Indian Journal of Spatial Science
Autumn Issue, 10 (2) 2019 pp. 123 - 133

Indian Journal of Spatial Science
Peer Reviewed and UGC Approved (Sl No. 7617)
EISSN: 2249 - 4316 homepage: www.indiansss.org ISSN: 2249 - 3921

Sprawling Urban Growth: A Case Study of Barasat Municipal Town, North 24 Parganas, West Bengal using Geospatial Technology

Debasmia Biswas#
Assistant Professor of Geography, Chandernagore College, Hooghly, West Bengal

Prof. Dr. Ashis Sarkar
Professor (Retd), West Bengal Senior Education Service
(Ex HOD, Presidency College/ University, Kolkata, and Chandernagore College, Hooghly)

 # Corresponding Author

Article Info

Article History

Received on:
30 June 2019
Accepted in *Revised Form* on:
31 July, 2019
Available *Online* on and from:
23 September, 2019

Keywords

Urban Growth
Urbanisation
Urban Sprawl
Entropy
Geospatial Technology

Abstract

All over the world, cities and towns are expanding. The process of urbanization expresses itself through a distinct set of land use and type of human behavior. It brings about phenomenal socio-economic transformation in the surrounding rural areas. The pressure of continuously growing population in towns / cities results in over-crowding and unplanned spatial growth and finally become a burden to limited civic cycle amenities which forces the middle class as well as builders to move to outlying suburbs, a phenomenon called, urban sprawl. Thus, any area, which is under the jurisdiction of a municipality corporation, cantonment, or any notified town, which exceeds its administrative boundary and grows outward without any check, is considered to be a sprawl. Hence, sprawl is the spreading out of a city and its suburbs over more and more rural land at the periphery of an urban area, essentially involving thereby the conversion of rural open space into a developed built-up landscape over time and space. All these are associated with the urban growth of Barasat Municiapal Town, the district head quarter of North 24 Parganas, West Bengal. Analysis has been done using multi-dated IRS Images in GIS and RS platforms. Sprawling has been primarily taking place along the Highways in different phases during the post-independence period conforming 'leap-frog' development.

Introduction

Cities and towns provide many opportunities for development compared to more remote sites. Land in cities/ towns is served by established road networks; water supply, wastewater and sewage disposal infrastructure is in place; and electricity and telecommunications can be easily connected. Established areas also have community infrastructure like schools, medical centres, playing fields and places of worship. Depending on the types of development being considered, cities and towns may be additionally appropriate locations as future employees, residents or customers already live nearby. Thus, the four key drivers of the population growth of cities in developed economies are: transportation and housing supply, amenities, agglomeration effects related to human capital and entrepreneurship, and technology (Duranton, 2013).

Globalization in early 1990s has led to the opening of Indian market to global players, which has contributed to rapid urbanisation in many parts of India. Urbanization is an irreversible dynamic phenomenon leading to large scale land cover changes with impacts on the regional environment and is certainly a product of demographic explosion and poverty induced rural-urban migration (Bhat, et al. 2015). Unplanned urbanisation leads to dispersed haphazard growth at outskirts which is referred as sprawl. These rapidly urbanising regions attains inordinately large population size with the gradual collapse of urban services evident from the basic problems in housing, slum, lack of treated water supply, inadequate infrastructure, higher pollution levels, poor quality of life, etc. In this regard, quantification of urban growth would help in evolving strategies for sustainable management of natural resources.

Urbanization refers to an increase in the size of urban places and growth in the number with increasing concentration of population in such places (Hausar and Duncan, 1954). The phenomena of high level of urbanization at the global level specially in the developing countries is relatively a recent

phenomena and has gained unprecedented momentum since the 1950's. By 2050, it is predicted that 64% of the developing world and 85.9% of the developed world would be urbanized (Potter, 1992).

Towns and cities in the third world are growing much more rapidly than cities in Europe and America in the contemporary world, leading to an urban explosion in the Third World. In India, urbanization has shown remarkable progress particularly in the post independence period. Urban population has increased from 10.84% in 1901 to 17.29% in 1951 to about 31.16% in 2011 (MHUPA, 2016). With 377.16 million urban people, India is now the second largest urban populated country and shares 11% of world's urban population and it is expected to increase by 13% by the year 2030 (Lauther, 2011). With dwindling job opportunities, vagaries like drought, flood, fluctuating crop price in agricultural sectors, urban centres have served as magnet for attracting rural crowd. The situation is almost identical in the Barasat subdivision (Mitra and Pahari, 2019). Urban growth, often unplanned, is taking a toll on the physical and socio-economic environment of Barasat town prompting the authors to explore the spatio-temporal growth of urban population in the town itself and examine its effects.

The Study Area

Barasat, a Class I Municipal town of West Bengal is located in the central part of the Ganges delta with an average elevation of 6m a.s.l. between 22º40′18″ - 22º44′32″N latitudes and 88º26′44″ - 88º 31′21″E longitudes. It is located close to the north-eastern part of the Kolkata metropolis and is the headquarter of the North 24 Parganas district (fig.1). It is a nodal settlement with roads connecting Kolkata from various parts of the state, e.g., NH 12 (formerly NH-34) connecting North Bengal and Assam, NH 112 (Jessore Road) connecting Bangladesh via Petrapole Border and the State Highway connecting Bashirhat. It is a railway junction on the Eastern Railway Chord line connecting Bahishat, Bongaon, Lalgola, and Sealdah.

Objectives

The objective of this study is to explore the temporal and spatial dimensions of change in the pattern of urban growth and urbanization leading to sprawling during the past couple of decades.

Methodology

The study is based on both primary and secondary data sources. Primary data has been collected through questionnaire and field observation methods on the basis of random sampling with focus on location, household information, landuse pattern, land acquisition, resettlement, compensation, demographic characteristics, occupational structure, civic amenities, etc. The demographic data has been collected from the primary census abstracts of North and South 24 parganas as well as of Barasat and Baruipur municipality till 2011, Directorate of Census Operations, Census of India. Data has also been acquired from various government and quasi-government agencies, Bureau of Economics and Statistics, District Gazetteers, reports and documents of Zilla Parishads etc.

Urban sprawls have been identified a set of multi-dated high resolution satellite images that are geometrically and radiometrically corrected for further use. The coregistered images were then classified by using nonparametric classifier for extracting the built-up area along with other impervious surfaces to determine the urban class. The images were digitally processed for identification and monitoring the dynamics of urban sprawl (Erdas / JT Spectral) by applying Shanon's model of entropy measurement. All entropy values were then further manipulated using various functionalities in order to predict the sprawls of the landscape in future. The results of the analysis has been documented with summary tables and cartographic presentations like graphs, diagrams and maps. The images were then manipulated in GIS platform (ArcGIS and Quantum GIS) with SQL (Structured Query Language) for further analysis, planning, modeling and management. The built-up and non-built up areas have been delineated and map densities computed by dividing the number of built up pixels to the total number of pixels in a kernel. The density levels then further grouped into low, medium and high classes and their shares have been computed to identify the levels of dispersion of urban growth as well as sprawl.

Sprawling Town/City Growth

Urban sprawls are characterized by unlimited outward extension, low density residential and commercial settlements, leapfrog development, fragmentation of powers over land use among many small localities, dominance of transportation by private automotive vehicles, no centralized planning or control of land uses, widespread strip commercial development, great fiscal disparities among localities, segregation of types of land uses in different zones, reliance mainly on the trickle-down or filtering process to provide housing to low income household, limited meaningful consumer choices about where and how to live, segregated housing, stores and work place from one another and decreased social and civic interaction and support, short term gain over long term public benefits. Today cities are expanding randomly in all directions, resulting in large scale urban sprawl and rapid changes in the land-use pattern of the urban fringe. This irregular growth not only consumes agricultural land on their periphery, but ultimately snowballs into a liability when they become a part of the city without adequate urban amenities. Therefore, proper planning is required to control and regulate the development of sprawls.

Sprawl has many facets. It is a typical component of urban landuse as a result of the processes, factors and consequences of development (Galster et al. 2001). Till the postwar suburban boom in USA and Northwestern Europe, urban sprawl was not recognised until 1960 but it was noted that sub-urbs of cities became more developed (Davis 1962). Clawson (1962) defined it as the spread of suburbs over the rural landscape which tends to discontinue and intermingle haphazardly with unused areas. Geddes (1997) defines it as a fragmented, incomplete, ad hoc, and uncentered pattern of urban growth. The Transportation Research Board of the USA (2002) views urban sprawl growing in a discontinuous manner in the periphery of the city centre. In late 1970's, many defined the urban sprawl as a low density development of the suburbs (Batty et al. (1999), while others defined it as the haphazard expansion of a city over its suburbs involving the conversion of rural land into built-up areas over

time (Burchell,1998). Galster et al. (2001) identified its eight components, viz., density, continuity, concentration, clustering, centrality, nuclearity, mixed uses, and proximity. Thus, the major attributes of sprawl are:

1) Availability of land and scattered population keeps the density of population low. It can be measured by residential plot size, the number of dwelling units per unit of area or floor space of single-family units (Song & Knaap, 2004; Ewing, 1997; Gillham, 2002, Popenoe 1979). Compared to the multi-storied and high-density urban centres, scattered, low-density sprawl consumes more land (Bullard et al., 2000) as non-compact growth zones (Gordon and Richardson 1997).
2) Large distances between dwelling lots increases dependency on automobiles. The street patterns (the cul-de-sac type) within these patchy neighborhoods create obstacles and as a consequence motorized transit replaces walking for every short distance (Benfield et al., 1999).
3) Areas under sprawl develop homogeneous landscape instead of mixed land-uses which is an outcome of heavy dependence on automobiles (Song & Knaap, 2004).
4) Economic and social costings are more than the compact development particularly with regard to transportation and other infrastructure costs (Benfield et al., 1999) because of long in-between distances among developed regions.
5) With the encroachment of urban land into open space and agricultural lands the distinction between rural and urban areas disappears, thereby blurring the edge between urban and rural domains (Heimlich & Anderson, 2001).

Urban sprawl ranges from continuous suburban growth, linear patterns of strip development, leapfrog to scattered development (Ewing,1994; Pendall, 1999; Razin & Rosentraub, 2000; Peiser, 2001). Barnes et al. (2001a) classified sprawls into three groups, as follows:

1) Radial sprawls develop when population spills over the urban limit and spreads randomly (U.S. General Accounting Office, 1999.) in the form of low-density settlements in all directions (Lockwood, 1999; Mills, 1980. It is the most common type which is supported by piecemeal extensions of basic urban infrastructure such as water, sewer, power and roads.
2) Ribbon or in other words, strip sprawl is another form of sprawling which follows major transportation arteries, primarily highways and rail lines (Farooq & Ahmad, 2008), while green lands remain undeveloped in between them because of lack of accessibility.
3) Being a scattered form of urbanisation with disjointed developmental units interspersed with undeveloped areas, the third type is highly patchy in nature. They are popularly known as leapfrog development caused by physical limitations such as rugged topography, water bodies and wetlands or by differences in policies among political j urisdictions (Barnes et al. 2001 a). This form is the most costly of all in terms of urban basic services.

Sprawl is a complex manifest of several physical and socio-economic factors. The urban population growth is the first and foremost reason; migration of people from small town to larger one in search of resource and amenities is the basic reason behind this (Bhagat, 2014). Secondly, rising per capita income, purchasing power and work force create aspiration in population and allow them to have choices of larger living space which is comparatively less expensive at the outskirts of metropolitan areas (Carruthers & Ulfarsson 2002). Investments in transportation infrastructure have reduced commuting costs (Brueckner, 2000) which in turn attracts people towards large urban areas. Difference in land value between rural and urban areas is often considered as another driver of sprawl that takes place in the urban periphery where land is cheaper (Pendall, 1999). Age often rules the decision of migration by seeking out affordable housing options at the urban fringe (Zhang, 2001) that indirectly determines the spatial pattern of development. Often planning policies of Government leads to scattered developments (Barnes et al. 2001). Decaying central city sometimes forces people to search for better affordable housing in the suburbs.

Urban sprawl also impacts heavily by reducing the quality of social and economic life of people (Kenworthy & Laube 1999, Hirschhorn 2001, Kahn 2000). Unplanned land use policies, taxes and financial pressure force the farmers to sell their land to individual buyers as well as to real estate owners which contribute to the loss of prime agricultural land and open spaces (Berry & Plaut 1978, Fischel 1982; Nelson 1990, Zhang et al. 2007). This indirectly impacts on the supply of fresh local crops and fruits, animal habitat as well as spices diversity and traditional culture. More houses and roads in terms of built-up area cover the natural landscape, thereby reducing infiltration of rain water into the ground and causing flood and soil erosion during rains (Jacquin, Misakova and Gay 2008, Morote & Hernández 2016). The run off often chokes the drainage causing waterlogging. The increasing impervious layer created absorbs the sun light and emit thermal infrared radiations that increase the temperature of urban atmosphere locally and globally, creating thereby, the 'urban heat islands (UHI) with a temperature increase by 3.5° to 4.5°C (Frumkin 2002). Excessive reliance on automobiles is burning more fossil fuel as well as creating more traffic problem (Stoel 1999, Nechyba & Walsh 2004).

Origin and Growth of Barasat

Barasat was one of the 10 municipalities in Bengal formed in 1869 under the supervision of British rulers. Infrastructure development programs all over the country were boosted up through these municipalities. Barasat was spread over the area of Badu, Bamanmurah, Quazipara, Choudhurypara, and Dakshinpara which now fall under the Wards of 17, 18, 15, 16, 14, 11, 9, 8 and 6. Formerly, most of its area was covered by marshy and vacant land. The Partition of Bengal (1947) contributed a huge population to get shelter in this border Municipality. Barasat became the District Head Quarter in 1986. A large area of 3 Gram Panchayats and a part of Gram Panchayat, covering an area of about 14 km^2 was added to this Municipality in 1995. It is bounded by part of Khilkapur and Chhoto Jagulia G.P. on the north, Madhyamgram Municipality and Khamarpara G.P. on the south, Kadambagachhi and Khamarpara G. P. on the east and Nilgunge G.P. on the west.

In 1901, Barasat Municipality had only 5 Wards that together contained a population of only 8,634 (Class V town). From 1901 to 1911 urban population grew from 8,634 to 8,790

persons. It took 10 long years to add just only 156 persons with the lowest positive growth rate of 1.81%. Till 1931, it grew sluggishly and slowly with negative decadal growth during 1911 21 and less than 6% during the remaining two decades. The reason may be cited as the negative difference between fertility and high mortality. This slow growth rate may be attributed to the high rate of mortality, poor resource distribution system and poor medical facilities.

Growth rate became positive during 1921-1931. The first spur of growth started with 1931 41 decade when the decadal growth rate was about 29.5%. It became a Class IV town in 1941 and remained so till 1951, The decadal growth rate rapidly increased and became about 82.70% in 1951 61 when Barasat grew to be a Class III town. This was the period that saw great socio-political changes. Indian became independent and the Bengal Partition happened. A huge population migrated from erstwhile East Pakistan and set up colonies in and around Barasat with Border connections through Bongaon, Bhomra, and Bashirhat and also well-connected with the city of Calcutta (fig.2 Table -1). The trend of growth of population is given by the exponential curve: $P = 3079\, e^{0.350t}$ with a goodness-of-fit of 92%.

The decadal growth rate was fluctuating between 1961 and 1981, but it was well above 45%. In 1981, it became a Class II town with nearly 70,000 population. This phase starts when the Indian economy started becoming open and liberal. Apart from natural increase, low rate of cross-border infiltration and rural to urban migration the urban centers of India started growing mostly became of urban-to-urban migration. Better job opportunities, civic amenities and a higher level of aspiration worked as a pull factor for the urban centers. With the sustained growth rate, it became a Class I town in 1991 with the 100,000+ population. Between 1991 2001, the decadal growth rate was well over 125% with the population more than doubled. The last decade of 2001 11 saw a very stagnating growth rate of about 20.26% (fig.3).

Similarly, density of population increased from 416/km^2 in 1901 to 772/km^2 in 1951 by almost 86%. In 1961, density suddenly jumped to 2055/km^2 i.e., by about 166% during 1951 61. Since then, density steadily and rapidly increased to 8071/km^2 in 2011. The trend of growth of density can be described by the exponential curve $D = 176.1e^{0.321t}$ with a goodness-of-fit of 92%.

Urban Growth of Barasat Municipal Town

Large urban centers tend to develop where transportation and communication connect with each other. This attracts the populations from the peripheral areas and consequently, the distinction between the urban and rural administrative unit becomes less distinct. Barasat has been connecting with the state capital and India-Bangladesh border towns. Even this is the only corridor of North Bengal from South Bengal and several other parts. This is also connected by roads- NH 34, 35 and 3 state highways across this city. In a few cases, the growth of the urban center becomes so vigorous and the size of the core towns so large that the nearby rural areas are absorbed and merged to form cities. After the Partition of India, Barasat became the space of rehabilitation of Indians living in East Pakistan (Now, Bangladesh) and gradually started gaining density. Vacant cultivated land, fallows started filling with the human habitation.

Growth of Built-up Area

Urban growth and built up area grow pari pasu and with these grows the area covered by impervious layer. To assess the growth of built-up area multi-dated satellite images (1990, 2002, 2014) with the following spectral details have been processed:

1. LANDSAT 5/TM (WRS-2/138/44) dated 14/11/1990
2. Landsat7/ ETM+ (WRS-2/138/44) dated 17/11/2000
3. Landsat 8/OLI_TIRS (WRS-2/138/44) dated 20/03/2014

Urban growth is a dynamic phenomenon as it changes over time and space. With the steady and continuous growth of area under 'urban', there occurs more growth in the area with impervious surface and vice versa. The classified images vividly show the growth of the built-up area. A huge growth has taken place during 2002 2014. The open spaces between previously built-up areas of 1990 and 2002 were cemented in 2014's image (fig.5).

To identify the direction and magnitude of urban growth, the classified images of three temporal instances were overlaid where 'green' represents the urban growth up to 1990, 'yellow' from 1990 to 2002 and 'red' during 2002 2014. A circle has been drawn with 3 km radius centered on the foci of Barasat covering the built-up areas in 2014 and is then divided into 8 sectors corresponding to 8 cardinal directions. From the overlaid image, the built-up areas have been estimated within the circle for the eight different zones in three different dates.

The cumulative growth of built-up area illustrates its trend (fig.6). The urban nucleus appears to have expanded centrifugally in all directions along the major transport arteries, the most predominant direction being SW that gradually merges with the urban area of Madhyamgram municipality. During 1990 - 2002, urban expansion was very high toward NW, followed closely by S and SW. Between 2002 and 2014, it was very high toward SW followed by SE.

In aggregate terms, urban growth in terms of built-up area was the highest in the SW sector, closely followed by SE, NW, and E (Table - 2). From these, the expected urban growth has been computed using the following equation in all the eight sectors for two periods, viz. 1990 2002 and 2002 2014:

$$e = (r \times c) / g$$

Where, e = expected urban growth, r = row total, c = column total and g = grand total

The difference between the observed and expected values gives an idea of significant growth. A positive value indicates more spatial urban growth with certainty, zero indicates sustained urbanization while a negative value implies no significant growth or stagnation. Therefore, during 1990 02 significant urban growth took place in the NW, S and W sectors. The pattern changed significantly during 2002 -14 when significant growth took place in the SW, E, SE and N sectors (fig.7, Table 3,4,5,6). During 1990 2002, rate of urban expansion was very high in the SW sector, followed closely by E. Between 2002 and 2014, it was very high toward E followed by SW (Table 3,4,5,6).

Shannon's entropy (Ei) has been computed to identify the degree of urban sprawl through the efficient detection of land development (Yeh and Li, 2001):

$$E_i = -\sum_{j=1}^{z} P_j \log_e P_j$$

where, z = no. of zones, P_j = ratio of the built-up growth rate in jth column by its total.

During the two periods, 1990 - 02 and 2002 - 14, the entropy values have been computed as 1.93 and 1.89 respectively. It ranges from 0 to Log_e (z) or 0 to 2.08 with z = 8. Therefore, a value of half the 2.08 or 1.04 implies that the town is definitely and significantly sprawling. Entropy value ranges from Here the maximum limit of entropy is 2.08. The value closure to 0 means the distribution of built-up area is compact. If the value of entropy is more than half the way mark of a maximum limit of entropy (1.04), then it can be said that the city is sprawling. Hence, Barasat shows a sure sign of sprawling during both the periods, although the rate is marginally lower during 2002 - 14. The same principle has been used to compute the entropy values in all the eight sectors for the two time periods, viz. 1990 02 and 2002 - 14. With z = 2, Log_e (z) = 0.69 and [Log_e (z)] / 2 = 0.35 (Table - 13, 14, 15). It is found that sprawling is a fact in all the eight sectors, the highest being in S and NW closely followed W, SE, SW, and NE (fig.8). Urban growth away from the central focus of Barasat has also been computed in five concentric zones at the half-km interval (Table - 7).

The built-up areas for each concentric zones have been computed thereafter. From this, the cumulative growth of urban areas have been calculated (Table 8 to Table - 15). A high accumulation of built-up area is found nearly around 1 - 2 km zones, which gradually disperses further away with distance (fig.9).

The entropy values within the largest circle have been computed for the periods, viz. 1990 - 02 and 2002 - 14 as 1.72 and 1.64 respectively. With z = 6, Log_e(z) = 1.79 and [Log_e(z)] / 2 = 0.895. It is found that sprawling is a fact in the region. The entropy values decreased marginally signifying increasing disorganization in the system. The entropy value for each concentric zone has also been computed by dividing the growth rate of the built-up area in the i^{th} zone by the total built-up growth rate for all zones together (Table - 16). Entropy value ranges between 0.36 (1.5 to 2.0km) and 0.69 (within 0.5km). It steadily decreases up to 2 km and then increases up to 3km.

A density matrix has been prepared using a (3 x 3) kernel by computing the number of impervious pixels per kernel (i.e. 9 pixels). The whole image (fig.10) has been grouped into three density classes, viz., low, moderate and high. The low density is considered when there is 1 to 3 impervious pixels per kernel, moderate and high-density classes are respectively defined with 4 to 6 and 7 to 9 impervious pixels per kernel. Percentage of the total built-up area in each density class are then computed for 1990, 2002 and 2014.

Conclusion

The above analysis shows that the steady and rapid increase of population has sustained an increasing demand for housing. The average ratio of number of persons per household is decreasing constantly since 2001. Moreover, the shift from joint to nuclear family structure creates more pressure on demand of houses, further pushing the expansion of built-up areas. The cheaper land away from city centre favours random sprawling. People migrate from the rural core to the urban fringes in search of better living and job opportunities. Anticipating this, the real estate marketers purchase land at cheaper rate from the old residents and sell it off at higher prices by developing residential complexes along the major district roads and highways, e.g., Sprawling housing projects abound along the Jessore Road (NH-34 to Kolkata) and Barasat - Barrackpore road. The price of the 2BHK residential flats in such projects ranges from 10 - 30 lakh which is quite affordable to the middle and lower middle class households.

The built-up areas that invaded the rural landscape of Barasat have not grown vertically as 1 - and 2 - storey buildings predominate. The size of residential plots ranges between 1 to 3 katta in the form of low density residential areas. In the urban periphery, the migrants are living almost for the past 10 - 20 years. Thus, these built-up areas have mostly grown during the period, 2002 - 2014 at the cost of the vacant lands of the period, 1990 - 2002. Sprawling has been maximum along the Barasat-Barrackpore road towards northwestern direction and southern direction i.e. between NH-34 to Kolkata and Badu road. It is minimum along NH-34 to Krishnanagar in northern direction. Towards northeast (NH-35 to Bongaon), east (road to Taki), southeast (road to Badu) southwest (railway to Kolkata) and west (between railway to Kolkata and road to Barrackpore), sprawling has been taking place at a moderate pace. A decreasing trend of sprawling is found upto 2 km from the town / city center being more near the urban fringe. High-density sprawl is found towards south-west along NH- 35 and railway to Kolkata. The low-density one is found towards north-west between Barrackpore and Sodepur roads. The same feature is found the north-eastern side of Barasat along the railway to Bongaon. It is also common in southern parts between NH 34 (to Kolkata) and Badu road. Ribbon or strip sprawl is found mainly along Badu road up to Kharibari along Taki road. Leapfrog sprawl is dominant mainly between NH 35 (to Bongaon) and Taki road in the eastern direction, and between NH 34 (to Krishnanagar) and Barrackpore in northern direction. More scattered patches of built-up areas are foundn between Taki and Badu road in south-eastern direction.

References

1. Ahmad, F., & Goparaju, L. (2016). Analysis of urban sprawl dynamics using geospatial technology in Ranchi City, Jharkhand, India. *Journal of Environmental Geography*, *9*(1-2), 7-13.
2. Alabi, M. O. (2009). Urban sprawl, pattern and measurement in Lokoja, Nigeria. *Theoretical and Empirical Researches in Urban Management, 4* (13), 158-164.
3. Barnes, K. B., Morgan III, J. M., Roberge, M. C. & Lowe, S. (2001 a). *Sprawl development: Its patterns, consequences, and measurement.* Towson University, Towson, 1-24.
4. Barnes, K. B., Morgan, J. & Roberge, M. (2001 b). *Impervious surfaces and the quality of natural and built environments.* Baltimore: Department of Geography and Environmental Planning, Towson University.
5. Basawaraju, R., et al. (2011). Analysis of the impact of urban sprawl in altering the land-use, land-cover pattern of Raichur City, India, using geospatial technologies. *Journal*

of Geography and Regional Planning., 4(8), 455-462.
6. Batty, M., Xie, Y. and Sun, Z., (1999). The dynamics of urban sprawl. CASA Working Paper 15, University College London, Centre for Advanced Spatial Analysis (CASA), London.
7. Bhat, P. A., ul Shafiq, M., Mir, A. A., & Ahmed, P. (2017). Urban sprawl and its impact on landuse/land cover dynamics of Dehradun City, India. *International Journal of Sustainable Built Environment*, *6*(2), 513-521.
8. Bhatta, B. (2010). *Analysis of urban growth and sprawl from remote sensing data, Advance in Geographic Information science*, Heidelberg, Springer Science & Business Media.
1. Bhattacharjee D and Hazra S (2019): The role of urban momentum in transformation of North 24 Parganas District, West Bengal. IJRC, Special Volume, pp106-118.
9. Brueckner, J.K. (2000). Urban sprawl: Diagnosis and remedies. *International Regional Science Review, 23*(2), 160-171
2. Census of India, 1991 to 2001, West Bengal Series 20, Directorate of Census Operations, West Bengal, Paper I. Http://censusindia.gov.in/
10. Chakraborty, S., Chatterjee, S., Das, K., & Roy, U. (2015). Changing Pattern of Urbanization in West Bengal: An Analysis of 2011 Census of India Data. *Asian Journal of Research in Social Sciences and Humanities*, *5*(5), 169-181.
11. Chatterjee, N. D., Chatterjee, S., & Khan, A. (2016). Spatial modeling of urban sprawl around Greater Bhubaneswar city, India. *Modeling Earth Systems and Environment*, *2*(1), 1 - 21.
12. Clawson, M. (1962). Urban Sprawl and Speculation in Suburban Land. *Land Economics 38*(2), 94-111
14. Couch, C., Petschel-Held, G., & Leontidou, L. (Eds.). (2008). *Urban sprawl in Europe: landscape, land-use change and policy*. London. Wiley-Blackwell.
15. Das, T., Chakraborty, S., & Samanta, K. (2016). Urban sprawl and urban growth detection analysis: A comparative study of Kolkata municipal corporation and Haora municipal corporation. *International journal of Geomatics and Geosciences*, *7*(1), 82-92.
16. Epstein, J., Payne, K., Kramer, E., 2002. Techniques for mapping suburban sprawl. *Photogrammetric Engineering and Remote Sensing, 63* (9), 913-918
17. Ewing, R. (1994), Characteristics, Causes and Effects of Sprawl: A Literature Review, *Environmental and Urban Issues*. FAU/FIU Joint Center.
18. Ewing, R., Pendall, R. and Chen, D. (2002). Measuring Sprawl and Its Impact: Volume I. Washington DC: Institute for Transportation & Development Policy.
19. Farooq, S., & Ahmad, S. (2008). Urban sprawl development around Aligarh city: a study aided by satellite remote sensing and GIS. *Journal of the Indian Society of Remote Sensing, 36*(1), 77-88.
20. Frenkel, A. and Ashkenazi, M. (2008). Measuring urban sprawl: how can we deal with it? *Environment and Planning B: Planning and Design, 35*(1), 56 - 79
21. Glaeser, E. L., & Kahn, M. E. (2004). Sprawl and urban growth. In *Handbook of regional and urban economics. 4,* 2481-2527.
3. Hauser PM, Duncan OD (1954):. The study of population - An inventory and appraisal. The University of Chicago Press; 34. Available: https://www.economist .com/special-report/2012/02/04/the-lure-of-the-city
22. Heikkila, E. J., & Peiser, R. B. (1992). Urban sprawl, density, and accessibility. *Papers in Regional Science, 71*(2), 127-138.
23. Jat, M. K., Garg, P. K., & Khare, D. (2008). Monitoring and modelling of urban sprawl using remote sensing and GIS techniques. *International journal of Applied earth Observation and Geoinformation, 10(1),* 26-43.
24. Jha, R., Singh, V. P., & Vatsa, V. (2008). Analysis of urban development of Haridwar, India, using entropy approach. *KSCE journal of Civil Engineering*, *12*(4), 281-288.
25. Kalota, D. (2015). Assessment of urban sprawl using landscape metrics: A temporal analysis of Ludhiana city in Punjab. *International Journal of Advances in Remote Sensing and Geoscience*, *4*(1), 45-54.
26. Kumar, A., Pandey, A. C., Hoda, N., & Jeyaseelan, A. T. (2011). Evaluating the long-term urban expansion of Ranchi urban agglomeration, India using geospatial technology. *Journal of the Indian Society of Remote Sensing*, *39*(2), 213-224.
27. Lata, K. M., Rao, C. S., Prasad, V. K., Badarianth, K. V. S., & Rahgavasamy, V. (2001). Measuring urban sprawl: a case study of Hyderabad. *GIS development*, *5*(12), 26-29.
4. Lauther, W (2011): The urban plan for India: A foundation for economic growth. Global Majority E-Journal. 2011;2(2).
5. MHUPA (2016): India Habitat III National Report 2016. New Delhi: Ministry of Housing and Urban Poverty Alleviation.
28. Mills, David E. 1980. Growth, Speculation, and Sprawl in a Monocentric City. *Journal of Urban Economics, 10* (2), 201-226.
29. Mitchell, J. G. (2001). Urban Sprawl: The American Dream? *National Geographic 200*(1), 48-73.
6. Mitra (Sinha) B and Pahari, DP (2019): Journal of Geography, Environment and Earth Science International 21(2): 1-16, Article No.JGEESI.49191
30. Nechyba, T. J., & Walsh, R. P. (2004). Urban sprawl. *Journal of economic perspectives, 18*(4), 177-200.
7. Potter P. Contemporary issues in Geography, urbanisation in the Third World. Oxford University Press. 1992:5.
31. Radhakrishnan, N., Eerni, S. K., & Kumar, S. (2014). Analysis of urban sprawl pattern in Tiruchirappalli city using applications of remote sensing and GIS. *Arabian Journal for Science and Engineering*, *39*(7), 5555-5563.
32. Rahman, A., Aggarwal, S. P., Netzband, M., & Fazal, S. (2011). Monitoring urban sprawl using remote sensing and GIS techniques of a fast growing urban centre, India. *IEEE Journal of selected topics in applied earth observations and remote sensing, 4* (1), 56-64.
33. Sahana, M., Hong, H., & Sajjad, H. (2018). Analyzing urban spatial patterns and trend of urban growth using urban sprawl matrix: A study on Kolkata urban agglomeration, India. *Science of the Total Environment*, *628*, 1557-1566.

34. Sankhala, S., & Singh, B. (2014). Evaluation of urban sprawl and land use land cover change using remote sensing and GIS techniques: a case study of Jaipur City, India. *Int. J. Emerging Technol. Adv. Eng*, *4*(1), 66-72.
8. Sarkar A. Evolution of the size and spacing of Urban Settlement in West Bengal. Unpublished Ph.D Thesis. 1991;37:42-44.
9. Sarkar JP: Bangladeshi migration to West Bengal: A cause of Concern, centre for the Study regional development, JNU, India; 2006.
35. Sarkar, A. (1997). *Urban Growth, Urbanization and Urban Hierarchy in the 20th Century West Bengal.* New Delhi, New Academic Publisher.
36. Singh, B. (2014). Urban growth using Shannon's Entropy: A case study of Rohtak city. *International Journal of Advanced Remote Sensing and GIS*, *3*, 544-552.
10. Subbarayan, A. and Kumar, G. (2016). Overall size distribution of cities and towns in India: 2011 census. Journal of Applied Sciences, 16(5), 230-235.
37. Sudhira, H. S., Ramachandra, T. V., Raj, K. S., & Jagadish, K. S. (2003). Urban growth analysis using spatial and temporal data. *Journal of the Indian Society of Remote Sensing, 31*(4), 299-311.
38. Sun, H., Forsythe, W., & Waters, N. (2007). Modeling urban land use change and urban sprawl: Calgary, Alberta, Canada. *Networks and spatial economics, 7*(4), 353-376.
39. Swerts, E., Pumain, D., & Denis, E. (2014). The future of India's urbanization. *Futures*, *56*, 43-52.

Table – 1: Trend of Growth of Barasat Municipality

Year	Area (Sq.km)	Population	Decadal Variation (%)	Population Density (persons/sq.km)
1901	20.77	8634	-	416
1911	20.77	8790	1.81	423
1921	20.77	8211	-6.59	395
1931	20.77	8672	5.61	418
1941	20.77	11230	29.50	541
1951	20.77	16027	42.72	772
1961	14.25	29281	82.70	2055
1971	14.25	42642	45.63	2992
1981	20.25	69586	63.19	3436
1991	20.25	102660	47.53	5070
2001	34.50	231521	125.52	6711
2011	34.50	278435	20.26	8071

Source: Computed by authors from different Census Reports, 1901-2011

Table – 2: Cumulative Growth of Built-Up Area

sq. km.

Year	N	NW	E	SE	S	SW	W	NW
Upto1990	0.24	0.19	0.12	0.21	0.2	0.16	0.15	0.24
Upto 2002	0.42	0.41	0.33	0.5	0.51	0.46	0.38	0.59
Upto 2014	1.16	1.25	1.42	1.67	1.4	1.9	1.19	1.55

Source: Computed and Tabulated by Author

Table – 3: Observed Growth in Built-Up Area of Barasat

sq. km

Year	N	NE	E	SE	S	SW	W	NW	Row Total
1990 - 2002	0.18	0.22	0.21	0.29	0.31	0.30	0.23	0.35	2.09
2002 - 2014	0.74	0.84	1.09	1.17	0.89	1.44	0.81	0.96	7.94
Column Total	0.92	1.06	1.30	1.46	1.20	1.74	1.04	1.31	10.03

Source: Computed and Tabulated by Author

Table – 4: Growth Rate for 12-Yearly Period of Barasat

? %

Year	N	NE	E	SE	S	SW	W	NW
1990 - 2002	75.00	115.79	175.00	138.10	155.00	187.50	153.33	145.83
2002 - 2014	176.19	204.88	330.30	234.00	174.51	313.04	119.00	162.71

Source: Computed and Tabulated by Author

Table – 5: Expected Growth for 12-Yearly Period of Barasat

ə *sq.km*

Year	N	NE	E	S E	S	SW	W	NW
1990 - 2002	0.19	0.22	0.27	0.3	0.25	0.36	0.22	0.27
2002 - 2014	0.73	0.84	1.03	1.16	0.95	1.38	0.82	1.04

Source: Computed and Tabulated by Author

Table – 6: Difference between Observed and Expected Built-up Area of Barasat

sq.km

Year	N	NE	E	SE	S	SW	W	NW
1990 - 2002	-0.01	0	-0.06	-0.01	0.06	-0.06	0.01	0.08
2002 - 2014	0.01	0	0.06	0.01	-0.06	0.06	-0.01	-0.08

Source: Computed and Tabulated by Author

Table – 7: Shannon's Entropy of Each Zones of Barasat

Zones	N	NE	E	SE	S	SW	W	NW
Entropy	0.61	0.66	0.65	0.66	0.69	0.66	0.68	0.69

Source: Computed and Tabulated by Author

Table – 8: Total Area of the Zones (Barasat)

Zones	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km
Area (sq.km.)	0.79	2.35	3.93	5.50	7.06	8.64

Source: Computed and Tabulated by Author

Table – 9: Observed Built-Up Area in the 6 Concentric Zones

sq. km.

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km
upto 1990	0.24	0.20	0.13	0.22	0.30	0.40
1990 – 2002	0.22	0.40	0.33	0.28	0.39	0.51
2002 – 2014	0.24	1.09	1.86	2.10	1.57	1.33

Source: Computed and Tabulated by Author

Table – 10: Cumulative Growth of Built-Up Area in 6 Concentric Zones

sq.km

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km
upto 1990	0.24	0.20	0.13	0.22	0.30	0.40
upto 2002	0.46	0.60	0.46	0.50	0.69	0.91
upto 2014	0.70	1.69	2.32	2.60	2.26	2.24

Source: Computed and Tabulated by Author

Table – 11: Observed Growth of Built-Up Area in the 6 Concentric Zones

sq.km

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km	ROW TOTAL
1990 - 2002	0.22	0.4	0.33	0.28	0.39	0.51	2.13
2002 - 2014	0.24	1.09	1.86	2.1	1.57	1.33	8.19
Column Total	0.46	1.49	2.19	2.38	1.96	1.84	10.32

Source: Computed and Tabulated by Author

Table – 12: Growth Rate of Built-Up Area for 12-Yearly Period in the 6 Concentric Zones

%

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km	Total
1990 - 2002	91.67	200	253.85	127.27	130	127.5	930.29
2002 - 2014	52.17	181.67	404.35	420	227.54	146.15	1413.88

Source: Computed and Tabulated by Author

Table – 13: Expected Growth of Built-Up Area in the 6 Concentric Zones

sq.km

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km	Total
1990 - 2002	0.09	0.31	0.45	0.49	0.40	0.38	0.09
2002 - 2014	0.37	1.18	1.74	1.89	1.56	1.46	0.37

Source: Computed and Tabulated by Author

Table – 14: Difference between the Observed and Expected Built-Up Growth of Barasat

sq.km

	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km	Total
1990 - 2002	0.13	0.09	-0.12	-0.21	-0.01	0.13	0.13
2002 - 2014	-0.13	-0.09	0.12	0.21	0.01	-0.13	-0.13

Source: Computed and Tabulated by Author

Table – 15: Shannon's Entropy of Each Zones of Barasat

Zones	upto 0.5 km	0.5 – 1 km	1 – 1.5 km	1.5 – 2.0 km	2.0 – 2.5 km	2.5 – 3.0 km
Entropy	0.69	0.58	0.42	0.36	0.50	0.60
$\text{Log}_e t$	0.69	0.69	0.69	0.69	0.69	0.69
$\text{Log}_e (t) / 2$	0.35	0.35	0.35	0.35	0.35	0.35

Table – 16: Change in Density of Built-Up Area, Barasat Municipality

Density Classes	Density (1990)		Density (2002)		Density (2014)	
	Total Impervious Area (%)	Area (sq km)	Total Impervious Area (%)	Area (sq km)	Total Impervious Area (%)	Area (sq km)
Low	44.52	4.55	44.34	6.27	27.66	8.83
Moderate	41.59	4.25	40.95	5.79	39.57	12.63
High	13.89	1.42	14.71	2.08	32.77	10.46
Total	100	10.22	100	14.14	100	31.92

Source: Computed and Tabulated by Author

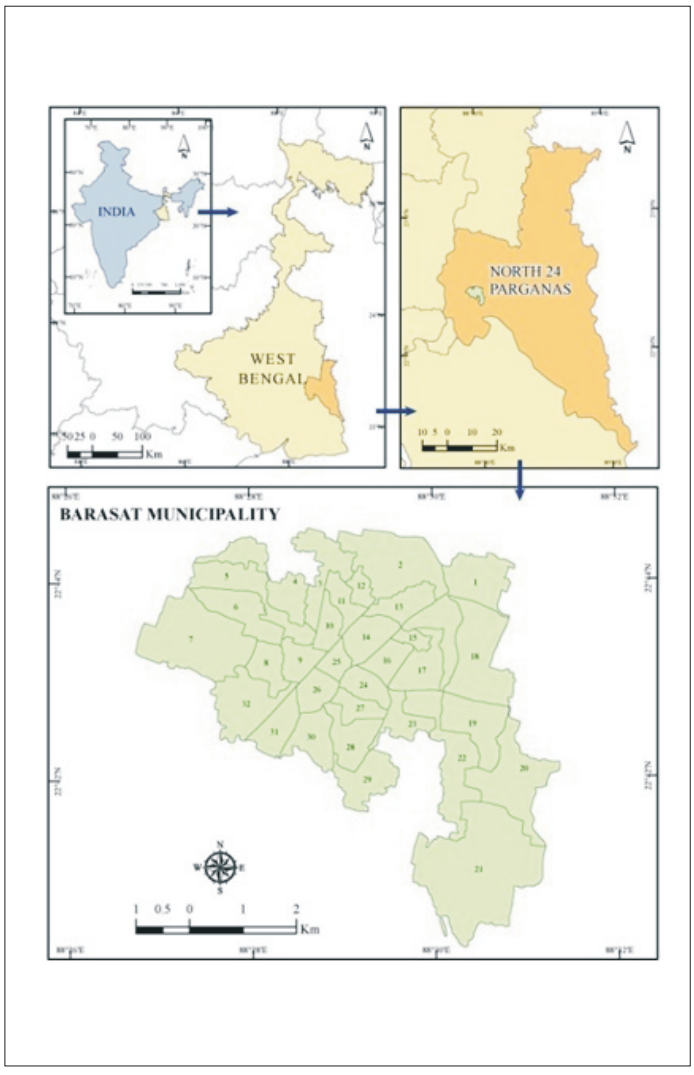

Fig. 1: Location of the Study Area

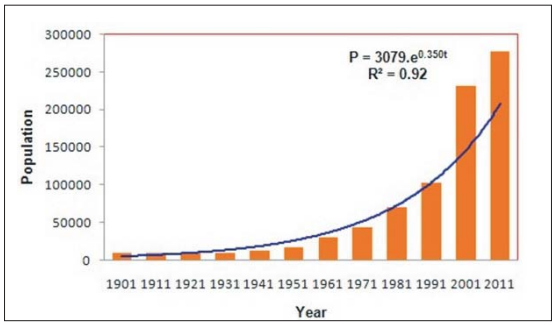

Fig. 2: Trend of Population Growth, Barasat 1901 - 2014

Fig. 3: Decadal Growth of Population, Barasat Municipality

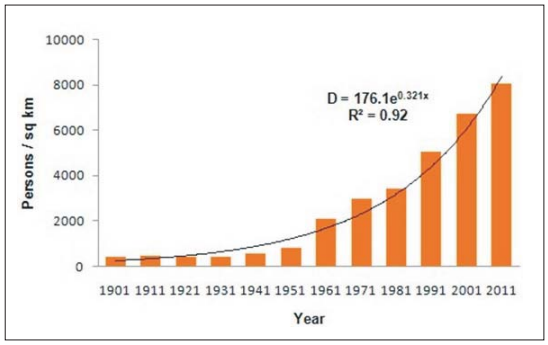

Fig. 4: Trend of Population Density, Barasat 1901 - 2014

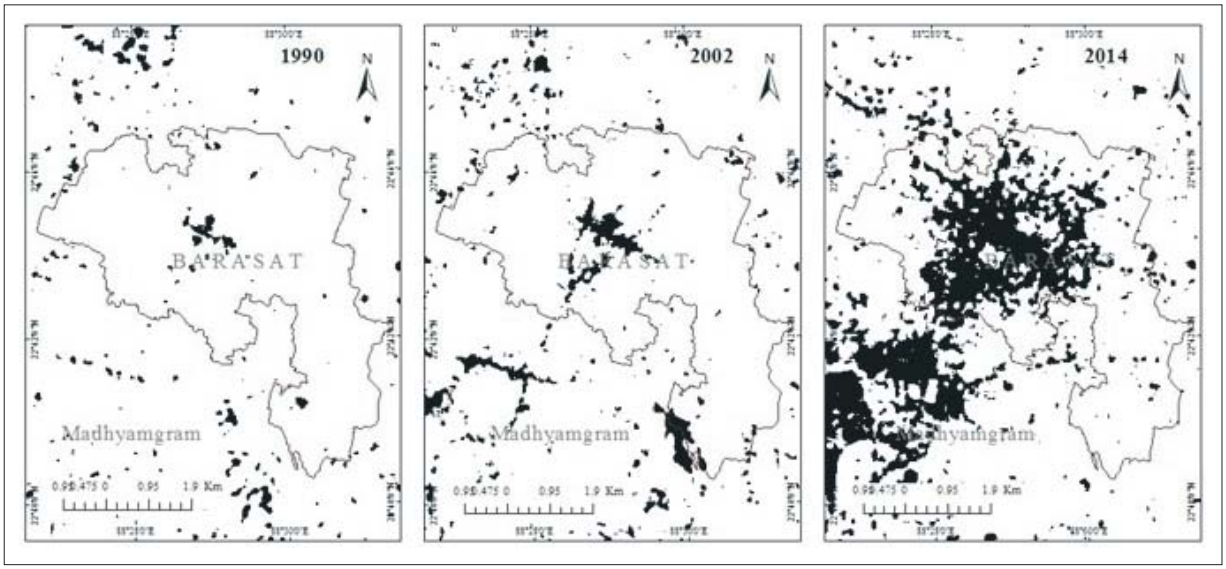

Fig. 5: Growth of Built-up Areas in Barasat, 1990 - 2014

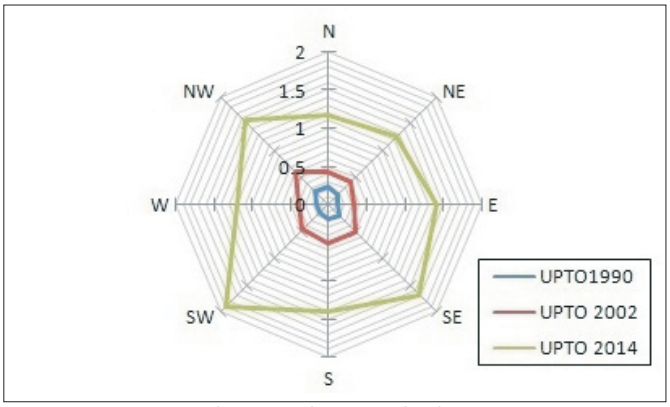

Fig. 6: Urban Growth in 8 Cardinal Directions

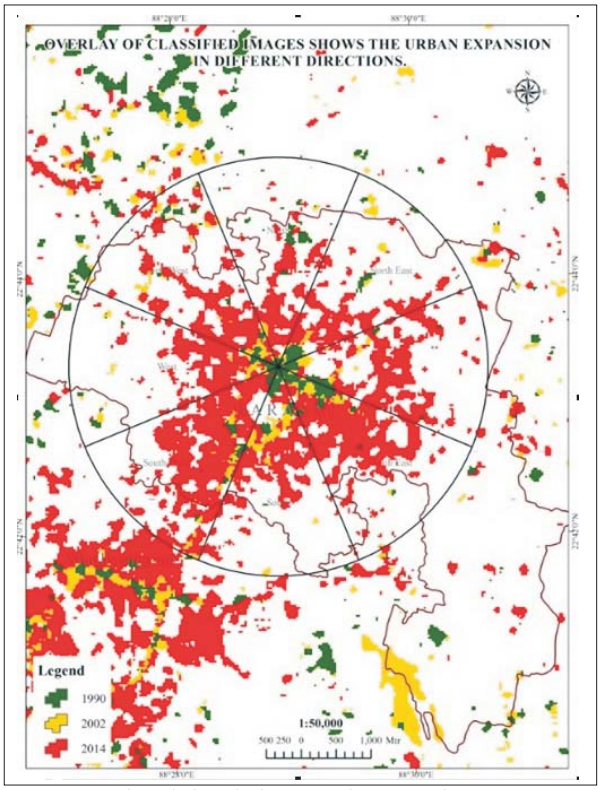

Fig. 7: Overlay of Classified Images showing Urban Expansion in Radial Directions

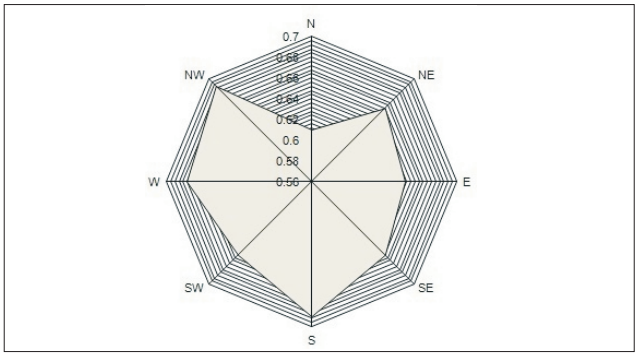

Fig. 8: Sprawling in Eight Segments

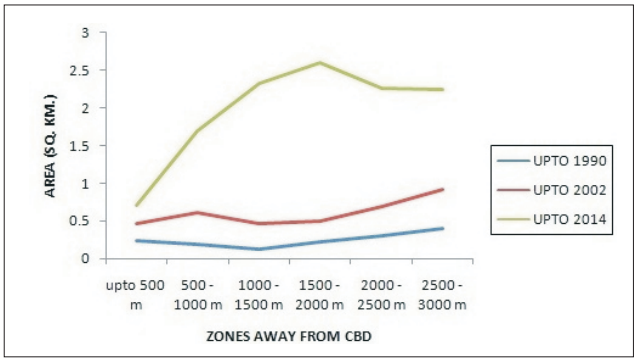

Fig. 9: Distribution of Urban Area with Distance from Town Center

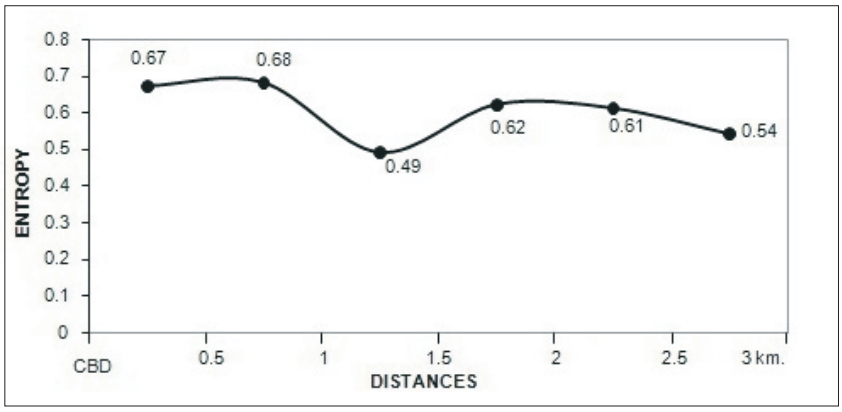

Fig. 10: Sprawling away from the Center of Barasat

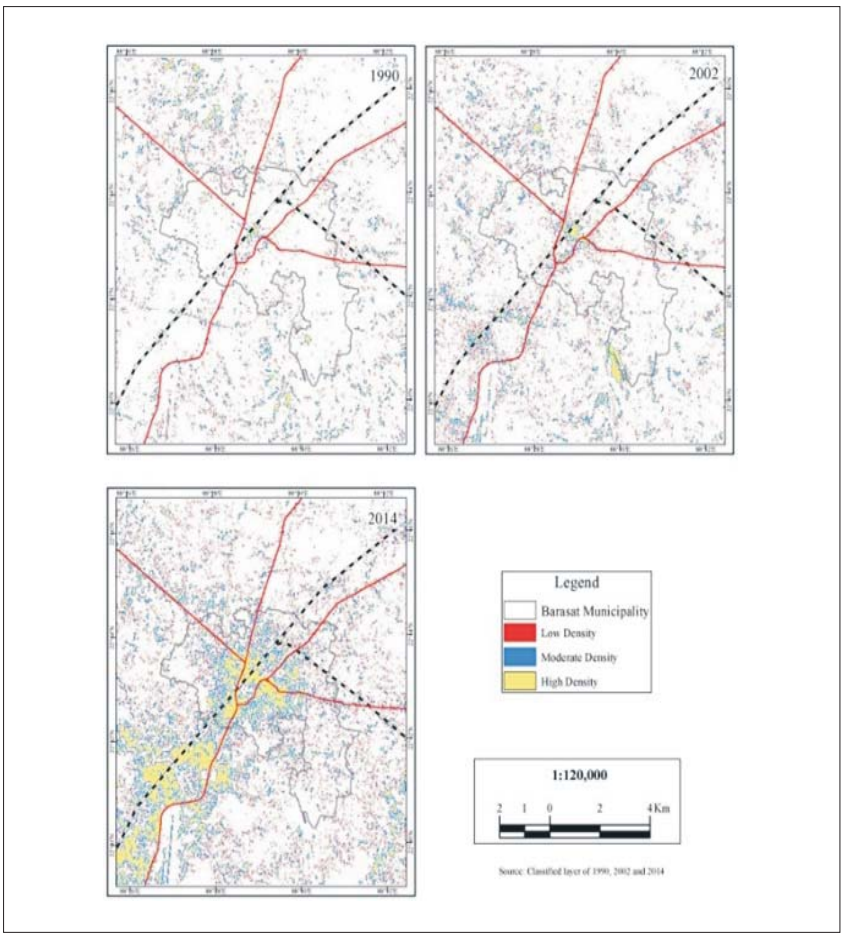

Fig. 11: Change of built-up Density of Barasat

Debasmita Biswas#
Assistant Professor
PG Department of Geography
Chandernagore College, Chandernagore, Hooghly
Email: debasmitaa@gmail.com

Prof Ashis Sarkar (retd)
Professor and HOD of Geography,
Presidency College/ University, Kolkata and
Chandernagore College, Chandernagore, West Bengal
Email: profdrashis@gmail.com