

URBAN SPRAWL MAPPING AND LAND USE CHANGE ANALYSIS USING REMOTE SENSING AND GIS

(CASE STUDY OF BHUBANESWAR CITY, ORISSA)

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ABSTRACT

This project examines the use of Remote Sensing and GIS in mapping of urban sprawl (1930-2005) and landuse /landcover change detection (A case study of Bhubaneswar, 2000-2005). So as to detect changes that has been taken place in this status between these periods. Subsequently, an attempt was made at projecting the observed urban built-up and population between 1930 - 2005. It is also observed that changes by 2031 may likely follow the trend in 1930 to 2005.

KEY WORDS: Remote Sensing, Geographical Information System (GIS), Urban Sprawl, Land Use Change Detection, Prediction of Population and Urban area growth.

INTRODUCTION

The landuse/land cover pattern of a region is an outcome of natural and socio-economic factors and their utilization by man in time and space. The terms “land use” and “land cover” are often used simultaneously to describe maps that provide information about the types of features found on the earth’s surface is called as land cover and the human activity that is associate with them. Land cover is an important input parameter for a number of agricultural hydrological and ecological model, which constitute necessary tools for development planning and management of natural resources in the territory. In order to use the land optimally and to provide as input data in modeling studies, it is not only necessary to have information on existing land use/ landcover but also the capability to monitor the dynamics of land use resulting out of changing demands. If the site is small and easily accessible a suitable land cover may be based on ground observation and surveys. However such methods are quickly become less feasible, if the site is large or difficult to access. Toposheets may be useful for reference but are generally outdated and too coarse for detailed analysis. With the improvement in software and hardware and decrease in the cost of imagery, satellite remote sensing is being used for more and more studies particularly at the landscape level.

Remote sensing and GIS are now providing new tools for advanced ecosystem management. The collection of remotely sensed data facilitates the synoptic analysis of earth’s system function patterning and change at local, regional and global scales. Overtime such data also provide an important link between intensive localized ecological research and regional, national and international conservation and management of biological diversity.(Willkie and Finn,1996).

Therefore at attempt will be made in this study to map out the status of land use/ land cover of the Bhubaneswar between 2000 and 2005 with a view to detecting the land consumption rate and the changes that has taken place in this status particularly in their built-up land. So as to predict possible changes that might take place in this status in the next 21 years using both Geographic information system and Remote Sensing data. The characterization of land cover from satellite data has conventionally provided a means of accessing a large geographical area with limited time and resources. However, satellite images do not record land cover directly rather they measure the nature and strength of solar energy being reflected from each small area or pixel of the scene. The amount of multispectral energy in multi wavelengths depends on the type of material at the earth’s surface. And the objective is to associate particular land cover with each of these reflected energies. This is generally achieved using either visual or digital interpretation methods. In this study, we demonstrate how satellite

imagery can be displayed and manipulate and analyzed using digital techniques in a popular digital image processing software programme Erdas Imagine 9.1 and GIS software ArcGis9.2.

AIMS AND OBJECTIVES:

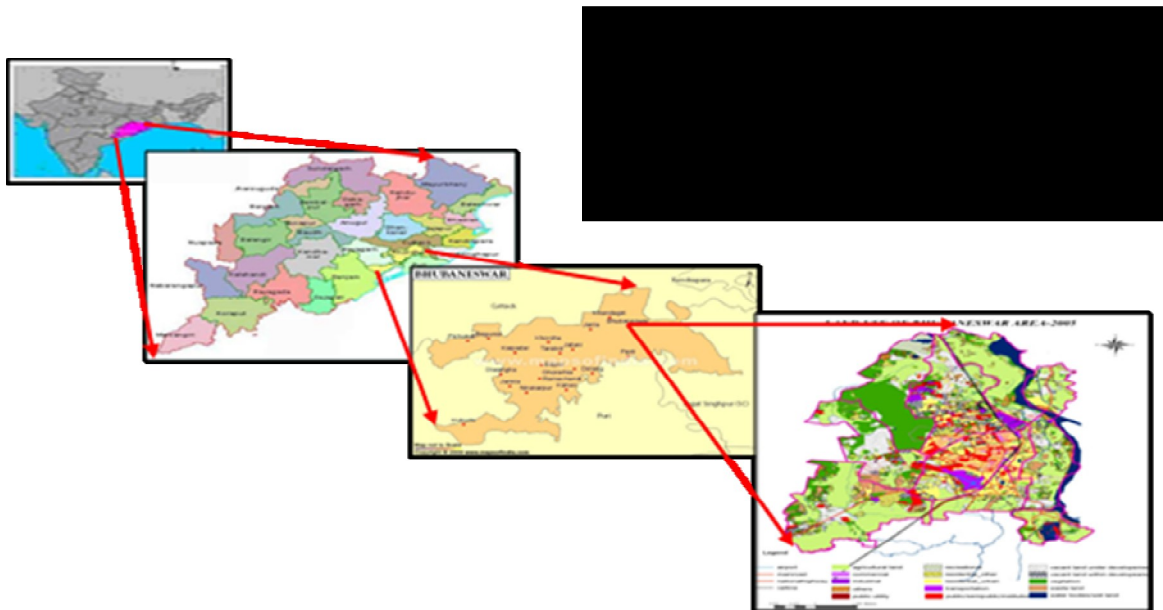
The **aims** of the this study is to produce a land use/ land cover map of Bhubaneswar at different year in order to detect changes that have taken place particularly in the built-up land and subsequently in the built-up land and subsequently to analyze the urban sprawl of the different time period and to predict the population growth and urban area growth in the same over a given period(1930-2031).

The **objectives** of the study is

- To analyze the urban sprawl of Bhubaneswar city.
- To monitor urban land use land cover change between2000-2005.
- To predict population and urban area growth for future.(1930-2030).

STUDY AREA:

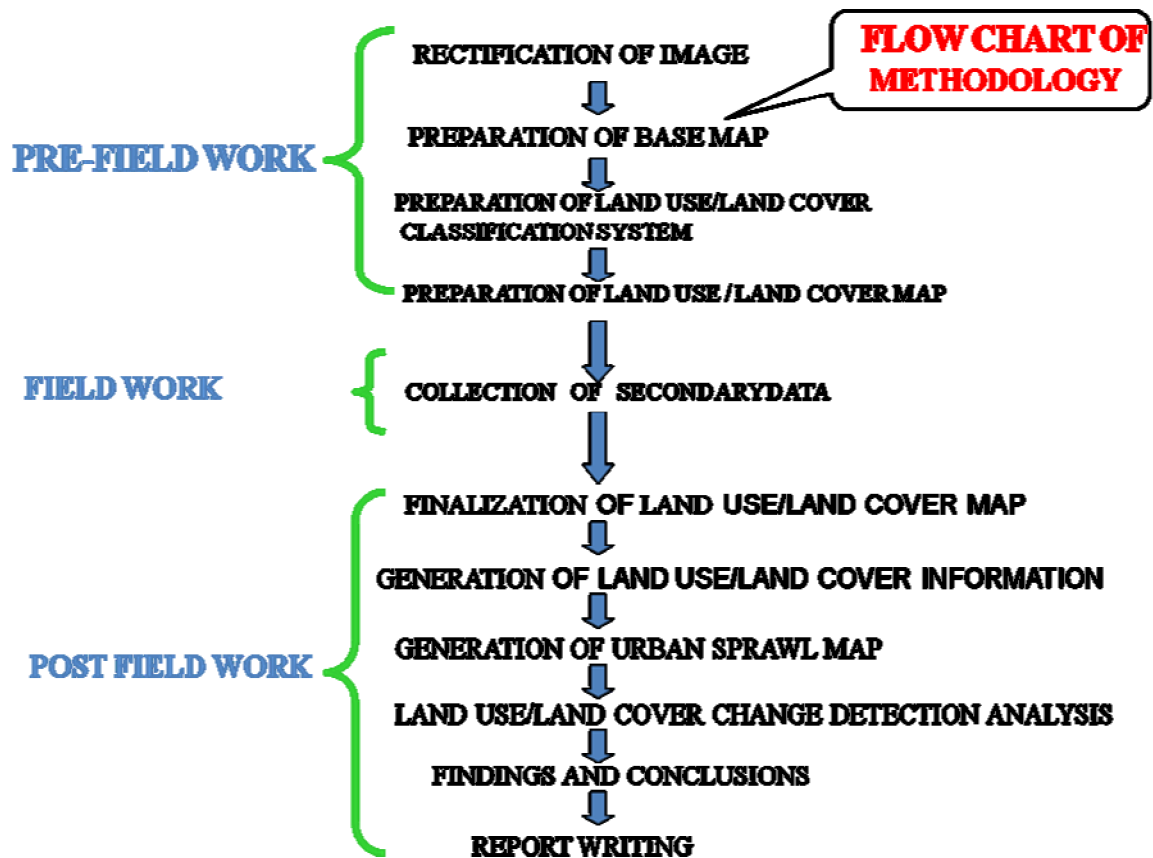
Bhubaneswar is located in the Khurda district of the state Orissa between 20°12'00"N to 20°23'00"N latitude and 85°44'00"E to 85°54'00"E longitude on the western fringe of the coastal plain across the main axis of the Eastern Ghats. It is situated on the Howrah -Chennai main south Eastern Railway line at 435km from Howrah and 1215km from Chennai and the National Highway no.5 connecting Kolkatta and Chennai passes through the city. The city lies to the western side of the "Mahanadi Delta" on the bank of the river Kuakhai, distributaries of river Mahanadi and 30 kms. South west of Cuttack city. The river Daya which has branched off from Kuakhai flows along the south eastern part of the city.



DATA USED AND METHODOLOGY:

Before committing to a data source and analysis strategy, we first need to define the scale, coverage and type of the data required. In this study, we need satellite data obtained from Liss-III imagery of 1997 and 2000 PAN, sensors carried by IRS-1D satellites data, Cartosat-1 image of Nov-2005. and toposheets of Bhubaneswar and its surrounding area on 1:50,000 scales numbered 73h/12,73h/13,73h/14,73h/15,73h/16 and other secondary Data.

The entire project work is divided in to following methodology.



LAND USE/LAND COVER CLASSIFICATION SYSTEM:

In the present study, a very detailed classification system is being adopted for mapping using large scale aerial photographs and high resolution satellite data. There are different classification schemes that are being adopted in the country today. In the present study the preliminary classification was conceptualized and design with the help of some secondary data. After that, the classification system was modified and designed keeping in mind the objective of the study and proposed methodology of the data processing and analysis. A detailed classification systems being developed for mapping using Bhubaneswar existing map and high resolution satellite data. However, the details of each class and their operational definition are described as below.

1. Residential urban
2. Residential other
3. Commercial
4. Industrial
5. Public/Semipublic/Institution
6. Public utility
7. Transportation
8. Recreational
9. Agricultural land
10. Vegetation/Forest land
11. Vacant land within developed area
12. Vacant land under development
13. Waste land
14. Water bodies/wet land
15. Others.

RESIDENTIAL: This includes land, which provides living space within and around buildings or houses to meet the daily needs of the families of different sizes and composition. This area is predominantly identified for the purpose of living accommodation. These areas are developed according to some plan or devoid of any plan. The following are two types of residential area.

Residential urban: Residential urban refers to those residences which are found mainly urban areas. These are homogeneous residential units mainly used for living purposes with a regular network of road pattern.

Residential other: Residential other refers to those residences which are found mainly fringe area. Compact cluster of dwelling units is found outside the main urban built-up area surrounded by agricultural land. These areas are generally unplanned and characterized by irregular layout.

COMMERCIAL: Commercial areas are those built-up land with non residential use and broadly classified in to some kind of business transaction. It includes wholesale market, retail trade, shopping complexes and other commercial activities but not related to the manufacturing industry. Commercial activities have inter relationships with storage functions.

INDUSTRIAL: Industrial areas include a wide array of land uses from light manufacturing to heavy manufacturing plants.

PUBLIC/SEMIPUBLIC/INSTITUTION: This class generally includes built up land use constructed purposefully as working place for government, semi government, private sector offices, and educational institutions, the built-up land predominantly under public authority utilized for providing basic amenities and service.

TRANSPORTATION: The land use included in the transportation, communications occurs to some degree within built up categories and actually can be found within many other categories. Roads, bus station, bus depots and workshops, railways, railway station and yard are covered in this category. The following are some classes of transport/communication.

- **National highway**
- **Main roads**
- **Railway**

RECREATIONAL: Areas within urban environment generally used for active and passive recreation purposes are being considered to put under this category. These are generally parks, gardens, play grounds etc.

AGRICULTURAL LAND: Agricultural land may be defined broadly as land used primarily for production of food and fiber. It is the land primarily used for production of food and fiber. It includes crop land, agricultural form and fallow lands.

VEGETATION/FOREST LAND: Forest lands have a tree-crown area density of 10 percentages or more are stocked with trees capable of producing timber or other wood products and extract an influence on the climate or water regime. The land under natural vegetation, tree cover with good canopy cover, it includes all agricultural plantation and forest plantation.

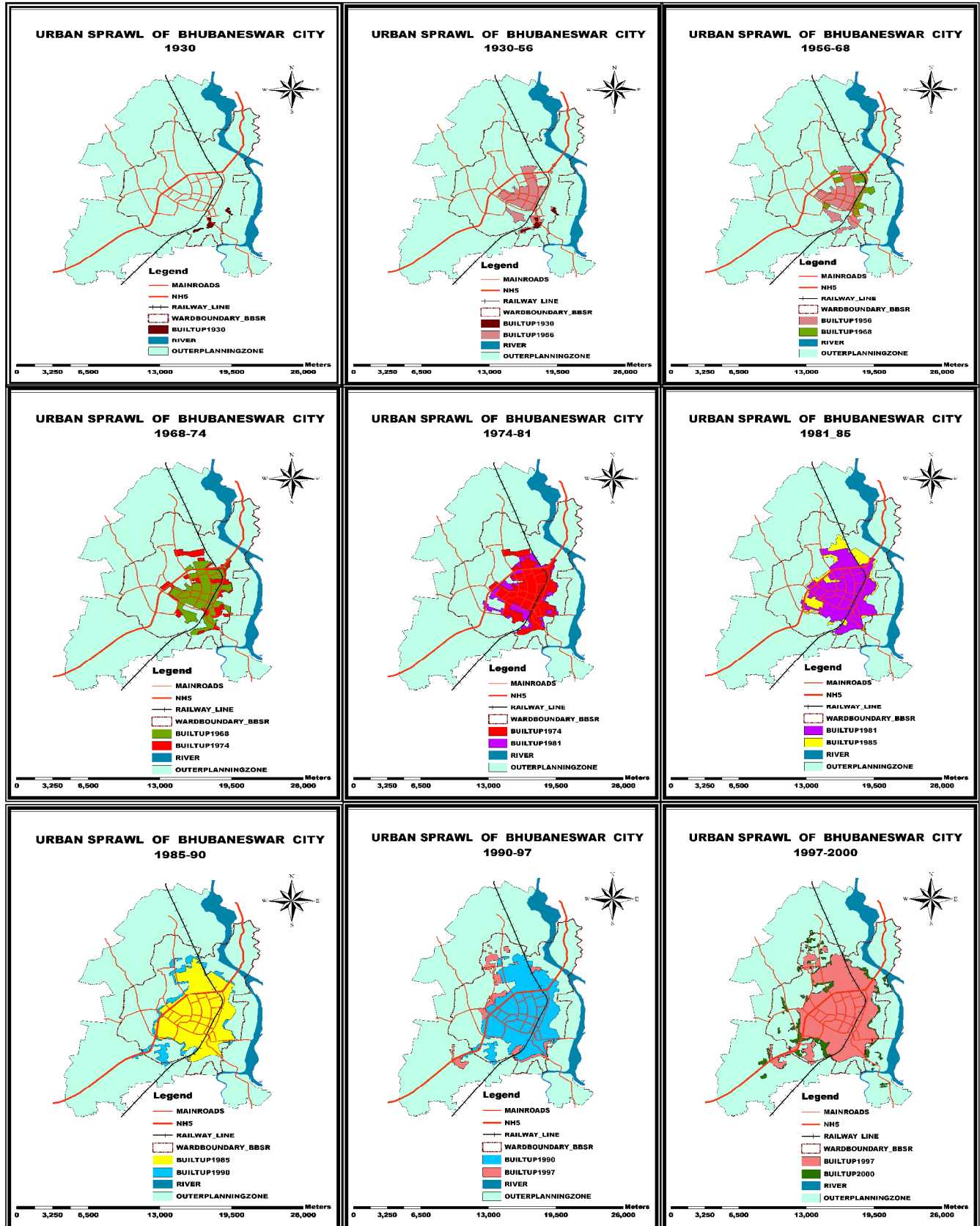
VACANT LAND: Vacant land is a non- built up land without any land use activity or land cover. These are mainly barren devoid of trees/bushes/scrub and may be found within or outside the urban built up area. Mainly two types of vacant lands are observed in the study area. First category is vacant land within development and second is vacant land under development.

WASTE LAND: Wastelands are those lands which are presently not being used to their optimum potential due to some constraints.

WATER BODIES/WET LAND: The delineation of water areas depends on the scale of data presentation and resolution characteristics of remote sensor data used for interpretation of land use and land cover. The land which covered with natural drainage system like rivers, streams as well as manmade features classified like tanks, ponds, canals, etc.

OTHERS: It includes the lands like restricted area, disused brick kilns, fallow land etc.

URBAN SPRAWL: The increase population and rapid urbanization causes great change in the centre of the city and the problem of the expansion of the city center is complicated by the fact that, its must take place within the built-up area which is not possible. Thus the pressures of the continuous growing city center gradually change the surrounding environment and neighborhoods. **Sprawl** generally refers to some type of development with impacts such as loss of agricultural land, open space, and ecologically sensitive habitats. In simpler words, as population increases in an area or a city expands to accommodate the growth; this expansion is considered as sprawl. Usually sprawls take place on the urban fringe, at the edge of an urban area or along the highways. The following maps are showing the urban sprawl from 1930-2005. (Fig.1, 2, 3, 4, 5, 6, 7, 8, 9)



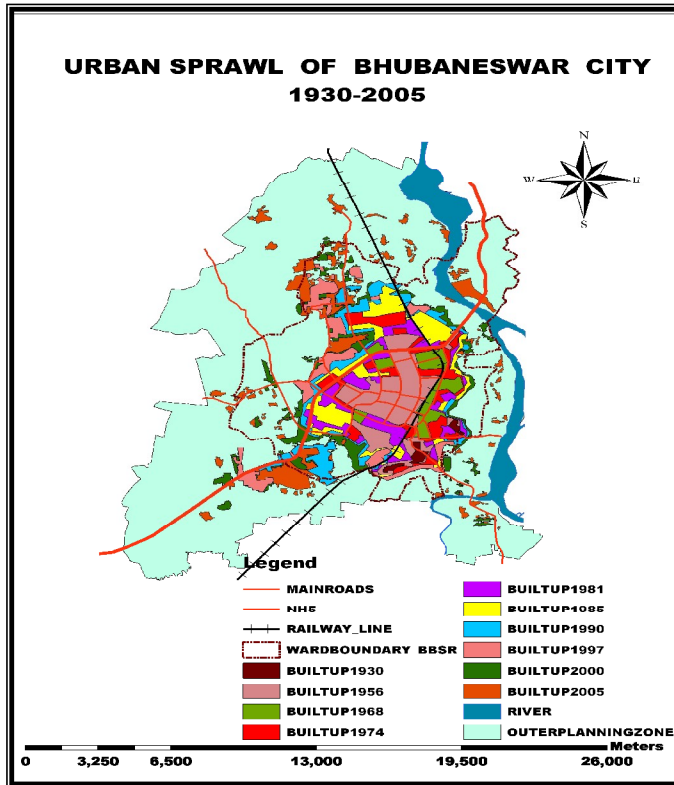


Fig. 10

The land use/land cover maps were prepared for the year 2000 and 2005. These two maps were then overlaid to find the land use/land cover change for year 2000-2005. (refer table) the amount of land use change from agricultural and forest to other land uses were found.

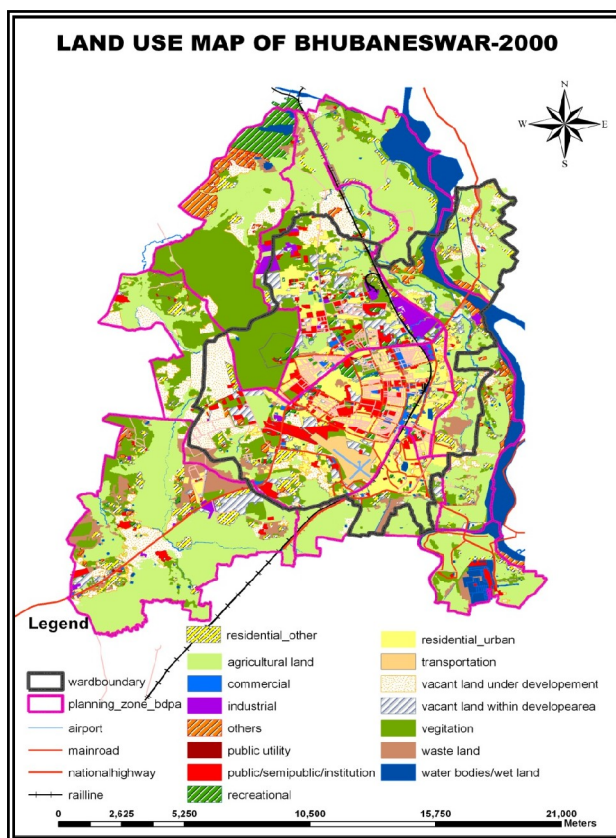


Fig.11

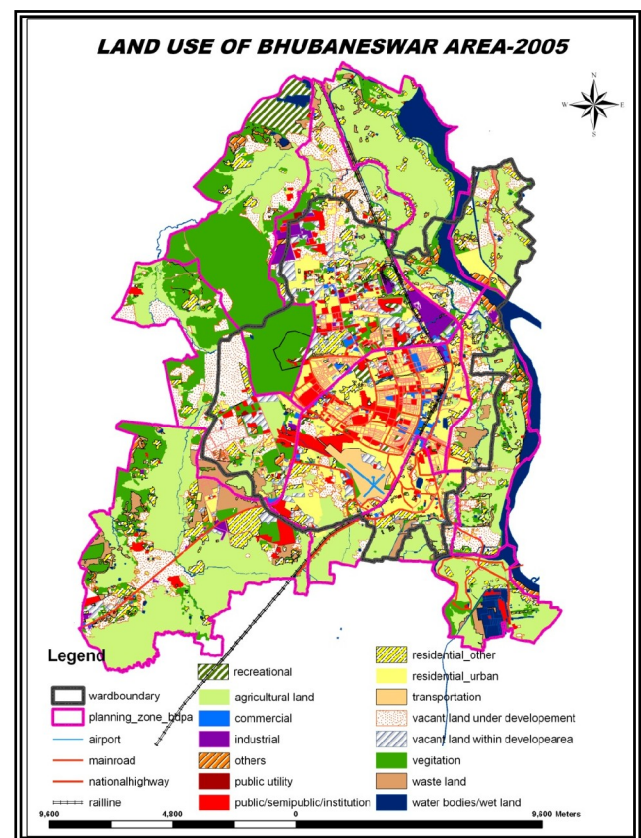
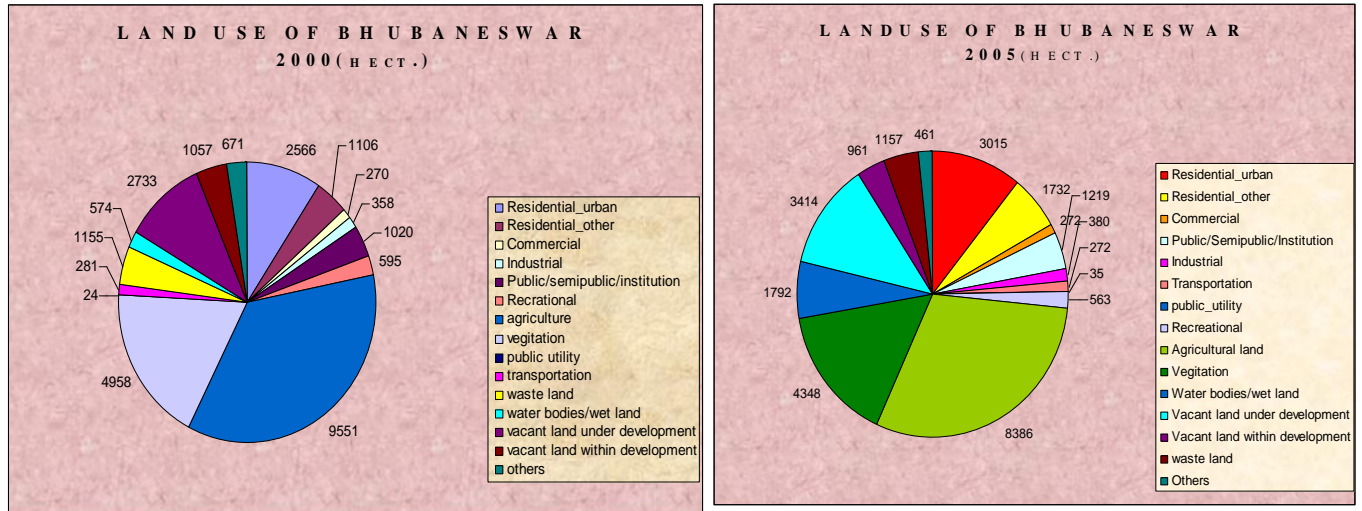


Fig.12

LAND USE/ LAND COVER CHANGE:

Bhubaneswar today, is one of the fast growing cities in India, the land use of the city over a period from 1998-2005 showed tremendous rises in the built-up-form from agricultural area, vegetation and vacant land. The city today has its centre at the core areas. Although, the city initially evolved in rectangular shape on a grid iron pattern outward from the centre. Now it is growing largely towards north, northwest and southwest direction along the main transport routes. The road structure of the city has not involved to cater the changing pattern in the city and the cater its functions. There were ample agriculture and vegetation land in outside the urban area. In this period of time industrial and residential areas were dominantly expanded.

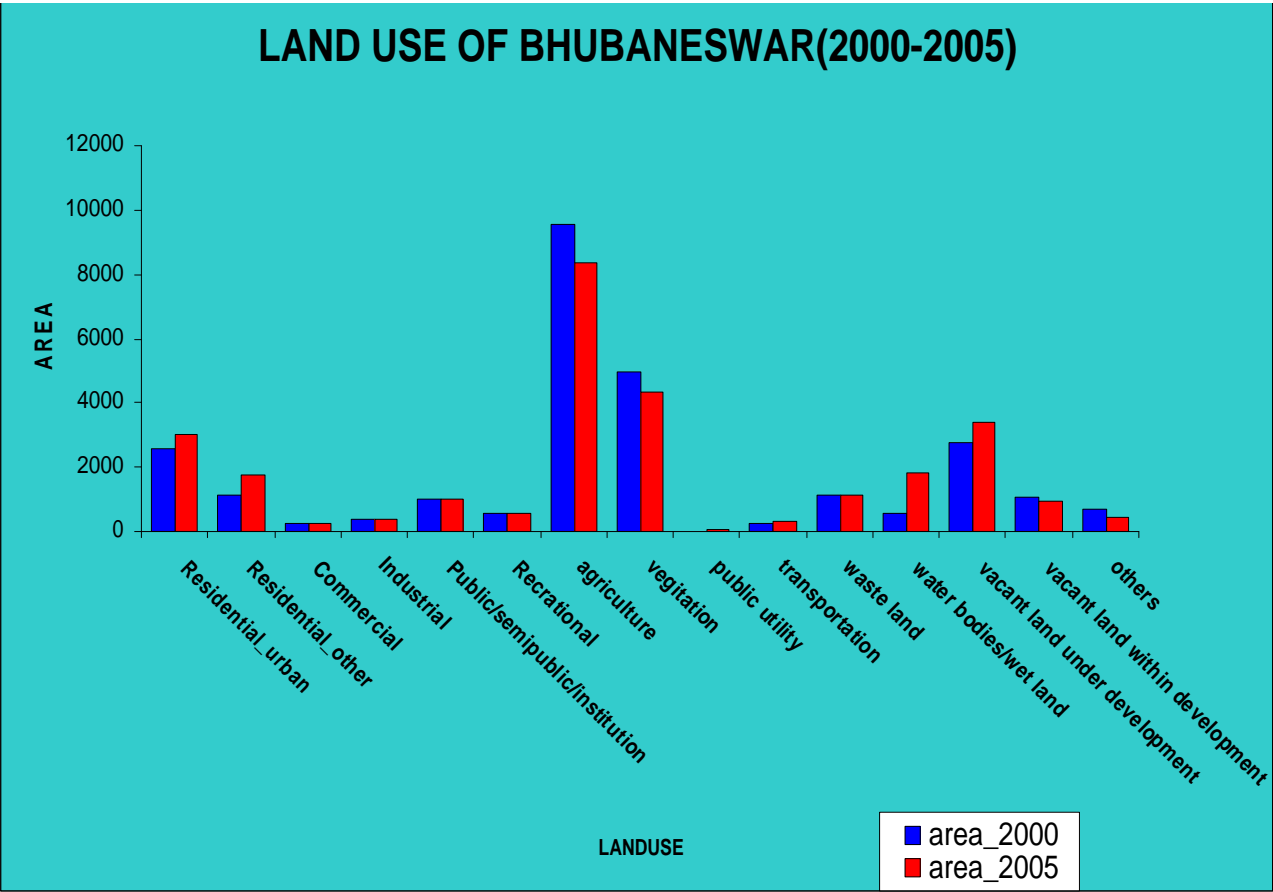
Pie chart of above maps:



Table—1: DIFFERENCE LAND USE BETWEEN YEAR 2000 AND 2005:

LANDUSE	AREA (IN HECT.)2000	AREA (IN HECT.)2005
Residential Urban	2566	3015
Residential Rural	1106	1732
Commercial	270	272
Industrial	358	380
Public/semi public/institutions	1020	1219
Recreational	595	563
Agriculture	9551	8386
Vegetation	4958	4348
Public utility	24	35
Transportation	281	272
Wasteland	1155	1157
Water bodies/wet land	574	1792
Vacant land under development	2733	3414
Vacant land within development	1057	961
Others	671	461

The following Bar diagram is shows the difference between Land use of Bhubaneswar (2000-2005).



LAND USE CHANGE FROM AGRICULTURE AND VEGETATION TO URBAN AREA:

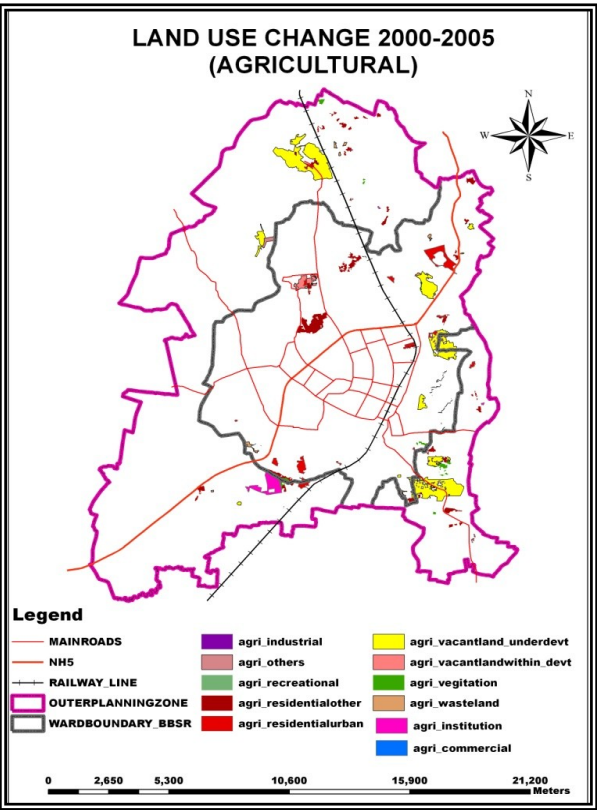


Fig 13

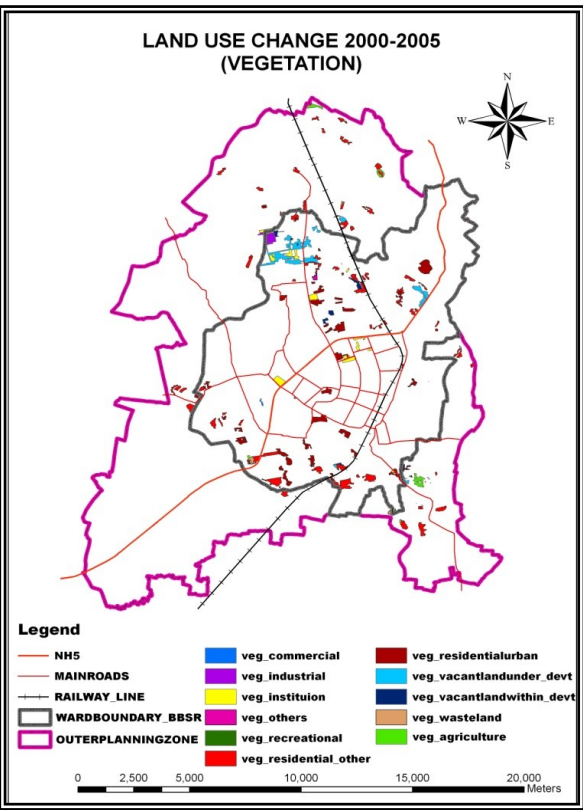


Fig 14

Table—2: LANDUSE CHANGE FROM VEGETATION TO OTHER CATEGORY (2000-2005):

LAND USE CHANGE CATEGORY	AREA IN HECT.	% CHANGE
FOREST-RESIDENTIAL URBAN	241	27.3
FOREST -RESIDENTIAL OTHER	317	36
FOREST - INSTITUTION	78	9
FOREST -VACANT LAND UNDERDEVELOPMENT	136	15.4
FOREST -VACANTLAND WITHINDEVELOPMENT	29	3.2
A FOREST - WASTELAND	10	1.1
FOREST -INDUSTRIAL	23	2.7
FOREST-COMMERCIAL	2	0.2
FOREST-AGRICULTURAL	39	4.4
FOREST -OTHERS	5	0.5
TOTAL	880	100

Table—3: LANDUSE CHANGE FROM AGRICULTURE TO OTHER CATEGORY (2000-2005):

LAND USE CHANGE CATEGORY	AREA IN HECT.	% CHANGE
AGRICULTURE-RESIDENTIAL URBAN	139	12.8
AGRICULTURE-RESIDENTIAL OTHER	214	19.6
AGRICULTURE- INSTITUTION	70	6.3
AGRICULTURE-VACANT LAND UNDERDEVELOPMENT	602	55.02
AGRICULTURE-VACANTLAND WITHINDEVELOPMENT	36	3.2
AGRICULTURE- WASTELAND	21	2
AGRICULTURE-INDUSTRIAL	0	0
AGRICULTURE-OTHERS	12	1
TOTAL	1094	100

POPULATION PREDICTION: POPULATION GROWTH (1930-2031)

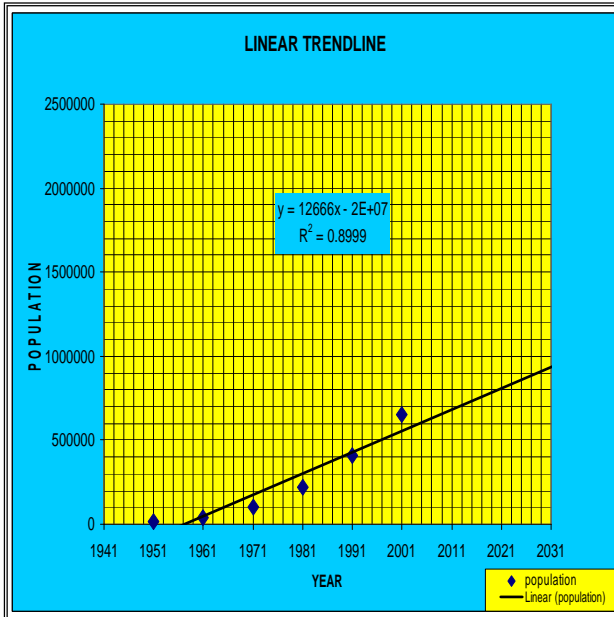


Chart 1

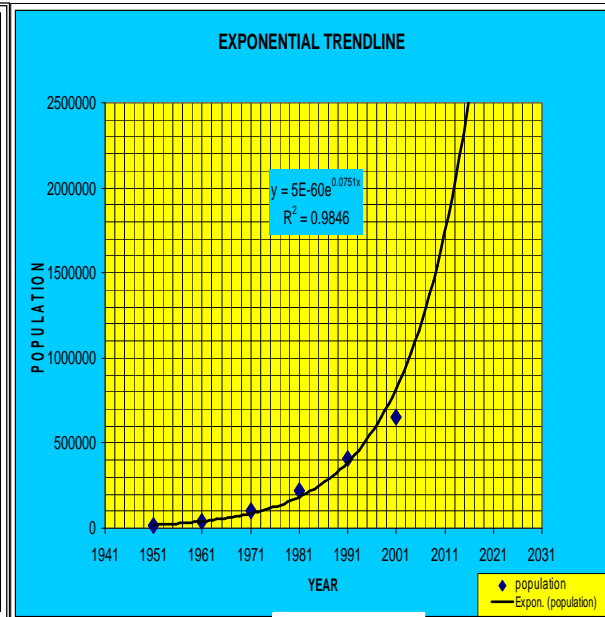


Chart 2

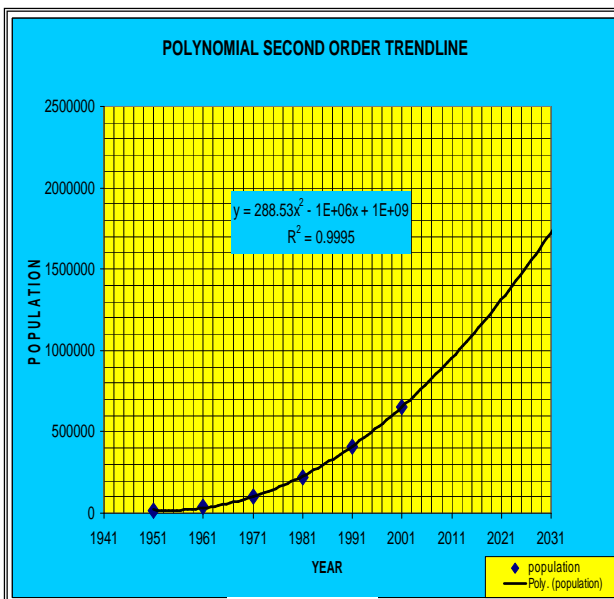


Chart 3

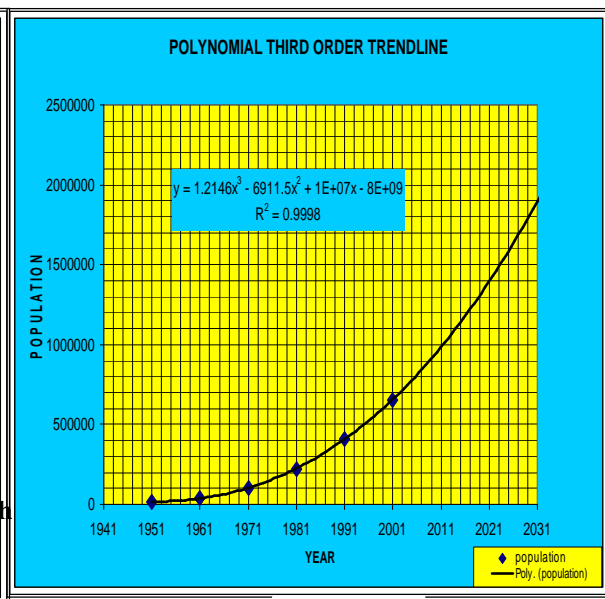
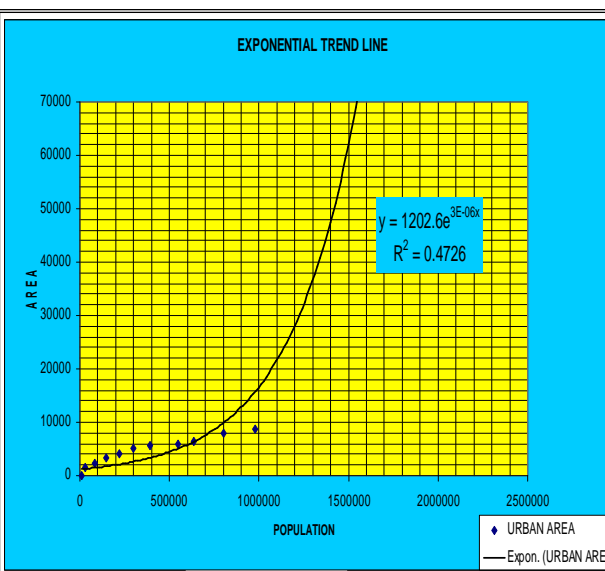
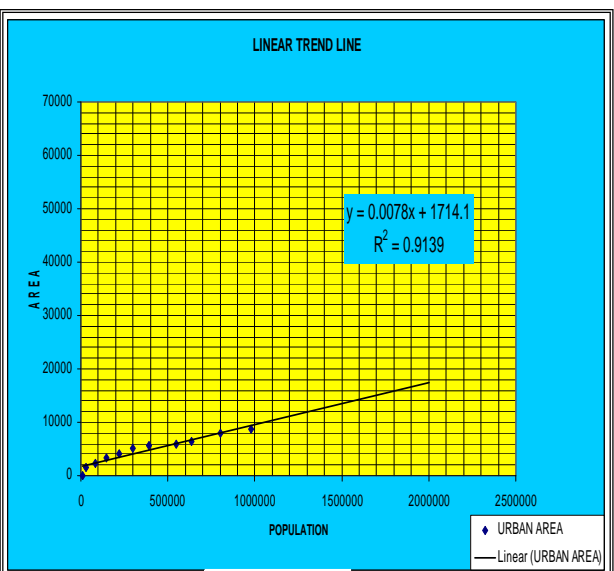


Chart 4

URBAN GROWTH AND POPULATION GROWTH:



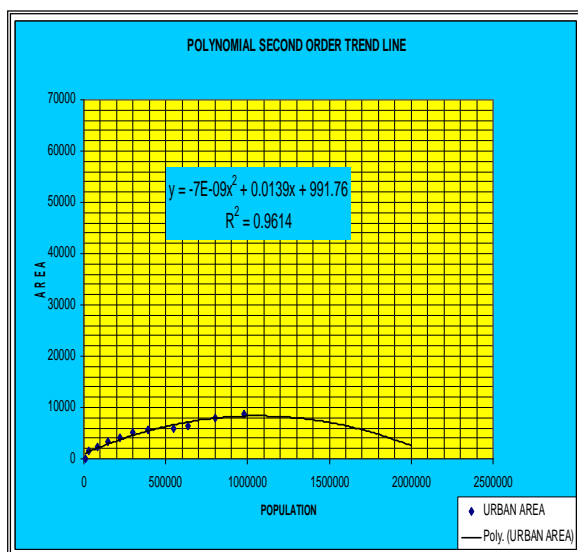


Chart 6

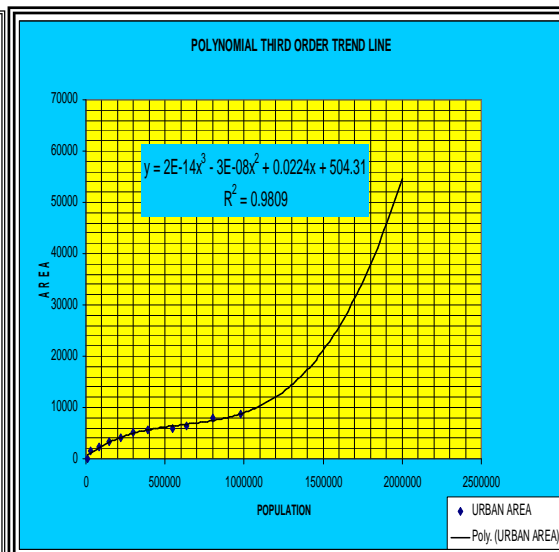
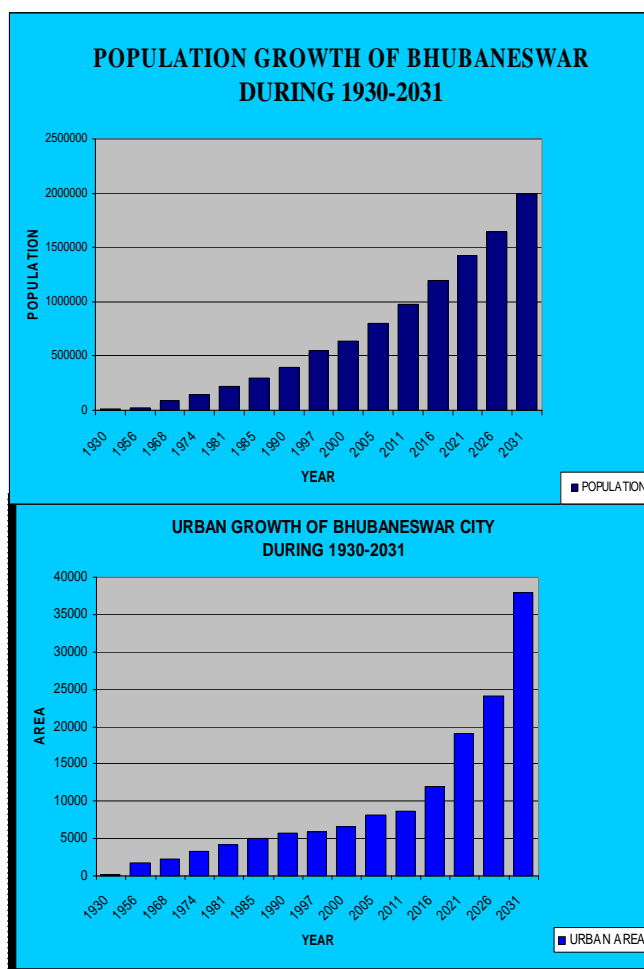


Chart 7

Table—4:URBAN GROWTH AND POPULATION GROWTH (1930-2031):

YEAR	URBAN AREA IN HECT.	% GROWTH	POPULATION	% GROWTH
1930	104.9		8940	
1956	1654.9	1478	27,400	206
1968	2237.9	35	85,000	210
1974	3234.2	45	145000	71
1981	4077.7	26	219211	51
1985	5091.8	25	300000	37
1990	5767.1	13	3,92000	31
1997	5958	3.31	5,50000	40
2000	6524	9.4	6,35000	15
2005	8052	23.4	8,00000	26
2011	8600	7	9,80000	23
2016	12000	40	1200000	22
2021	19000	58	1,430000	19
2026	24000	26	1650000	15
2031	38000	58	1,900000	16



ANALYSIS OF DATA:

Urban sprawl refers to the area expansion of urban concentration beyond what they have been. Urban sprawl can be of three types-continuous, ribbons or check board type. The above table explains the area growth of city in different time periods. The following observations are made from the above trend.

During 1930-1956 the construction of city was started and during 1930-56 many urban facilities were provided apart from large scale construction of residential quarters, so that the population growth is four times less the urban area growth. There is a total absence of provision of areas for a number of urban activities such as industrial, institutional etc. which were not envisaged.

During 1956-68 the population growth rate is four times the area growth, as during this period employees of various departments came to reside in residential quarters, construction for the government employees.

During 1968-74 the population growth and urban area growth are proportional. During 1974-81 the population growth rate has doubled compared to urban area growth.

From 1981 onwards even though the population growth is proportional to urban area growth. The areal growth is constantly increasing whereas the population growth is constantly decreasing.

The growth during 1885-1990 is more in outer periphery zone i.e. 7.5 km to 10.5 km. From 1997-2005 showed tremendous rise in the built-up from agricultural area, vegetation and open spaces. The city has its centre at the core areas. Although, the city initially evolved in rectangular shape on a grid iron pattern from the centre, now it is growing largely towards north, northwest and southwest direction along the main transport route.

MODELLING:

A methodology has been adopted for predicting future population and built up area. The methodology was applied for predicting the population and built up area for the year 2011, 2021, 2031 for the Bhubaneswar city.

MODELLING POPULATION GROWTH:

Various trend lines were fitted to predict the population growth of Bhubaneswar city, the best result was given by a polynomial of third order $Y = 1.2146x^3 - 6911.5x^2 + 1E+07x - 8E+09$ and $R^2 = 0.9998$. The estimated population in 2011, 2021, and 2031 will be around 980000 and 1430000 and 1900000 (refers to chart.4).

MODELLING POPULATION GROWTH AND URBAN AREA GROWTH:

Various trend lines were tried to fit in between the population and urban area data as shown below. It was found that the fitting trend line was a polynomial third trend line curve with $Y = 2E - 14x^3 - 3E - 08x^2 + 0.0224x + 504.31$ & $R^2 = 0.9809$. As the urban area in 2005 was found to be 8052 hect. (Using maps prepared by cartosat-1 data). The population of year 2005 was found to be 8,00,000. (Refer to chart no. 8). Thus the built up area for year 2011-2031. it is estimated to be 8600 in 2011, 12000 in 2016, 19000 in 2021, 24000 in 2026 and 38000 in 2031.

LAND USE/ LAND COVER CHANGE:

Bhubaneswar today, is one of the fast growing cities in India, the land use of the city over a period from 1998-2005 showed tremendous rises in the built-up from agricultural area, vegetation and vacant land. The city today has its centre at the core areas. Although, the city initially evolved in rectangular shape on a grid iron pattern outward from the centre. Now it is growing largely towards north, northwest and southwest direction along the main transport routes. The road structure of the city has not involved to cater the changing pattern in the city and the cater its functions. There were ample agriculture and vegetation land in outside the urban area. In this period of time industrial and residential areas were dominantly expanded.

The land use/land cover maps were prepared for the year 2000 and 2005. These two maps were then overlaid to find the land use/land cover change for year 2000-2005. (refer table) the amount of land use change from agricultural and forest to other land uses were found.

FINDINGS AND COCLUSION:

This study amply demonstrates the use of Remote sensing and GIS to analyze the urban sprawl mapping and detect changes of urban land use/ land cover through different year. Satellite data are found to be useful in mapping and quantifying the extent of urban area in different time periods. New urban region development growing largely towards north, north-west and south-west direction along the main transport route of the city. New urban development occurs mainly on vegetation and agricultural land. The above study provides a methodology for better estimation of urban growth and population using various land uses with time. Geographical information system (GIS) and satellite images have been used in this study to provide spatial inputs and test the statistical model describing growth. The model developed in this study can be used for predicting the future land uses even when not much of old land use data is available. This is useful for the urban planning authorities in developing countries where land use data is not available regularly. GIS and Remote sensing can help a lot in monitoring urban sprawl compared to conventional techniques.

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