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Geoinformatics Based Sprawl Dynamics Analysis of Berhampur Development Authority Area, Odisha, India

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Abstract: ***Urban and Regional planners need accurate and authentic spatio-temporal information of urban sprawls for efficient and sustainable planning of towns & cities worldwide. Geoinformatics powered with temporal high resolution satellite images, Geographic Information System (GIS), mobile technology, etc is now emerged as the most powerful tool for mapping and monitoring the sprawls of urban habitations. In this paper an attempt is made for analysing the dynamics of sprawls of three statutory towns of Berhampur Development Authority (BeDA) area of Ganjam District, Odisha state, India. The spatial information of urban sprawl of each town has been generated using openly available toposheets and multi -sensor & multi - temporal satellite images and the spatio temporal characteristics of sprawls has been analysed in Arc GIS software. The sprawl area as well as the population of the three towns have been analysed and the future scenario of sprawl-population dynamics has been forecasted for the years 2021 and 2031.The result of this paper highlights that sprawls of the three towns i.e Berhampur, Chhatrapur and Gopalpur will expand their spatial dimension by 22,18 and 97 percent by 2031 whereas population of the three towns will increase by 43, 19 and 15 percent between 2011 -2031.Finally the result indicates that there will be decrease in population density in the three towns which will ultimately force the Development Authority to plan more basic infrastructures and transportation in the newly expanded urban areas.***

Keywords : Arc GIS , Geoinformatics ,Urban Sprawl, Population Density

I. INTRODUCTION

As the urban population increases, the land area occupied by cities has increased at an even higher rate.
A global sample of 120 cities observed between 1990 and the year 2000, shows that while the population grew at a rate of 17 per cent on average, the built-up area grew by 28 per cent. It has been projected that by 2030, the urban population of developing countries will double, while the area covered by cites would triple. 55.4 % of the World's population reside in urban areas.

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The causes of area expansion may vary according to different contexts, but uncontrolled growth, privatization of public goods, lack of regulations and institutions as well as forms of collective indolence are often the key factors behind a model of urbanization that is becoming highly unsustainable.
Urbanization is at the same time a positive force underpinning profound social, political and economic transformation [1].Therefore, proper identification and recognition of urban sprawl (city's spread areas) as well as knowledge of geography, ecology, economies, cultures and institutions of the expanded areas becomes pre requisite for the planners while taking decisions on sustainable city planning[2],[3]&[4]. Use of proper technologies like different platform based high resolution remote sensing, Geoinformatics and Information & Communication Technology (ICT), is much required to identify, monitor and regulate the geography and ecology of urban sprawls /growth of cities in a short time span but in a much unbiased way.

A. Urban Sprawl –Causes & Effects

Sprawl is defined as the spreading of urban development (such as houses and shopping centers) on undeveloped land near a city [5]. Urban sprawl, the rapid expansion of the geographic extent of cities and towns, often characterized by low-density residential housing, single-use zoning, and increased reliance on the private automobile for transportation. Urban sprawl is caused in part by the need to accommodate a rising urban population; however, in many cities/towns it results from a desire for increased living space and other residential amenities. Urban sprawl has been correlated with increased energy use, pollution, and traffic congestion and a decline in community distinctiveness and cohesiveness. In addition, by increasing the physical and environmental "footprints" of cities/towns, the phenomenon leads to the destruction of wildlife habitat and to the fragmentation of remaining natural areas [6].There are many factors that contribute to urban sprawl. Population growth, economic growth and industrialisation can be cited as the principal microeconomic drivers of urban sprawl. However, increased affluence, attractive land and housing prices, and the desire for larger homes with more amenities (such as yards, household appliances, storage space, and privacy) play significant roles at the level of the individual city/town. Urban sprawl causes decline in population density, major losses of agricultural land and natural vegetation & wildlife habitat, higher commuting time and costs, an increase in greenhouse gas emissions, as well exacerbating socio-spatial segregation and segmentation.

On the whole, built-up area densities have been on a decline around the world especially in developing countries: from an average 170 persons per hectare in 1990 to 135 a decade later. A one per cent annual decline in average densities in developing countries is projected to quadruple the urban land area by the year 2050 from 2000 levels in recent years [7].

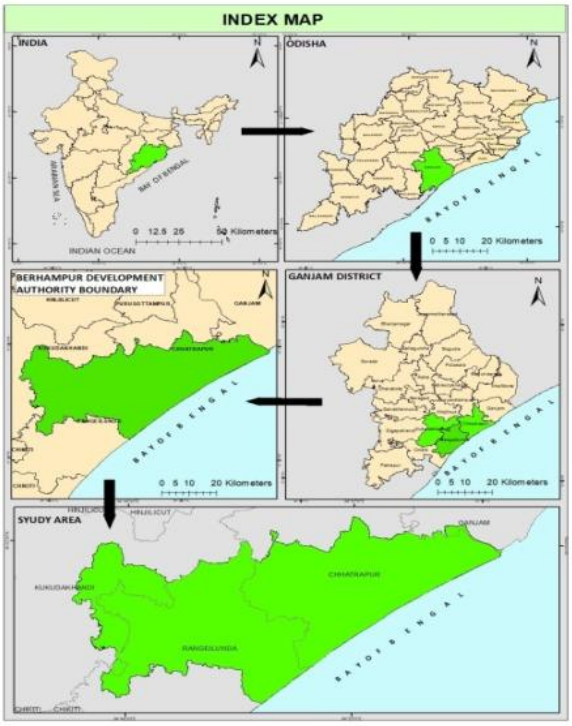


Figure 1 Index Map of Berhampur Development Authority (BeDA) area

II. STUDY AREA

Berhampur Development Authority Area (BeDA) comprises of Berhampur Municipal Corporation, Gopalpur Notified Area Council, Chhatrapur Notified Area Council and 90 revenue villages/mouzas of rural area and stretches over an area of 32061 Hectare of lands .Berhampur Development Authority area is located between 19^0 13' 48.948"N to 19^0 23'59.046" N latitudes and 84 °43'58.877"E to 85 °04'16.707"E longitudes in parts of Chhatrapur, Rangeilunda and Kukudakhandi Community Development Blocks of Ganjam district of south eastern region of Odisha state, India (Fig 1). Berhmapur Development is a statutory body constituted under the Orissa Development Authorities Act, 1982. It came into existence with effect from 26.07.1993. It is the successor to the erstwhile Berhampur Regional Improvement Trust a statutory body constituted under Orissa Town Planning and Improvement Trust Act, 1956 which in turn was successor to the erstwhile Special Planning Authority, Brahmapur under the same Orissa Town Planning & Improvement Trust Act,1956[8]. Berhampur Municipal Corporation, Chhatrapur NAC and Gopalpur NAC consist of 34,09 and 06 revenue mouzas/villages respectively.Among the three focal urban areas in side Berhampur Development Authority Area(BeDA), Berhampur is the first urban area in spatial extent. This is the fourth most populous City in Odisha State and 122nd in India. Berhampur also known as "The silk City" was declared as Municipality in 1867 and up-graded as Municipal corporation in the year, 2008. Chhatrapur is the second urban area in spatial extent in side BeDA. It is the district headquarter of Ganjam District . The third urban area inside BeDA ,i.e. Gopalpur, is a small town ,16kms. away from Berhampur. Form an obscure little fishing village Gopalpur became a predominant trading port during the days of the British East-India Company .The company built large warehouses and godowns because trade with Burma had picked up and was an important port for trading rice. It has now grown in to a major port along the east coast of India[9]&[10].The State capital, Bhubaneswar, is situated at a distance of 169 Kilometre .from the Berhampur city, the administrative headqurter of BeDA. This area is well connected to remaining parts of the state as well as the country. National Highway No-16 connecting Chennai with Kolkata passes right through the middle of BeDA linking Bhubaneswar with Chattrapur and Berhampur. National Highway No-516 connects Berhampur with Rayagada town thus links the BeDA area with the southern districts of Odisha state.

III. DATA SOURCE & METHODOLOGY

Data source for this paper is discussed at Table I, which as follows

Table I: List of Data Source for Analysis of Urban Sprawl and Population of BeDA

Sl No	Data Type	Source Year	Source
	Spatial-Topo Map-NE-45-1	1935	
	Spatial-TopoMaps of 1:50,000 scale	1975	Survey of India
	Spatial-Satellite Image-IRS 1B LISS III	1995	www.bhuvan.nrsc.gov.in[11]
	Spatial-Satellite Image-CARTOSAT-1 PAN	2005	www.bhuvan.nrsc.gov.in
	Spatial-Satellite Image-Resourcesat 2 LISSII	2011	www.bhuvan.nrsc.gov.in
	Spatial-Satellite Image- Resourcesat 2 LISSII	2015	www.bhuvan.nrsc.gov.in
	Spatial-Satellite Image-High Resolution	2018	www.google.com/earth[12]
	Ward/Village wise Population	1991,2001& 2011	Census of India[13]

The spatial data on urban sprawl has been extracted after georeferencing of all satellite images and topomaps with respect to the Ground Control Points collected in side BeDA through Global Positioning System. The spatial extent of sprawls of each different year has been extracted from the satellite images/ topo maps using On Screen interpretation method through Arc GIS version 10.6 software.

All the standardised vectors on sprawls have been generated in Universal Transverse Mercator (UTM) projection and World Geodetic System(WGS)-84 Datum. Attribute database on population of each ward & village has been linked to the spatial (vector) database of village/ward unit of BeDA boundary in Arc GIS platform. Sprawl extent change vector data has been generated in Arc GIS-Arc Map. Statistical Analysis for projecting sprawl and population has been carried out using projection - linear operation using MS Excel software.

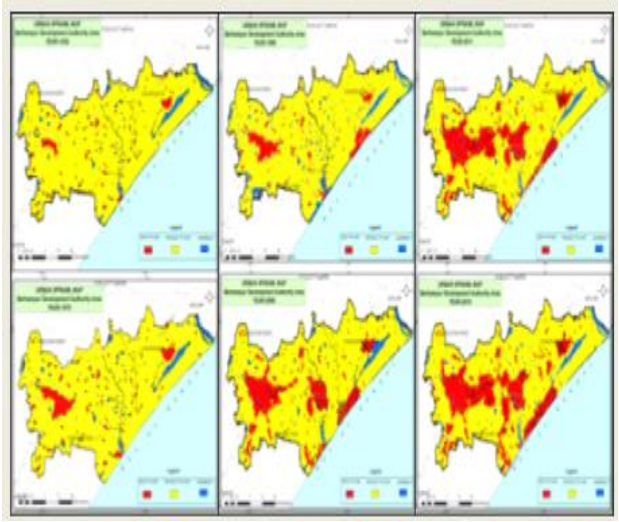


Figure 2 Urban Sprawl of BeDA in 1935, 1975,1995,2005,2011 &2018

Table II Spatio- Temporal Footprint Analysis of Urban sprawl of BeDA area

Year wise Area in Hectare							
Name of Statutory Towns	1935	1975	1995	2005	2011	2015	2018
Berhampur	232.64	873.51	928.78	2072.56	3533.49	3704.16	4027.79
Chhatrapur	162.29	247.39	287.36	304.87	387.42	406.31	433.42
Gopalpur	28.91	75.33	90.28	110.55	190.73	248.88	438.43

IV. RESULT & DISCUSSION

A. Urban Sprawl Temporal Spatial Dimension Analysis

During the last 83 years(1935-2018), it is observed that spatial growth in Berhampur, Chhatrapur and Gopalpur towns are 17.33, 2.67 and 15.16 times respectively(Table II) .Drastic sprawl growth has occurred in Berhampur town during the period 1995-2011 whereas Gopalpur town has experienced maximum sprawl growth during 2011-2018.Berhampur town is expanding mostly in South east direction whereas Gopalpur is stretching linearly along the sea beach. Growth of

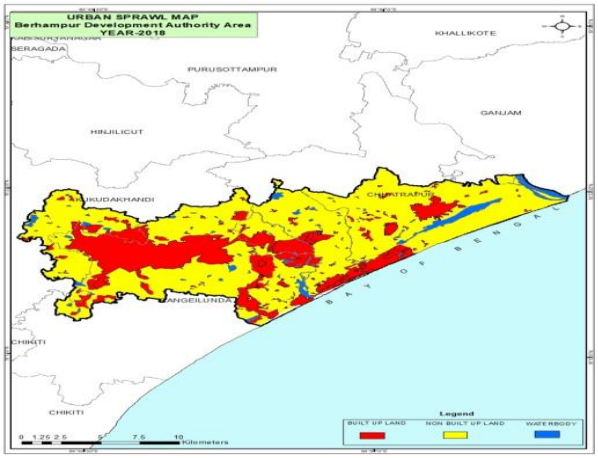


Figure 3 Urban Sprawl of BeDA-Year 2018

Chhatrapur town is occurring in all the directions except towards the Tampara lake(Figure 2,3 ,4 &5).

B. Identified remarkable sprawl growth sites in BeDA:

The GIS based analysis of temporal spatial datasets (Figure 2 to Figure 4) has identified sites where major sprawl growth has occurred in side BeDA (Table III).

Tata Steel occupied Special Economic Zone(SEZ) area in Gopalpur Industrial Park (5Km from Gopalpur and 7 Km from Berhampur town) has expanded by additional 119 Ha of lands including industrial infrastructure area of 57.39 Ha. The total area presently acquired by Tata Steel in Year 2019 is 1202 Ha of lands. Indian Rare Earths Limited & Gopalpur Port Ltd in Gopalpur have acquired extra 306 Ha of land during the period 2005 to 2015. Army Air Defence College (AADC), Gopalpur has expanded its jurisdiction area by 65 Ha of land within 2005-2015. Saraf Titanium Industry (special economic zone) has come up acquiring nearly 100 Ha of land adjacent to Chhatrapur town in 2015.

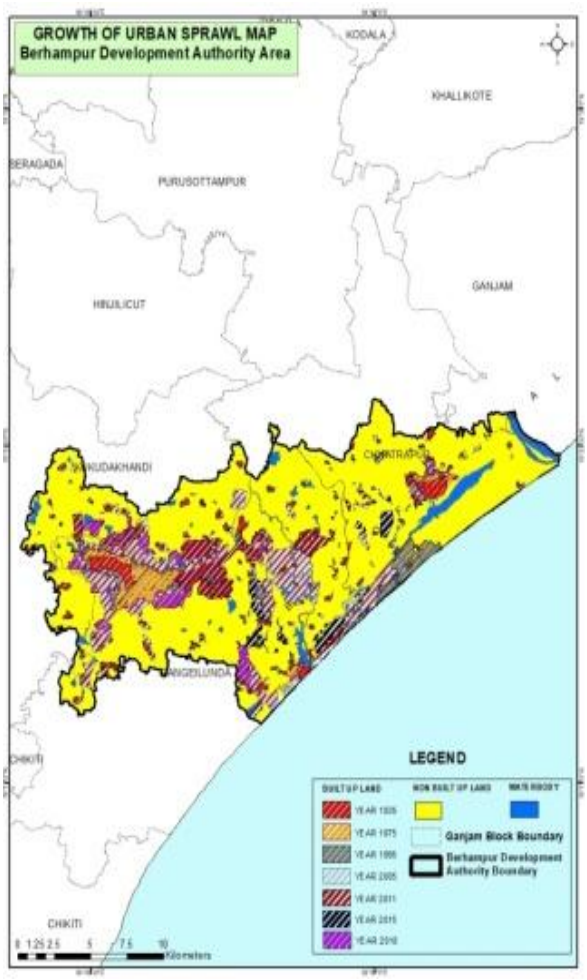


Figure 4 Composite Map showing Temporal Urban Sprawl Growth in BeDA-1935-2018

Table III. Identified remarkable sprawl growth Sites and their spatio-temporal Dimensions(in Hectare) inside BeDA

Name of the Sites	Year-2005	Year-2011	Year-2015
Tata Steel-Gopalpur Industrial Park	712.39	931	931(with Industries of 57.39 Ha area)
Indian Rare Earths Limited & Gopalpur Port Ltd	552.38	641.42	858.97
Army Air Defence College(AADC), Gopalpur	163.17	180.08	218.23
Saraf Titanium Industry	0.0	0.0	100.82

C. Forecasting of Urban Sprawl vrs Population of BeDA:

Statistical analysis indicates that there may be a growth in spatial extent of sprawl by 4.09,3.65 and 17.14 percent for Berhampur, Chhatrapur and Gopalpur towns respectively by Year 2021.Sprawls will increase their spatial dimension by 22,18 and 97 percent by 2031 for the three towns,i.e Berhampur,Chhatrapur and Gopalpur towns. Rate of sprawl expansion seems to be the highest in Gopalpur town and the town will almost double its extent by 2031.Similar statistical analysis has also forecasted the population of the three towns and indicates that there will be 43, 19 and 15 percent of population growth respectively in Berhampur, Chhatrapur and Gopalpur between 2011 -2031. Based on the current figure, trend of population density decrease in Berhampur and Gopalpur towns by 2031 because sprawl growth versus population growth is drastically high in these two towns. Population density (persons per Hectare of land) has come down from 226 in year 1991 to 101 in year 2011 in Berhampur. It is estimated that population density will be 104 in year 2031 in Berhampur. Similarly for Gopalpur the projection shows population density of 62 of the year 2001 will be dropped to only 10 by year 2031.In case of Chhatrapur town the trend is in a decreasing node i.e. from 62 to 51 by year 2031 (Table IV, Table V,Table VI Figure 6, Figure 7& Figure 8).

Table IV . Statistics of Actual and Projected Spatial Extent of Sprawls of Statutory Towns of BeDA

Name of Towns	Actual Area in Ha in 2018	Projected Area in Ha in 2021	% of forecasted Growth of Area (2018-2021)	Projected Area in Ha in 2031	% of forecasted Growth of Area (2018-2031)
Berhampur	4027.79	4192.803	4.09	4883.84	21.25
Chhatrapur	433.42	449.24	3.65	512.71	18.29
Gopalpur	438.43	513.61	17.14	862.46	96.71

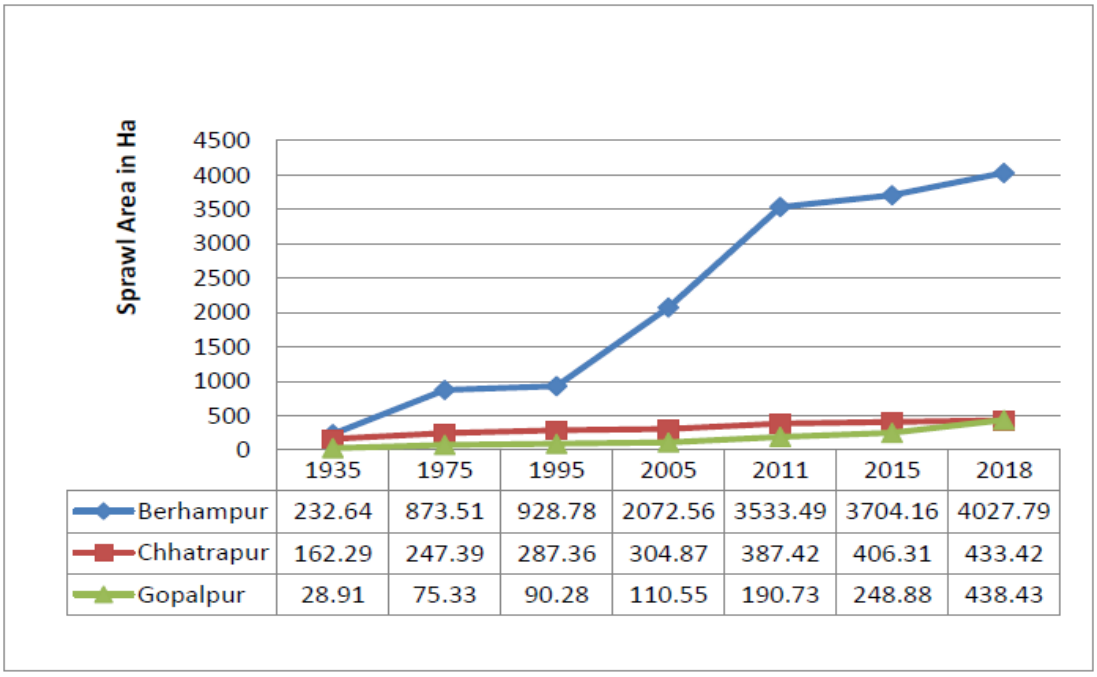


Fig-5. Sprawl Growth in BeDA area

Table V..Statistics of Actual and Projected Population of Statutory Towns of BeDA

Sl No	Name of Statutory Urban Local Body	Population as per Census 2011	Projected Population for Year 2021	% of Growth of Population-2011-2021	Projected Population for Year 2031	% of Growth of Population-2011-2031
1	Berhampur MC	3,56,598	4,37,782	22.7	5,10,872	43.26
2	Chhatrapur NAC	22,027	24164	9.7	26,201	18.94
3	Gopalpur NAC	7,221	7779	7.72	8337	15.45

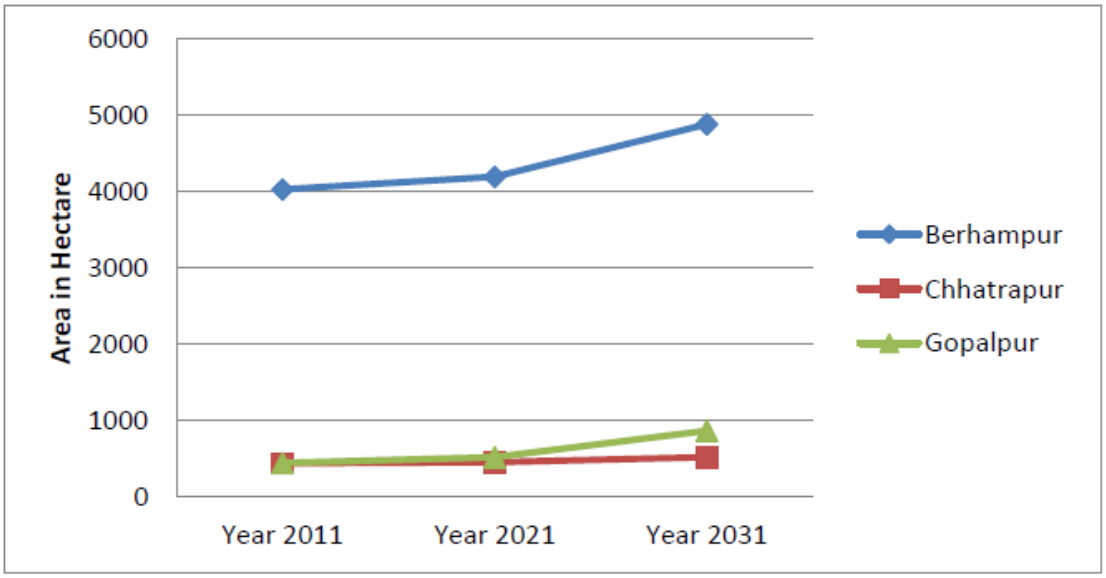


Figure 6. Projected Sprawl Area Of Major Towns Of Beda

Table VI. Statistics of year wise Sprawl area versus Population of Statutory towns of BeDA

	Berhampur Town			Chhatrapur Town			Gopalpur Town		
Year	Sprawl Area in Ha	Population	**Density**	Sprawl Area in Ha	Population	**Density**	Sprawl Area in Ha	Population	**Density**
1991	928.78	210418	226	287.36	17952	62	90.28	----	----
2001	2072.56	307792	148	304.87	20289	66	110.55	6663	60
2011	3533.49	356598	101	387.42	22027	56	190.773	7221	38
2021	4192.803	437782	104	449.24	24164	54	513.61	7779	15
2031	4883.84	510872	104	512.71	26201	51	862.46	8337	10

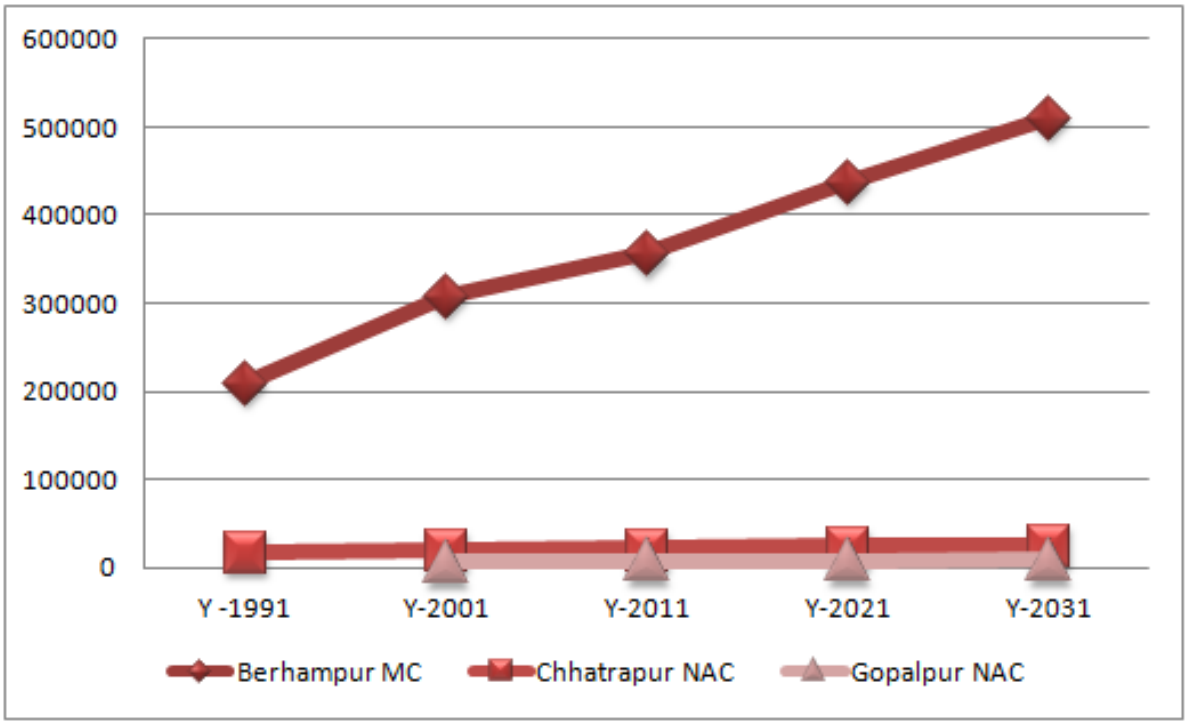
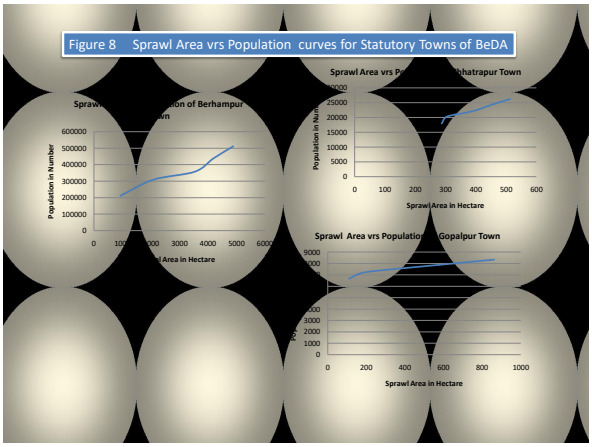


Figure 7. Projected Population Growth In Major Towns Of Beda



V. CONCLUSION

The temporal satellite images have seen to be very useful in extraction of footprints of sprawls inside Berhampur Development Authority Area. The freely available high resolution satellite images have been found more beneficial in this type of study. However care need to be taken for proper mosaiciking and georeferencing of all the satellite images.For achieving more accuracy in this type of study, sufficient number of Ground Control Points need also be established. This study further indicates that urban sprawl growth is influencing population density in the region in a reverse manner. As the three towns i.e Berhampur, Chhatrapur and Gopalpur of BeDA expand, the projection has reflected that the population density will decrease .Gopalpur town will be expanding in double manner between 2018 and 20131.Industrialisation ,mining under Atomic Energy Department ,expansion of the Gopalpur port as well as day by day expansion of tourism infrastructure seem to be the causes of sprawl growth in the region. Transportation and installation of basic amenities in the expanded areas of the towns needs to be priority for the authority.

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AUTHORS PROFILE

Mrs Binita Tripathy is a Post Graduate in Geography from Department of Geography, Utkal University in 1985 and completed her M.phil degree from the same Department in I986.She has carried out her Post Graduate Diploma in Remote Sensing for Urban Studies from Indian Institute of Remote Sensing, Department of Space in 1991. She has been working as a Scientist at Odisha Space Applications Centre (ORSAC) , Department of Science & Technology, Govt of Odisha for the last 32 years .Mrs Tripathy has undergone several professional courses in Digital Image Processing, GIS, Urban Planning, Disaster Management High Resolution Satellite Image Processing,etc from National Institutes like Department of Space, Delhi School of Planning ,Indian Institute of Technology, Kharagpur & Mumbai, etc. Has published nearly 26 scientific papers in National & International journals and guided 21 students in carrying out their dissertations for M.Sc/M.Tech/B.Tech degrees. She was involved in National level projects like National Land Use mapping, Wastelands mapping, Land Degradation mapping, National Urban Information System ,NRIS, etc. She has successfully led the project of High Resolution Satellite Image based cadastral level mapping of Land Use and Infrastructures in Odisha state, the first ever such attempt in the country. She is also a Life member to Indian Society of Remote Sensing and also presently an Executive Body member of ISRS, Bhubaneswar chapter. Mrs Tripathy is carrying out her Ph.D research work in Remote Sensing & GIS at PG Department of Geography on Use of High Resolution Satellite Image and Geospatial Input for Berhampur Development Authority .

Dr. Kabir Mohan Sethy is presently holding the post of Professor at Post Graduate Department of Geography of Utkal University, Bhubaneswa, Odisha. After completion of his Post Graduation and M.Phil in Geography from Utkal University ,Dr Sethy has achieved his Ph.D degree for the topic "Settlement Pattern and Service Center Analysis for Rural Development - Planning of Compound Delta of Orissa Coastal Plain" .His areas of specialisation are Regional Planning, Economic Geography, Remote Sensing & GIS, Climate Change & Natural Hazards. So far 65 M.Phil students and 30 P.G Diploma students in Utkal University have completed their dissertations under the guidance of Professor Sethy. Till date 06 nos of Research Scholars have successfully completed their Ph.D degrees and 08 Research Scholars are presently carrying out their Ph.D work under Professor Sethy's guidance. Author to 03 different books and hoding Honorary posts in different organisations,Professor Sethy has already completed 06 projects sponsored by different agencies. He has attended and presented 65 numbers of papers in different National and International Seminar/Symposia/workshops, published 52 numbers of research papers in different National and International journals so far and delivered 14 numbers of popular lectures in different forums.

Dr. P. Mishra is presently holding the post of Scientist at Odisha Space Applications Centre (ORSAC), Bhubaneswar, Odisha. After completion of his Post Graduation in Applied Geography from Ravenshaw College, Dr Mishra has achieved his Ph.D degree for the topic "Geoinformatics for Planning Sustainable Watershed Development in Orissa" from Utkal University .He has completed his Post Graduate Diploma in Remote Sensing from Indian Institute of Remote Sensing, Department of Space. His areas of specialisation are Remote Sensing based Natural Resources Management, Web GIS, GPS based vehicle tracking, Mobile Applications, etc. Three of the projects of ORSAC designed, developed and coordinated by Dr Mishra have bagged World Geospatial Excellence Awards. So far 51 M.Phil, M.Tech and P.G Diploma students from different colleges & Universities have completed their dissertations under the guidance of Dr Mishra. He has already coordinated more than 50 projects sponsored by different agencies like World Bank, Department of Space, ICAR,ICMR,NABARD and other State & Central Govt Departments . He has attended and presented 41 numbers of papers in different National and International Seminar/Symposia/workshop, published 38 numbers of research papers in different National and International journals so far and delivered 32 numbers of popular lectures in different forums. Dr Mishra is a Life Member of Indian Society of Remote Sensing and regularly works as a Visiting Faculty for teaching Remote Sensing &GIS to the Graduate & Post Graduate students of various Colleges/Universities in Odisha state.