# A Statistical Approach to Urban Sprawling using RS & GIS - A Case Study of East District, Sikkim.

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## ABSTRACT

Rapid and unplanned industrialization along the low lying regions of East Sikkim has marked an irreversible adverse impact on the ecological, hydrological and geographical attributes. Urban sprawling leading to escalated encroachment is one of the prime factors contributing extensively to the changes environmental attributes are subjected to. It is therefore important to evaluate land coverage and utilization pattern so as to enable agencies to plan efficient mitigation strategies to contain its effect. Urban sprawling may be due to various factors such as inception of industrialization, ease of transportation and availability water sources etc.

The present study focuses on nature and pattern of sprawling linear as well as radial in east district of the state Sikkim by identifying the influential parameters responsible for it and to identify the locations subject to maximum changes and to devices method for forecasting direction of sprawling.

## Keywords

Sprawl, Sprawling, RS & GIS, Sikkim, radial, linear.

## 1. INTRODUCTION

Urban sprawl is dispersed development taking place along the landscape pattern. It could be either linear or radial. [5]. Development taking place along the drainage pattern or transportation channel is linear and development taking place around a specific location is radial.[3] Greater the advancement made to the networks of roads and its dimension greater will the prospects of business and industrialization linearly sprawling along the pattern and greater the concentration of business affairs at a particular location greater would be the prospect of radial sprawling centered at the location. So, urban sprawl is a consequence of both linear as well as radial urbanization.[1]

Spatial pattern of sprawl may vary with time due to changes brought to the factors affecting it,[10] so it is very important for us to monitor, map, assess and perform statistical analysis for the same. [6][7]

## 2. OBJECTIVE OF THE STUDY

The objective of this study is to

- identify the pattern of sprawling along the low lying area of the east Sikkim
- identify demographic changes
- perform statistical analysis to determine the degree of changes
- forecast the direction of sprawl

## 3. RELATED WORKS

Jianyong Cui et al. [1] has worked on Yutian Oasis and has proposed an approach using GPS enhancement classification precision as a basis for classifying landscape in order to increase the accurateness for analysis. Hannes Taubenböck et al. [2] proposed a holistic assessment of urban situations of Hyderabad taking into consideration a multi-scale view as well as interdisciplinary collaboration with the help of remote sensing for generation of upto date datastore. Peng Wenfu et al. [3] firstly categorized the landscape of Chengdu city into seven identifiable types such as built-up land, road land, vegetation land, crop land, water bodies, open land and then tried to identify the change induced upon the identified categories. Ab. Latif bin Ibrahim et al.[4] has carried out a work on Shiraz City taking into basis data from 1976 to 2005, Iran by firstly generating a DEM of the area of interest and then has applied supervised classification technique using maximum likelihood and then identified the degree diversion of sprawling Saravanan.P et al. [5] demonstrated urban expansion of Madurai city from 1991 to 2006 by identifying the temporal and spatial development patterns by using multitemporal remote sensing images. Prakasam.C[6] has analyzed the nature and extend of land use change in Kodaikanal Taluk in 40 from 1969=2008 and identifed potential factors causing changes in landuse pattern.
S.Prabaharan et al. [7] designed an approach for determining changes along the coastal region by classifying the satellite image and then performing post classification comparison of the imageries.Yusheng Shi et al. [8] proposed a method for determining sprawling in Shijiazhuang by combining gradient analysis and landscape metrics. Wan Li et al. [9] proposed an approach for extracting Landuse information for Beijing City by combining maximum likelihood classification (MLC) and neural network classification (NNC) method. Yu Cheng et al. [10] proposed a way for identifying change in landuse pattern of Baotou city using GPS, GIS.

# 4. STUDY AREA

Situated along the foot hills of the mighty Himalayan range Sikkim is a state of great diversity and prosperity. It is located between 27°04'46" and 28°07'48" north latitudes and 88°00'58" and 88°55'25" east longitudes. It has total geographical area of 7096 sq km. The entire landscape of the state is divided into four districts namely east, west, south and north.

The study is carried out taking into consideration east district of state Sikkim geographical location between 27°08´05″ – 27°25´24″ and 88°26´27″ - 88°55´06″ with an area of 964 Sq.km with district headquarters located at Gangtok. It has two subdivisions namely Gangtok and Pakyong with one hundred and twenty Revenue Block and three towns. The district has the highest density of population compared to that of the others districts. The region is sustained by three major drainage line namely Tista, Rangpo Chhu and Dik Chhu.

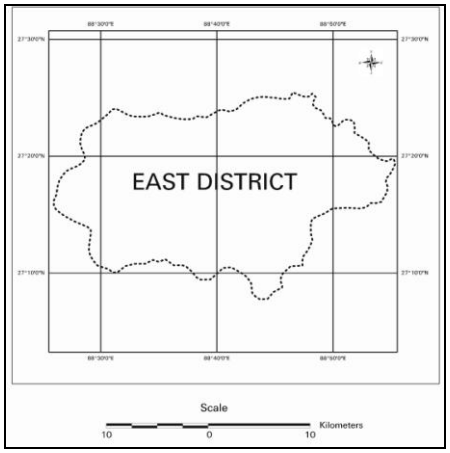



Figure 1: District boundary

# 5. DATA AND APPLICATION USED

- Four toposheets prepared with a scale of 1:150000 covering the four districts of state was used for creating the base map.
- IRS LISS III satellite images with a resolution of 23.5 meters for the year 2004, 2006, and 2008 were used for classification.
- Population statistics for the year 1981, 1991, and 2001 were used for analyzing population growth.
- Purpose specific thematic maps released by National Atlas and Thematic Mapping Organization were used for extracting the major transportation channels.
- The base map generation and the classification was done using the assistance ERDAS 9.4 tool kit by Leica Systems.

# 6. METHODOLOGY

## 6.1 Preparation of base map

*6.1.1 Registration of the topographic sheets:*

Registration of the topographic sheets and the thematic maps were done taking into consideration polynomial projection scheme and reference datum as Everest 1969. The registered topographic sheets were then mosaiced to create a map that contained the AOI (area of interest). The AOI was then extracted from the mosaiced image by creating its subset.

*6.1.2 Creation of thematic vectors:*

The thematic vector that were created for identifying,

- AOI.
- Drainage pattern covering the AOI along with their attributes.
- Transportation channels.
- Portion of the AOI subjected to sprawling.

## 6.2 Satellite image classification

The satellite images taken into consideration were from IRS LISS III with a resolution of 23.5 meters. Satellite images for the years 2006 and 2008 were taken into consideration for the study.

*6.2.1 Satellite image classification:*

The images were classified using supervised classification by specifying the signature values pertaining to the respective classes representing landuse type. The classification technique used was Maximum likelihood technique.

Maximum likelihood technique was selected because the sample size taken into consideration was large and the intensities in the specific classes were considered to be normally distributed.

*6.2.1 Map Generation:*

The classified images are then organized into maps for visual interpretation.

## 6.3 Calculation of population growth using predictive approach

*6.3.1 Calculate growth rate*

A percent growth rate is used to represent the growth or decline in population in a particular region.

$$G=(P_{present}-P_{past})/P_{past}*100 \quad (1)$$

$$AG=G/Interval \quad (2)$$

Where,

$P_{present}$ present population
$P_{past}$ past population
G growth rate
AG annual growth rate
Interval Time gap

*6.3.2 Calculation of population*

*6.3.2.1 Considering normal growth*

$$P_{present} = P_{past+} \; P_{past} * (G) \qquad (3)$$

$$= P_{past}(1+G) \qquad (4)$$

$P_{present}$ present population
$P_{past}$ past population
G growth rate

*6.3.2.2 Considering exponential growth*

$$P_{present} = P_{past*}e^{(AG*Interval)} \qquad (5)$$

$P_{present}$ present population
$P_{past}$ past population
G growth rate
AG annual growth rate
Interval Time gap
e Constant

## 6.4 Identification of Extend and trend of sprawling pattern

*6.4.1 Identification of linear sprawling*

Identification of sprawling along linear features such as roads and drainage system. In this step the base maps prepared that contains the rivers, roads and selected location in combination with process satellite image is analyzed to identify locations subjected to linear sprawling.

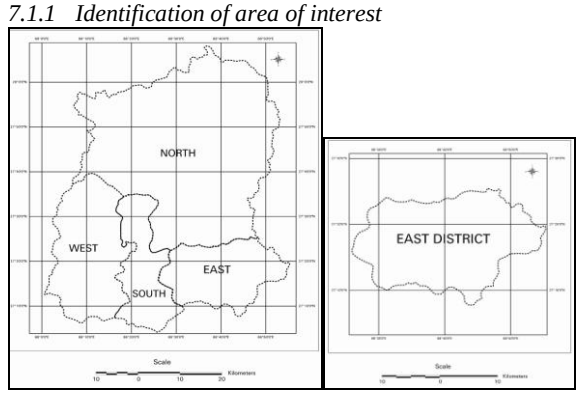
*6.4.2 Identification of radial sprawling*

Identification of sprawling with reference to a point or a location. In this step the base map prepared that selected location in combination with process satellite image is analyzed to identify locations subjected to linear sprawling.

# 7. RESULTS

## 7.1 Identification of AOI

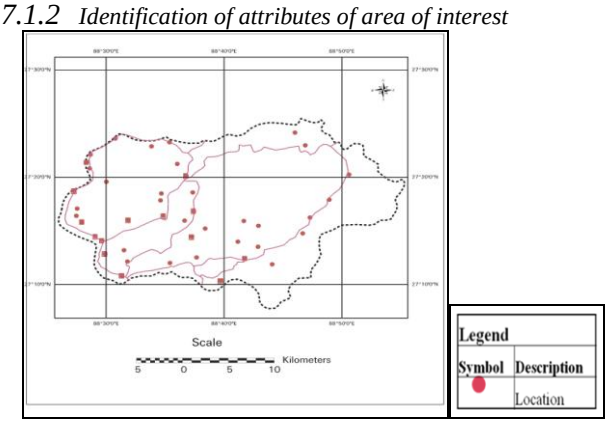
*7.1.1 Identification of area of interest*



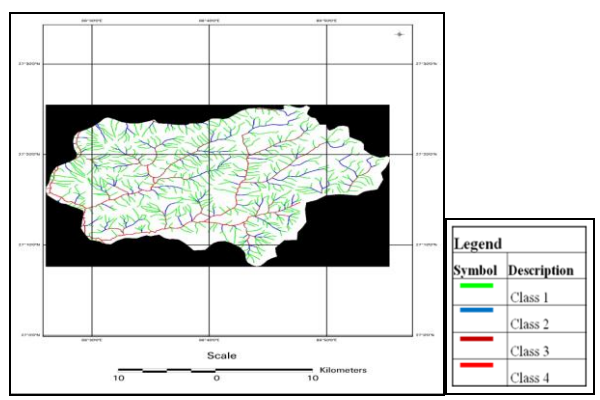

(a) (b)

Figure 1: (a) State boundary (b) District boundary

*7.1.2 Identification of attributes of area of interest*




(a)




(b)

Figure 2: Road and river channel between locations

*7.1.3 Identification of location subjected to sprawling*

There are fourteen locations selected for observation (Table I)

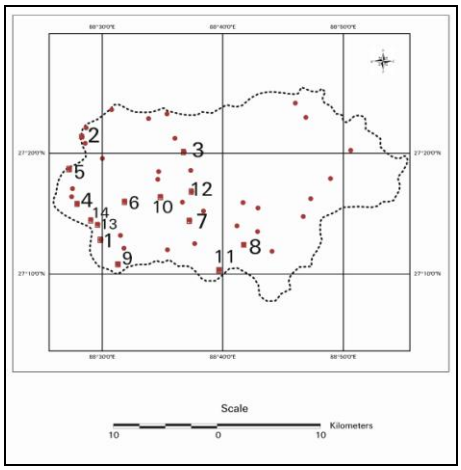



Figure 3: Identification of places which may be subjected to sprawling

Table I: Selection of location for sprawling

| | | | |
|---|---|---|---|
| 1 | Bardang | 8 | Rangli |
| 2 | Bazaar | 9 | Rangpo |
| 3 | Gangtok | 10 | Ranipool |
| 4 | Khandong | 11 | Rhenok |
| 5 | Mangkha | 12 | Saramsa |
| 6 | Martam | 13 | Singtam |
| 7 | Pakyong | 14 | Sirvani |

## 7.2 Satellite image classification

*7.2.1 Satellite image taken into consideration*

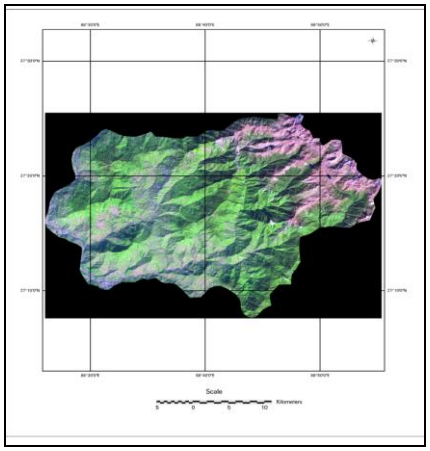


Figure 4: LISS III image of East Sikkim 2006

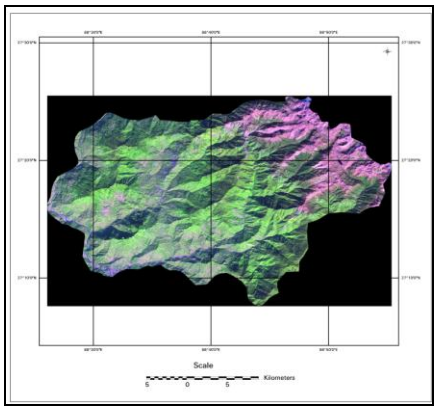



Figure 5: LISS III image of East Sikkim 2008

*7.2.2 Classification of satellite imagery*

Classification of satellite imageries were done using supervised classification based on maximum likelihood technique

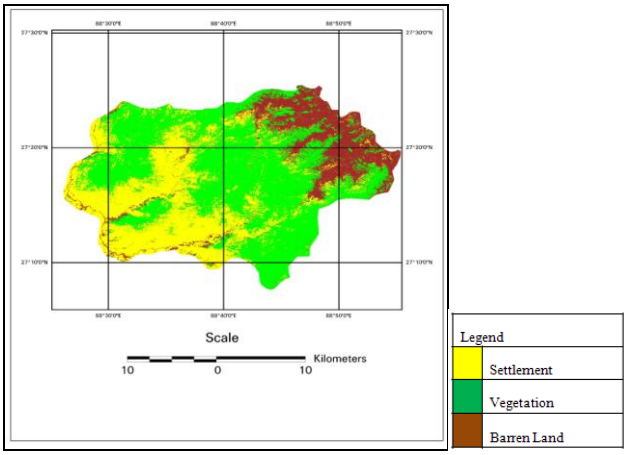



Figure 6: Classified image of LISS III image of East Sikkim 2006

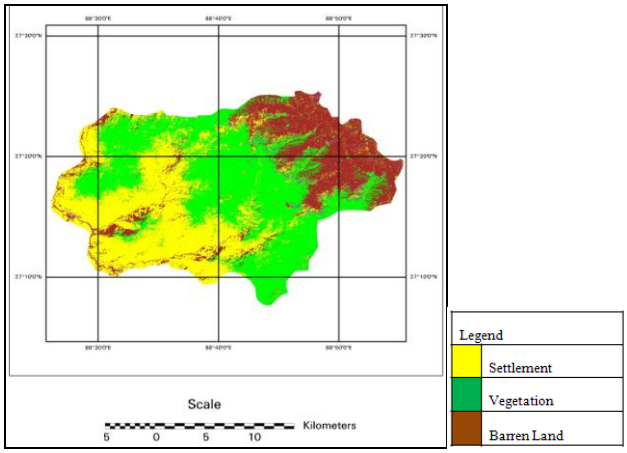



Figure 7: Classified image of LISS III image of East Sikkim 2008

*7.2.3 Identification if location stated in Table I in the satellite imagery.*

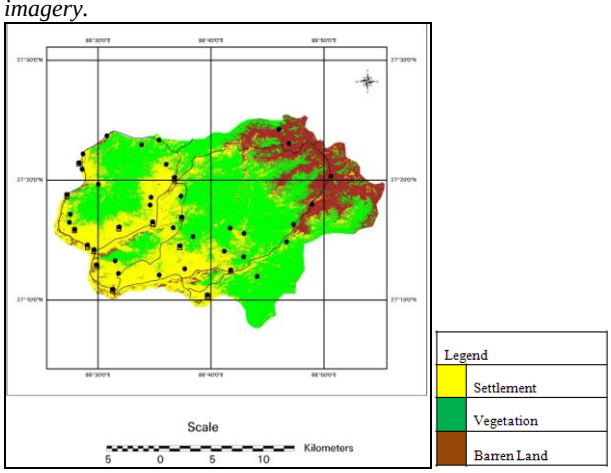



Figure 8: Classified image of LISS III image of East Sikkim with selected location in table I 2006

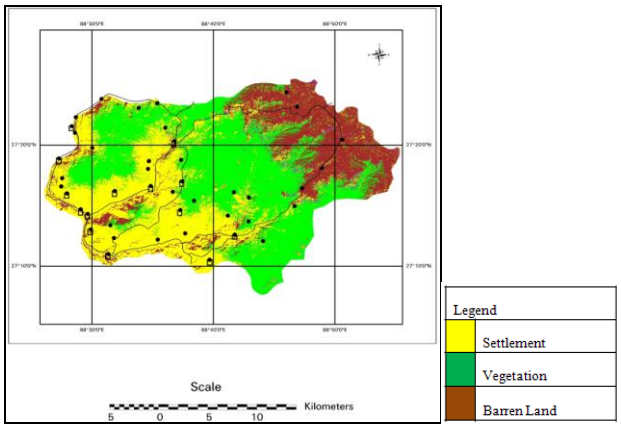



Figure 9: Classified image of LISS III image of East Sikkim with selected location in table I 2008

## 7.3 Calculation of population growth and Population

*7.3.1 Calculation of approximate population for entire Sikkim from 1951-2001(Table 3) taking into consideration the census data for 1981-2001 (Table 1) and the decadal growth rate (Table 2).*

Table 1: Population table 1981-2001(Source Census of India)

| YEAR | POPULATION |
|---|---|
| 1981 | 316385 |
| 1991 | 406457 |
| 2001 | 540507 |

Table 2: Growth rate 1951-2001

| DECADE | GROWTH RATE |
|---|---|
| 1951-61 | 17.8 |
| 1961-71 | 29.38 |
| 1971-81 | 50.77 |
| 1981-91 | 28.47 |
| 1991-2001 | 32.98 |

Table 3: Population from 1951-2001

| START YEAR | START POPULATION | GROWTH RATE | END YEAR | END POPULATION |
|---|---|---|---|---|
| 1951 | ***137686*** | ***17.8*** | ***1961*** | ***162194*** |
| 1961 | ***162194*** | ***29.38*** | ***1971*** | ***209846*** |
| 1971 | ***209846*** | 50.77 | 1981 | 316385 |
| 1981 | 316385 | 28.47 | 1991 | 406460 |
| 1991 | 406457 | 32.98 | 2001 | 540507 |

*7.3.2 Calculation of percentage contribution of east district to the entire population (Table 4)*

Table 4: Percentage Contribution by east district 1981-2001

| YEAR | EAST POPULATION | TOTAL | CONTRIBUTION |
|---|---|---|---|
| 1981 | ***138762*** | ***316385*** | ***0.44*** |
| 1991 | ***178452*** | ***406460*** | ***0.44*** |
| 2001 | ***245040*** | ***540507*** | ***0.45*** |

*7.3.3 Calculation of approximate population of east district by assigning average contribution to 1951-1971 into consideration average contribution (Table 5)*

Table 5: Estimated population for east district 1951-2001

| YEAR | EAST POPULATION | TOTAL | CONTRIBUTION |
|---|---|---|---|
| 1951 | ***60582*** | ***137686*** | ***0.44*** |
| 1961 | ***71365*** | ***162194*** | ***0.44*** |
| 1971 | ***92332*** | ***209846*** | ***0.44*** |
| 1981 | 138762 | 316385 | 0.44 |
| 1991 | 178452 | 406460 | 0.44 |
| 2001 | 245040 | 540507 | 0.45 |

*7.3.4 Calculation of approximate growth rate for 1951-1991 (Table 6)*

Table 6: Estimated growth rate for east district 1951-2001

| START YEAR | START POPULATION | GROWTH RATE | END YEAR | END POPULATION |
|---|---|---|---|---|
| ***1951*** | ***60582*** | ***0.18*** | ***1961*** | ***71365*** |
| ***1961*** | ***71365*** | ***0.29*** | ***1971*** | ***92332*** |
| ***1971*** | ***92332*** | ***0.50*** | ***1981*** | ***138762*** |
| ***1981*** | ***138762*** | ***0.29*** | ***1991*** | ***178452*** |
| ***1991*** | ***178452*** | ***0.37*** | ***2001*** | ***245040*** |

*7.3.4 Calculation of approximate population for 2010 into consideration (Table 6) using simple moving average (Table 7)*

Table 7: Estimated population for east district using simple moving average 1951-2010

| START YEAR | START POPULATION | GROWTH RATE | END YEAR | END POPULATION |
|---|---|---|---|---|
| ***1951*** | ***60582*** | ***0.18*** | ***1961*** | ***71365*** |
| ***1961*** | ***71365*** | ***0.29*** | ***1971*** | ***92332*** |
| ***1971*** | ***92332*** | ***0.50*** | ***1981*** | ***138762*** |
| ***1981*** | ***138762*** | ***0.29*** | ***1991*** | ***178452*** |
| ***1991*** | ***178452*** | ***0.37*** | ***2001*** | ***245040*** |
| ***2001*** | ***245040*** | ***0.33*** | ***2010*** | ***325111*** |

*7.3.5 Calculation of approximate population for 2010 into consideration (Table 6) using exponential growth (Table 8)*

Table 8: Estimated population for east district using exponential growth 1951-2010

| START YEAR | START POPULATION | GROWTH RATE | END YEAR | END POPULATION |
|---|---|---|---|---|
| ***1951*** | ***60582*** | ***0.18*** | ***1961*** | ***71365*** |
| ***1961*** | ***71365*** | ***0.29*** | ***1971*** | ***92332*** |
| ***1971*** | ***92332*** | ***0.50*** | ***1981*** | ***138762*** |
| ***1981*** | ***138762*** | ***0.29*** | ***1991*** | ***178452*** |
| ***1991*** | ***178452*** | ***0.37*** | ***2001*** | ***245040*** |
| ***2001*** | ***245040*** | ***0.33*** | ***2010*** | ***340843*** |

## 7.4 Identification of type and direction of sprawling

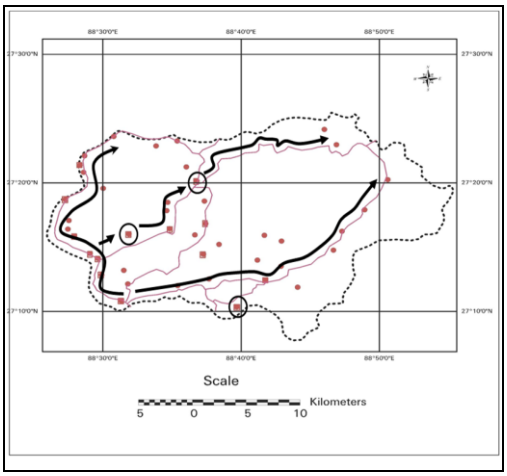



Figure 10: Image representing linear and radial sprawling

The circles in the image (Figure 10) represents the location by which radial sprawling is observed and the directed lines represents the linear sprawling along the road pattern and the direction represents the direction of sprawling. Radial sprawling has been observed around vertex 3, 6, 11 representing Gangtok, Martam and Rhenok. Linear sprawling has been observer around 1, 2, 4, 5, 7, 8, 9, 10, 12, and 13.

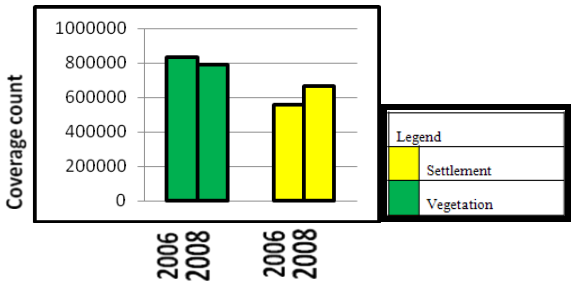



Figure 11: Graph Showing vegetation and settlement coverage of 2006 and 2008 obtained after classification.

## 8. CONCLUSION

This paper demonstrates the parameters that can be taken as a scientific basis for identifying the types and direction of sprawling. It shows the urban expansion taking place in the east district of state Sikkim by using satellite imagery and GIS application tools.

The paper tries to determine,

- The location subjected to linear and radial sprawling along the fourteen locations selected for study and direction of sprawling.
- The population, taking into consideration the growth rate observed, using simple moving average and exponential growth technique.

The percentage coverage of landscape by sprawling can be calculated by taking into consideration the,

- Circle function and the resolution for radial sprawling
- irregular rectangle function for linear sprawling

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