up area.



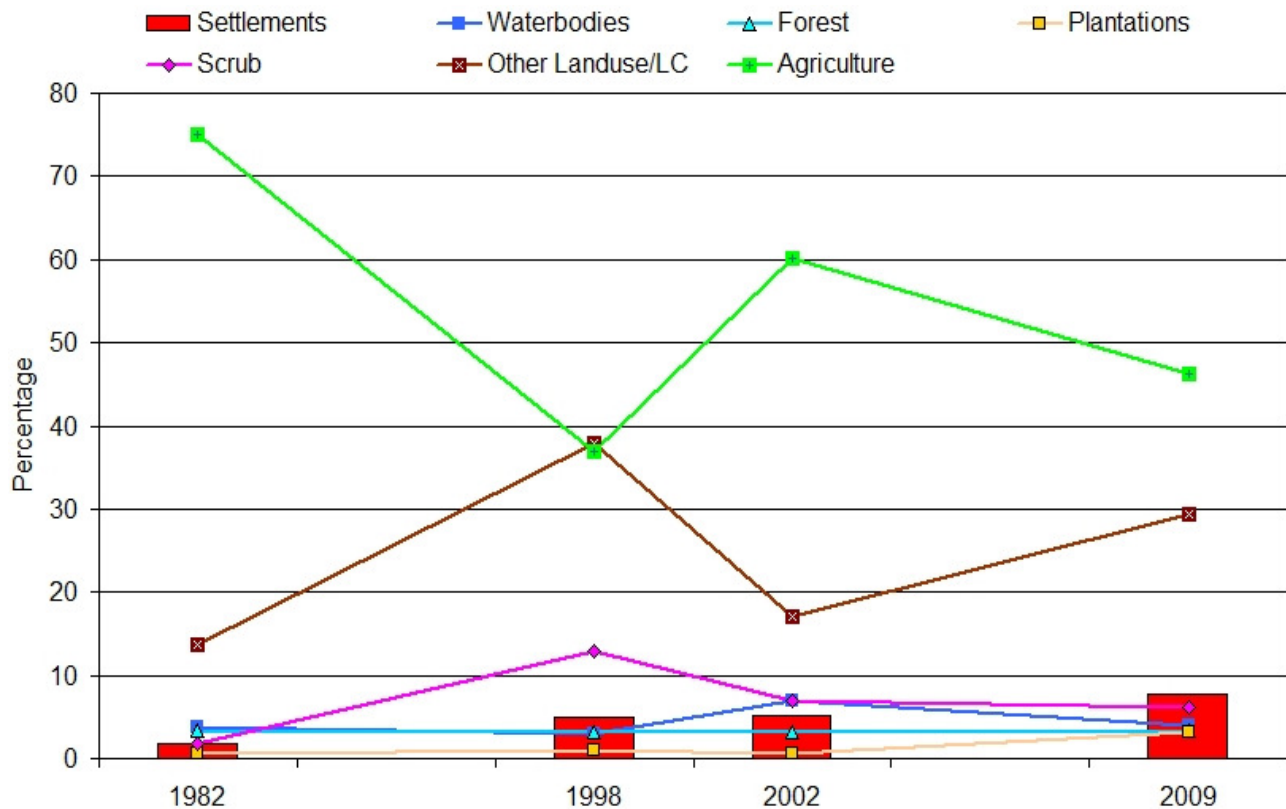
**Figure 4.** The pattern of land-use and land-cover during 2009. (a) Raichur and its surroundings (b) Within the limits of Raichur city.



**Figure 5.** Temporal change in the land-use / land-cover pattern for Raichur city.

**Table 2.** Regression statistics for Equation 1.

<b>Regression statistics</b>						
Multiple R = 0.999964069						
R Square = 0.999928139						
Adjusted R Square = 0.999856279						
Standard error = 0.088853464						
Observations = 3						
	df	SS	ANOVA MS	F	Significance F	
Regression	1	109.8565717	109.8565717	13914.81	0.005397	
Residual	1	0.007894938	0.007894938			
Total	2	109.8644667				
	Coefficients	Standard error	t Stat	P-value	Lower (95%)	Upper (95%)
Intercept	-7.823962616	0.178442143	-43.84593507	0.014517	-10.0913	-5.55665
pop	9.99975E-05	8.47716E-07	117.961058	0.005397	8.92E-05	0.000111



**Figure 6.** The temporal change in the land-use, land-cover pattern.

which is too close to the core of Raichur city. Surprisingly, since the last 29 years, there has been neither any encroachment nor addition to this category.

**Conclusions**

The present agrarian land-use of Raichur city is under

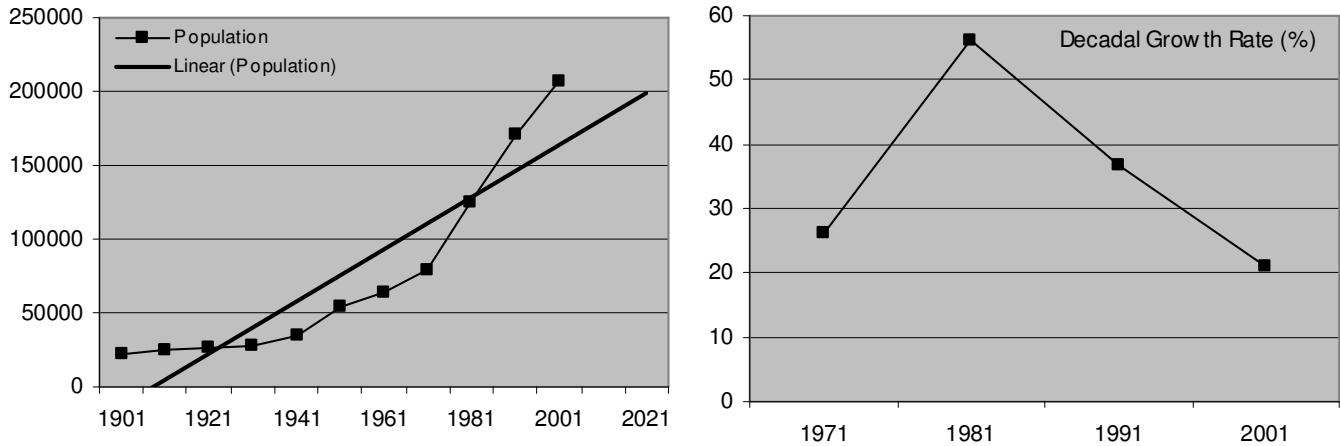


Figure 7. Population and decadal growth rate of Raichur city (Census of India).

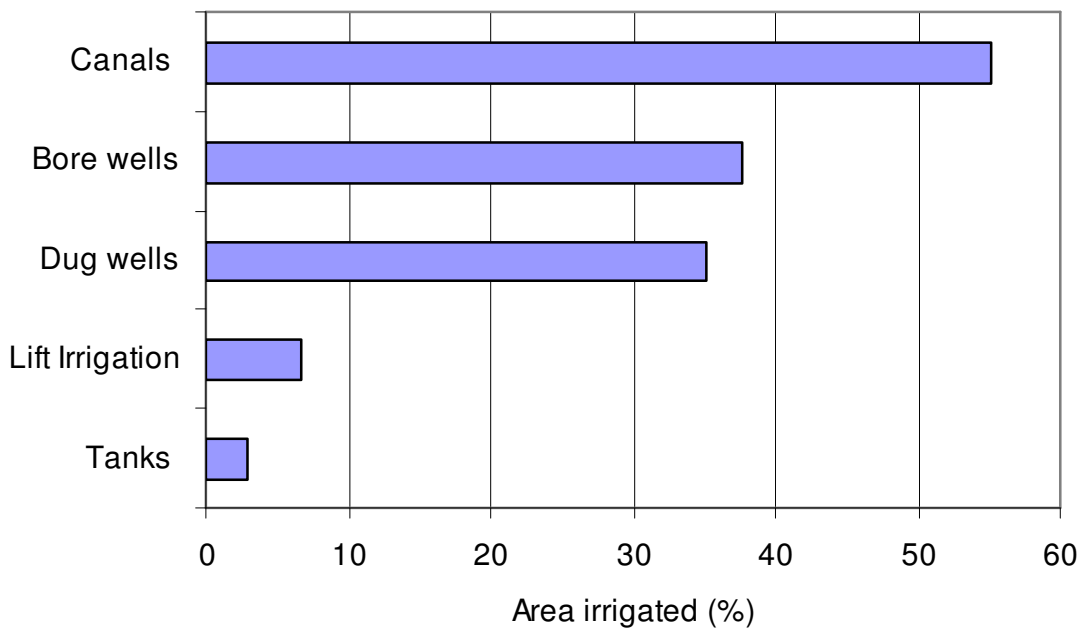


Figure 8. Typical pattern of the land irrigated through various sources.

imminent threat from the rapid and burgeoning urbanization. Considering the present trend, by 2021, nearly 27% of the agricultural land would be converted to settlements. Moreover, agriculture in this region depends on both the surface and ground water resources. The increasing urbanization would increase the demand of ground water which in turn would further impact the agriculture. Thus, it is imperative to formulate appropriate measures to check the haphazard growth of urbanization.

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