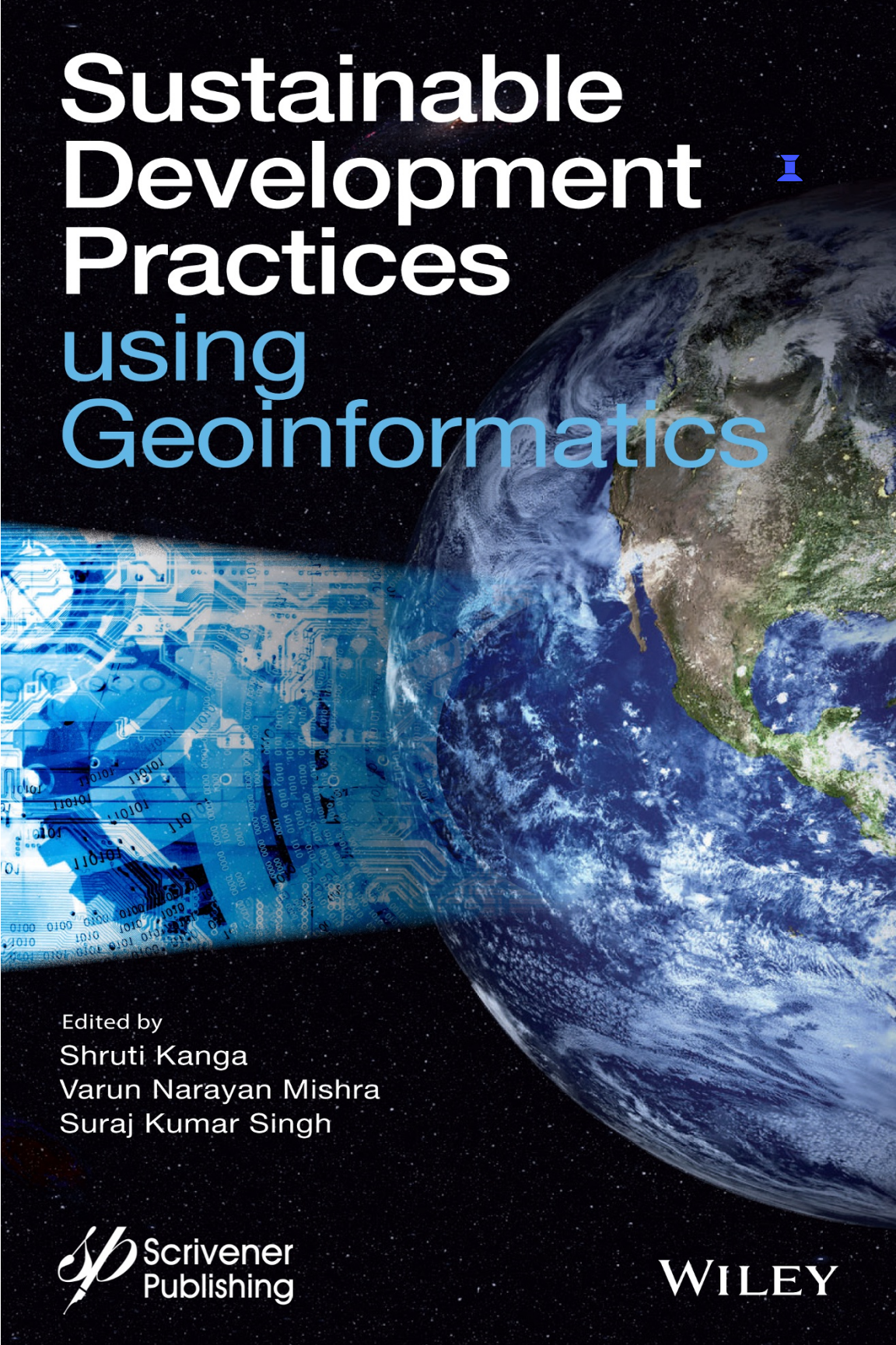
Sustainable Development Practices using Geoinformatics



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Contents

Preface

The sustainable development refers to the qualitative and quantitative stability in the use of natural resources. It involves equilibrium between anthropogenic activities as influenced by social activities, acquired knowledge, applied technology, and food production. Sustainability attempts to address the issues such as resource degradation, deforestation, ecosystem loss, and environmental deterioration from global to local scale. The sustainable use and management of essential natural resources cannot be done without considering the direct and indirect impacts of human. It is required to apply an interdisciplinary approach in order to ensure long-term conservation of natural resources and its sustainable use at ecological and socioeconomic perspectives.

Geoinformatics, including Remote Sensing (RS), Geographical Information System (GIS), and Global Positioning System (GPS), has tremendous potential to effectively monitor the natural resources and addressing the concerns related to sustainable development and planning of society. RS is a quick and cost-effective technique to measure the location and spectral properties of earth surface features in comparison to traditional ground-based surveying. It provides reliable geospatial information for comprehensive sustainable development plans, policy making, and decision. GIS is a computer-based system used to digitize remotely sensed data matched with various ground-truth data, which are geo-coded using a GPS. It is able to manipulate, analyze, and display spatial database. Applications of Geoinformatics include land use change and planning, agriculture and soil, water resource management, forest resource mapping and management, glacier mapping and monitoring, climate change, disaster management, and many more.

Sustainable applications of Geoinformatics have become more essential in understanding various characteristics of Earth surfaces with the launch of Landsat mission in the 1970s. Many studies of direct relevance to the sustainable development and management have been reported. However, few studies have been reported using the harmonized approach of core science

and research basics, as there are larger concerns of capacity building to use Geoinformatics in sustainable development practices and management. This could be overcome by taking the advantages of Geoinformatics into consideration to the scientific and research communities. The book entitled "Sustainable Development Practices Using Geoinformatics" contains chapters written by well-known researchers, academicians, and experts. The potential readers of this book are scientists, environmentalists, ecologists, policy makers, administrators, university students, urban planners, land managers, and professionals working in the field of sustainable development and management of natural resources.

In Chapter 1, multi-temporal Landsat images are used to investigate the change in variability of surface temperature in the Barasat municipal area, West Bengal, India. A correlation analysis is performed between Normalized Difference Vegetation Index (NDVI), and Land Surface Temperature (LST) to show the urban growth and its pattern and trend in relation to surface temperature variation. This study is very useful for investigating the changes in environmental condition due to human activity in an urban area.

In Chapter 2, attempts are made to estimate the geo-environmental hazards and risks in South Karanpura Coalfield region using information on land use/land cover (LU/LC), aerosol optical thickness (AOT), precipitable water vapor (PWV), and temperature conditions integrated with socio-economic vulnerability using Geoinformatics approach. Most of the risk-prone zones are found to present in the vicinity of industry and mining areas with higher population density. This study provides a basis to allocate resources for risk mitigation, improve community preparedness, and prepare cost-effective emergency planning.

In Chapter 3, a co-polarized radar system is investigated for the estimation of soil moisture along specular direction. The data are collected by indigenously designed ground-based scatterometer system for 20°–60° incidence angles at steps of 10° in the specular direction for HH- and VV-polarizations at L-band. In this study, a hybrid machine learning algorithm combined with fuzzy inference system and artificial neural network called neuro-fuzzy inference system were evaluated for the estimation of soil moisture. The performance index Root Mean Squared Error (RMSE) was used to evaluate the estimation efficiency of the algorithm. This study is very useful for accurate and timely soil moisture estimation for agricultural practices.

In Chapter 4, a study is conducted for detailed morphometric analysis of Tapi basin using Geographic Information System (GIS) technique. Different morphometric parameters analyzed, *viz*., stream order, stream

length, bifurcation ratio, drainage density, relief ratio, drainage density, stream frequency, texture ratio, form factor, circulatory ratio, elongation ratio, etc., are calculated. The stream order of the basin is mainly controlled by lithological and physiographic conditions of the area. The present study will be helpful for sustainable water resource management and agricultural applications.

In Chapter 5, the demand for fossil fuels is increasing speedily with the rapid population growth and development. It is a leading factor of greenhouse gases emission, global warming, and climate change. There are some satellites are available to monitor the concentration of these gases in the atmosphere. This chapter described the importance and capacity of GOSAT satellite to observe and monitor the global distribution of carbon dioxide (CO_2). The kriging method is applied to analyze the global distribution of CO_2 during 2009 to 2020 for the months of December, January, February, and March.

In Chapter 6, a study is performed for micro-level planning and development of natural resources available in Jangal Aurahi village, Gorakhpur district, using high resolution satellite images like CARTOSAT-I, LISS IV merged, and DEIMOS. The basic objectives are to map, monitor, and manage existing resources, facilities, and infrastructures of a village. This kind of study will be very useful for the decision makers and planners to prepare the action plans for all the resources available within the rural area

In Chapter 7, land suitability evaluation has been performed for potato crop in the Sagar Island using multi-criteria decision-making (MCDM) and Analytical Hierarch Process (AHP) methods. To find out more accurate suitability for potato crops, the derived suitability zones for the have been veteran by compared criteria-based suitability map and present land-use map using weighted sum overlay techniques in spatial analysis method. The techniques employed in this study provide valuable information that could be utilized by farmers to choose the suitable cultivation areas for potatoes at local level.

In Chapter 8, a geospatial technology assisted overlay and index approach is applied to derive a landslide susceptibility zonation map for Western Ghats, India. Different thematic layers responsible for landslide are developed in GIS platform. The sub-class weightage indexes are feed in to the respective thematic layer in the GIS platform to generate landslide vulnerability zonation map into very low, low, moderate, high, and very high categories. An accurate spatial mapping of landslide vulnerability is important for disaster mitigation and regional planning.

In Chapter 9, the underground mining activities may have devastating effect on the forest land and its soil. This chapter provided the review of

existing information of the subsidence impacts on forest lands. It showed that there are reasonably impacts on the topography, hydrology, and soil properties of the area. These multiple impacts need to be considered at local level with particular concern to the interaction of subsidence disturbances with the forest ecosystems. This work can be useful to suggest appropriate adaptation strategies during subsidence for the suitable sustenance of healthy forest environments.

In Chapter 10, an approach based on GI Science is demonstrated for Morphometric analysis of Gomati watershed from the lesser Himalaya terrain in district Bageshwar, Uttarakhand. Several morphometric parameters are calculated and analyzed. The drainage density for Gomati river basin is found to be 0.81 km/km^2 which show the high runoff in the channels. The methods utilized in this study will be helpful for the planners and decision makers in the development and management of the basin.

In Chapter 11, water is an essential natural resource for human being. The adequate supply of water is of highest importance for survival. In this paper, water audit has been attempted for the campus of Birla institute of Technology, Mesra, Ranchi with case studies of two hostels. The water audit is assessed lobby wise to conclude the gaps. Water harvesting potentials was assessed for the study area, and recommendations were made for water management and planning.

In Chapter 12, this study is conducted to analyze LULC changes during the period of 2006 to 2017 in Durg block of Chhattisgarh state, India using multi-temporal Landsat satellite imageries. Thematic layers and maps for the year of 2005 and 2016 (post-monsoon) and 2006 and 2017 (pre-monsoon) are prepared. A map is generated for LULC change analysis with the help of the intersection tool. The LULC categories showed changing patterns during the period. This type of study can be very useful for policy makers and planners for the management of land resources.

In Chapter 13, this study attempts to apply livelihood vulnerability index (LVI) for the assessment of the livelihood risks of the vulnerable communities because of climate change. The socio-economic vulnerabilities suggested by IPCC's three contributing factors such as exposure, sensitivity, and adaptive capacity of the region are taken into consideration. The study revealed that livelihood options in the region are limited and mainly dependent on agriculture and labor sector. The communities in the region are highly vulnerable due to changing climatic conditions.

In Chapter 14, this work is carried out for suitable site selection for the sustainable urban groundwater management in the Dhanbad Block in Jharkhand state, India. Different datasets such as Landsat 8 satellite image, DEM, Toposheet, and secondary data are used in this study. It facilitated

to know the complexities of a dynamic phenomenon like suitability site sustainable water management, land use/land cover benefits, and urban development planning pattern. The weights have been assigned to different layers as per the need for the acceptable site selection for the sustainable groundwater management planning.

In Chapter 15, this paper presents a study to detect changes in land use and land cover over a period of 30 years from 1988 to 2018 in the Kamrup district of Assam, India. Multi-temporal Landsat satellite images of year 1988, 1998, 2008, and 2018 are used in this study. The images are classified into different categories using visual interpretation and manual digitization methods. The change matrix approach is used for evaluating the net loss and gain of different land use and land cover classes. This study can be useful for sustainable urban management and land use planning in the region.

In Chapter 16, on May 03, 2019, a rare summer cyclone named "*Fani*" hit Puri, a small coastal town of Odisha, India. This cyclone resulted into the loss of 64 human lives and affected about 16.5 million people in 18,388 villages of the entire state. It also severely affected power, telecommunication infrastructure, and road services. The damage to housing has been extensive, particularly in the Puri district of Odisha. This examines how climate resilient houses with "Build Back Better" features can save valuable human lives through use of eco-friendly, durable, cost effective, and non-pollutant building materials.

In Chapter 17, disasters resulting in substantial loss of deaths, disruption of normal life, and the developmental process for years to come. This paper systematically describes the application Geoinformatics technique for disaster management. It has robust data handling capabilities that is ideal for disaster risk reduction, mitigation, and management from global to local scales. This technique is capable to create awareness to dissemination of information during disaster mitigation, preparedness, and response as part of disaster management measures.

In Chapter 18, the food processing industries play a key role in economic development of any country. This work analyzes the locational factors how favored in rice mill clustering in Ernakulam district, Kerala state, India. The environmental concerns were identified through field and house hold survey in the select areas or panchayats of Kalady, Okkal, and Koovappady. The physio-chemical analysis of waste water effluent carried out revealed the organic and inorganic presence of the pollutants and its extent.

In Chapter 19, this study demonstrates the importance of the Digital Elevation Model (DEM) and satellite images for evaluation of drainage and extraction of their relative parameters for the Wainganga River watershed

area of the Godavari River, India. Several hydrological parameters including drainage analysis, topographic parameters, and land use patterns were evaluated and interpreted. The climatic condition based on hydrological investigation, of the basin is characterized by hot summer from March to May followed by a rainy season from June to September using.

This edited book entitled "Sustainable Development Practices Using Geoinformatics" contains chapters written by prominent researchers and experts. The key focus of this edited book entitled "Sustainable Development Practices Using Geoinformatics" is to replenish the available resources on the topic by integrating the concepts, theories, and experiences of the experts and professionals in this field.

Acknowledgement

The completion of this edited book entitled "Sustainable Development Practices Using Geoinformatics" could not have been possible without the grace of almighty God.

We are grateful to Hon'ble Sunil Sharma, Chairperson, Suresh Gyan Vihar University, Jaipur for his encouragement and support. The words cannot express our indebtedness to Hon'ble Dr. Sudhanshu, Chief Mentor, Suresh Gyan Vihar University, Jaipur for his continuous guidance, expert suggestions and motivation during the completion of this edited book.

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Dr. Shruti Kanga
Dr. Varun Narayan Mishra
Dr. Suraj Kumar Singh
Editors
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The Impact of Rapid Urbanization on Vegetation Cover and Land Surface Temperature in Barasat Municipal Area

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Abstract

India is a developing country and its growing phase is facing the trio of urbanization, modernization, and globalization. The study pertains to find out the impacts of rapid urban development on vegetation cover and its inter-relationship with the variability of Land Surface Temperature (LST). The study area, Barasat municipality, is facing rapid urbanization since mid of 1990s; hence, the number of people residing in Barasat is increasing rapidly, resulting in dense, concrete, and high-rise buildings. The Barasat city is adjacent to Kolkata metropolitan city and is a part of Greater Kolkata. Therefore, there is escalation in number of multi-storied buildings along with proliferating population leading to urban sprawl in the study area. These facts promote Barasat to be an Urban Heat Island (UHI). The study aims to show the change in variability of surface temperature from 2001 to 2017 with the help of geospatial techniques and using Landsat data of multiple dates in order to uncover the modification/variation in the urbanization and then correlate it with NDVI (Normalized Difference Vegetation Index), and LST. The 17 years' time scale is very small period for change detection of urban land use change but enough to show the urban growth and its pattern and trend in relation to surface temperature variation. The remote sensing and GIS provides very useful tool for the analysis of changes in environmental condition due to human activity in the study area.

Keywords: Urbanization, UHI, NDVI, LST

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1.1 Introduction

Urban land is primary resultant feature on the Earth surface, induced by human activities from centuries. Urban area is defined as the area having facilities of higher administrative departments in which most of the population belong to secondary and tertiary division, these segments comprises a city or a town, etc. (McGranahan, Satterthwaite, and International Institute for Environment and Development 2014). Urbanization can be simply defined as the conversion of any spatial entity from rural to urban with the help of technology and sustainable uses of resources (Datta 2007). Since ancient era, modification, and transformation of the geographical areas are steady, and great example of this is urban landform. World's earliest industrial revolution took place in Britain in the 18th century, which caused the rural mass movement toward cities. This era was considered to be the footstep of urbanization. However, in India, the wind of urbanization was initiated by the Britishers, while India being once a domicile of British Empire. The modification in the settlements and settlement zone continue to vary till date, which commences urban sprawl (Narayan 2014).

In the phases of urban development, continuous changes on land surface are observed, from small houses to tall buildings, agriculture to industry, pervious surface to impervious (paved) surface, kaccha road to highway, etc. (Grimmond 1998; Gál and Unger 2009). The two most important controlling factors responsible for the development and also retreat of urban region are pull factors and push factors. With the rapid urban sprawl, it results in the increase of inhabitants with a balance of demand and supply. Along with the proliferation of the crowd toward a separate area, there is burgeoning demand of supply for the inhabitants, which further entice entrepreneurs. The urban sprawl cannot be controlled; hence, it appears as an interrelated network of a complex system. The socio-economic development of an urban area is an impact of migration that escalates the growth of urban society. The constant process of growth leads to urban spread and agglomeration, which is continually an ongoing process (Yeh and Li 2001).

The scope of application of "Remote Sensing and GIS" is widening day by day from cryosphere to biosphere to hydrosphere to atmosphere, etc. Subject to mankind, most of application parts are broadly used like study of land cover dynamics, spatial growth, trend analysis, rainfall monitoring, zoning of hazard risk assessment mapping, global climatic imbalance, atmospheric phenomenon, etc. (Wijeatne and Bijker 2006). Contemplating the urban application part, it is largely used in the fields of urban morphology structure, urban flooding, urban planning, ventilation mapping,

urban climatic zones, urban pollution, urban population, urban growth modelling, etc. (Grimmond and Oke 1999; Gál and Unger 2009; Mirzaei 2015; Wong, Nichol, and Ng 2011). With the advancement in technologies, it is aimed to gather data from the underground and under water also. Various endeavors were done to discover the prototype of urban growth and examine the several spatial patterns of urban area with the help of various algorithms including geographical weighted regression, Sleuth model, multivariate regression, etc. In India, the urban growth scenario is changing rapidly and poses complexity in measuring urban growth parameters, but use of remote sensing and GIS techniques are becoming handy in to perform analysis on urban growth and its impact on natural vegetation and local surface air temperature.

Urban sprawl is a continuous process, which leads to decrease in the amount of green space and increase in the density of concrete garden of buildings (Capozza and Helsley 1989). To demarcate the consistency of vegetation canopy layer, NDVI (Normalized Difference Vegetation Index) is a very useful index (Bhandari, Kumar, and Singh 2012; Volcani, Karnieli, and Svoray 2005). The increase density of buildings is the major cause of increasing surface air temperature that is trapped by the building infrastructure (Unger, Sümeghy, and Zoboki 2001). From this point of view, the concept of Land Surface Temperature (LST) is inspired, which is the temperature of the near surface area within specified limit, but it is entirely different from atmospheric temperature. The LST is a new emerging concept in the field of remote sensing and it plays a key role in establishing an inter-relation between NDVI and LST (Deng *et al.*, 2018). The relationship between LST and NDVI ponders on the concept of surface temperature in cram-full areas (Yuan and Bauer 2007). From this point of view, the area can be delineated as a Heat Island as the core area of the city experiences relatively high temperature than the surrounding and rural areas. The domain of UHI can be easily detected using these two crucial indices. The urban area that is comparatively hotter than the surrounding area can be considered as a UHI (Tso 1996).

India is home of 1,210,193,422 people (Census of India, 2011) and having a population density about 382 persons/km^2, which represent a mass of population pressure on less amount of land. As a developing country, India is bound to see increase in urban area or converting land use into boundless built-ups. India is facing force of population toward urban areas and converting land use into boundless built-ups. Since independence, the growth rate of urban population is gradually rising and recorded 17.46% as per Census of India, 2011. Kolkata is one of the renowned metropolitan cities having the

population density of approximately 24,000 persons/km^2 (Census of India, 2011), one of the highest in the world. The suburbs (Barasat, Barracpore, Kalyani, Kashba, Rajarhat, etc.) are having density of almost 9,000 persons/km^2, which is increasing rapidly. Because Kolkata is having limited land, the suburbs are developing at faster pace than the core city from last few decenniums. Barasat city is adjacent to Kolkata; therefore, the branches of Kolkata city are expanding toward the outskirt areas at faster rate and that can be clearly estimated from the difference in 2001 and 2011 Census.

1.2 Study Area

Barasat city is in the northern outer periphery of Kolkata city, in West Bengal, India, facing problems of unplanned urbanization in a short span of time after getting declared as district head quarter town within the jurisdiction of Kolkata Metropolitan Development Authority (KMDA). It has a total area of 31.41 km^2 and extends between 88°27' E and 88°31'E longitude and between 22°40'58" N and 22°44'44"N latitude (Figure 1.1). There are 32 wards in Barasat municipality. The growth rate of population in this town is very high and approximates around 3.5% per year. As per the provisional reports of census of India, population of Barasat in 2011 is 283,443. Barasat has a population density of 9,023 persons/km^2.

1.3 Datasets and Methodology

1.3.1 Datasets

The satellite images of Landsat 5 TM for the year 2001, Landsat 5 TM for the year 2011, and Landsat 8 OLI and TIRS for the year 2017 were obtained from USGS official website and processed for analysis (Table 1.1), and to quantify the changes due to urbanization. The datasets used for various analyses and for preparing different maps along with census data are listed in Table 1.1.

1.3.2 Methodology

Landsat images of different time are very helpful for the analysis of land use and land cover change pattern and to measure the increase in urban

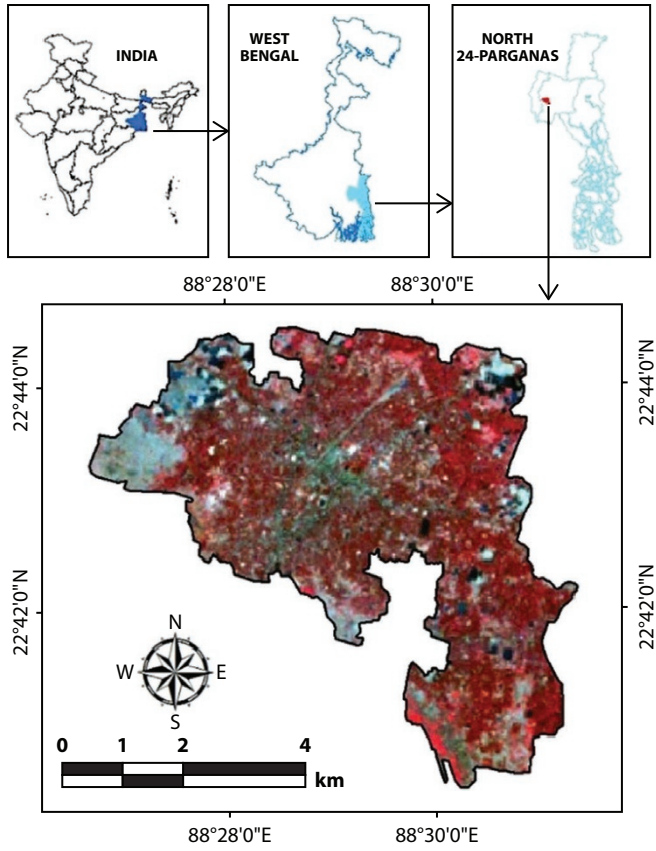

Figure 1.1 Location map of Barasat municipality.

Table 1.1 List of datasets used for the study.

Satellite/Sensor	Date	Source
Landsat 5 (TM)	January, 2001	USGS
Landsat 5 (TM)	January, 2011	USGS
Landsat 8 (OLI and TIRS)	January, 2017	USGS
MOD11A1	January: 2001, 2011, 2017	USGS
Census	2011	Census of India
Barasat municipality boundary	2014	Barasat municipality

built-up area (Song *et al.*, 2001). To meet the objectives of the study, the following procedures were done. Pre-processing is an essential step for removing the atmospheric noise and haze, which is there in the image due to atmospheric scattering of solar radiation due to atmospheric elements (Chander, Markham, and Helder 2009). Satellite images were classified using Maximum Likelihood classification algorithm because it gives better accuracy than other available techniques like box classifier, minimum distance to mean, etc., available in published literature (Lyon *et al.*, 1998; Reis 2008; Patidar and Sankhla 2015).

The study area was classified into six classes inclusive of built-up area, agricultural fallow, bare land, water body, green space, and built up with green space. The main aim was to measure the increase in built-up area, which is an indicator of urbanization. Further, accuracy of the classified images was calculated, and confusion matrix generated to highlight the user accuracy, producer accuracy, and Kappa statistics thus obtained (Foody 2002; Berberoglu and Akin 2009).

The urban growth is a process of urbanization, which always follows a pattern of development. In urban areas, the pattern differs from core to periphery region. In this study, two different types of pattern had been observed, one was concentric, and another one was linear. The concentric circular pattern was found in the areas of tri-junction of roads or in the "Y" point where the development is very rapid and shows multiplier effect of growth. The linear pattern of development was observed from 2001 to 2017 along the sides of roads and railway lines (Figure 1.2), which is very

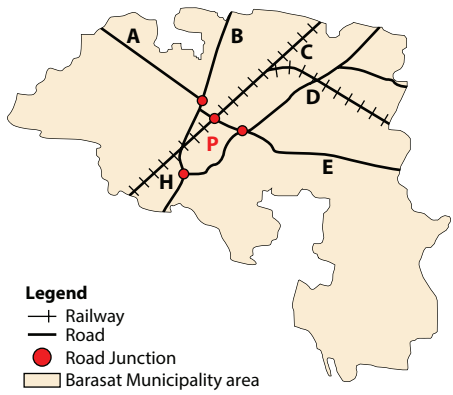

Figure 1.2 Road and railways network in Barasat municipality.