Advances in Geographical and Environmental Sciences

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Geospatial Technology for Landscape and Environmental Management

Sustainable Assessment and Planning

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Preface

Landscapes are spatial mosaics of interacting biophysical and socioeconomic components that provide living space for mankind. A landscape can be described by its composition and configuration. The composition refers to the variety and abundance of patch types within a landscape. The configuration refers to the spatial character of patches within a landscape. These two aspects can separately or together affect the ecological processes. The heterogeneity, scale, pattern, hierarchy, disturbance, coupled ecological–social dynamics, and sustainability are the key factors in landscape monitoring. The geospatial distribution and quantification of landscape components is of critical significance in support of sustainable land-use planning, natural resource management, and environmental monitoring. The landscape change can also provide important information to land managers relating to environmental impacts of various types of land use and patterns. The continuous monitoring of landscape and environment at a large scale and at a regular interval can only be possible by using advance technologies.

With the advent of multi-scale geospatial information on composition and configuration of landscapes, the acquisition of spatial information on landscape metrics using geospatial technology has become a common practice. These technologies offer considerable potential for sustainable assessment and planning of landscape and environment. Geospatial technology is a combination of state-of-the-art remote sensing, GIS, and global navigation satellite system (GNSS) technology for the mapping and monitoring of landscapes. The main thrust of using geospatial technology is to understand the causes, mechanisms, and consequences of spatial heterogeneity, while its ultimate objective is to provide a scientific basis for developing and maintaining ecologically, economically, and socially sustainable landscapes.

This book will highlight the state-of-the-art new approaches, various modeling aspects, the role of field and earth observations technologies in landscape, and environmental management practices. It addresses the interests of a wide spectrum of readers with a common interest in geospatial science, geology, water resource management, database management, planning and policy making, and resource management. The chapters in this edited book mostly emphasize the study of landscape and environmental components through advanced computational techniques in conjunction with earth observation data sets and GIS for better assessment, planning, and management of landscape and environment. It also seeks to provide a comprehensive approach for professionals, policy makers, researchers, and academicians across the countries.

In Chap. 1, an attempt is made to analyze the spatiotemporal variability of channel planform dynamics of Ichamati River, West Bengal, India. In this study, the US-Army Toposheet of 1922 and multi-temporal Landsat images of 1976, 1996, and 2016 were used. Besides, the cross-sectional survey of the river was conducted with the help of an echo-sounder and a GPS during 2013–2018. A questionnaire survey was also performed to acquire information regarding the expansion of brick kilns, annual rate of brick production, sediment extraction rate, and land-use activities of brick kilns. This study revealed that the natural shifting and meander mobility of the river have been gradually decreasing with the expansion of brick kilns in the last few decades. The excessive siltation within the channel causes upliftment of the riverbed as measured 9 cm year^{-1} during 2013–2018.

In Chap. 2, a study has been carried out to prepare an integrated water resource action plan for conjunctive use of available water resource in a sub-humid tropical watershed of East India. Delineation of potential zones is done by developing various thematic maps using satellite imagery and associated databases. Overlaying the thematic maps and keeping in view the available groundwater resource, an integrated water resource plan is prepared in ArcGIS software. The net annual groundwater availability is found to be 80.989 ha.m, while the annual draft is 10.18 ha.m. After superimposing all thematic layers, four groundwater potential zones such as poor, moderate, good to moderate, and very good are identified. More than 50% area of the watershed falls in a moderate prospect zone.

In Chap. 3, a hydrologic modeling using the HEC-RAS model in combination with watershed modeling system (WMS) tools compared with the flood hazard index (FHI) method using GIS in the Seyad basin situated in the southwestern region of Morocco. The HEC-RAS approach combines the surface hydrologic model and the digital terrain model data. This combination allows the mapping of the flood zones by using the WMS tools. A weight is calculated from the analytic hierarchy process method and applied to each parameter. HEC-RAS method allows the mapping of a flood with a flood water surface profile that shows the depth of flood for annual exceedance probability (AEP), while FHI permits establishing flood risk level without indicating the depth of water.

In Chap. 4, a geospatial modeling is performed in assessing sustainable water resource management in a Gondia district, India, using remote sensing (RS) and geographical information system (GIS) techniques. The monsoon rains in Gondia district are concentrated in the four months from June to September and receive 90.81% rainfall, post-monsoon 1.86%, pre-monsoon 4.83%, and winter 2.48%. The distribution of annual rainfall in study area is very uneven. Out of the total area in the district, reserved forest area is 56.4%, protected forest area is 26.3%, and unclassified forest area is 17.3%. There are 192 small irrigated ponds below 100 hectares, and its projected irrigation capacity is 10,897 hectares. There are also 294 Kolhapuri-type dams with a projected irrigation capacity of 10,075 hectares and 1559 storage dams with a projected irrigation capacity of 14,817 hectares. The water is neutral to alkaline in nature with pH ranging from 6.6 to 8.92 with high TDS range from 140 ppm to 2184 ppm. The study can be useful for area management, restoration, and conservation of natural resources in the future.

In Chap. 5, groundwater samples were obtained in the 2016 and 2017 pre-monsoon and post-monsoon seasons at 105 locations from dug wells and bore wells along the coast of Andhra Pradesh in the Krishna and Godavari deltas. Groundwater samples are tested for large ions to determine the infiltration of salt water and to classify the salinity sources in the delta zone. Various hydrogeochemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), Ca^{2+}, Mg^{2+}, K^{+}, Na^{+}, CO_3, HCO_{3-}, Cl^{-}, and SO_4^{2-} are evaluated for the delineation of the intrusion of saltwater in terms of Ca^{2+}/Mg^{2+}, $Cl^{-}/(CO^{3+}\ HCO^{3-})$, Na^{+}/Cl^{-} ratios. It is reported that the availability of fresh groundwater is 14 and 62%, respectively, during the pre-monsoon and post-monsoon seasons. The percentage levels of contamination in groundwater for slight, moderate, injuriously, highly, and severely categories are 43, 22, 12, 8, and 1%, respectively, for pre-monsoon season. However, during the post-monsoon season, the levels of contaminations in the above-mentioned categories are 22%, 9%, 4%, 1%, and 3%.

In Chap. 6, an attempt has been made to use the geospatial technology in the land and water resources management of a village enclosed within a micro-watershed. The geospatial database has been generated at the cadastral level or plot level, i.e., at 1:4000 scale. The resource inventory includes land use/land cover, digital elevation model (DEM), slope, geomorphology, ground water prospect, soil, land capability maps. The site suitability analysis technique is used to develop the land and water resources management action plan. In the land resource management plan, seven types of alternative land-use practices are suggested for the study area. The integration of the action plan map on the DEM gives a 3D perspective which will be an add-on in terms of visualization to the administrators and decision makers.

In Chap. 7, the lakes are important ecological units in urban ecosystem which preserve local climate, groundwater, and biodiversity. The unplanned continuous population growth in urban area causes severe destruction to the urban ecosystem across the world. Between 1970–2009, around 108 lakes were lost, and in between 2009–2013, around 230 lakes have been lost and cannot be revived. The present study is an attempt to create an inventory for current status of the lakes and wetlands using remote sensing and GIS techniques and their ecohydrological consequences on the surrounding environment. Time series satellite images from LISS-III and Survey of India maps of 1:50,000 were used for the study. For the study, six lakes have been identified from different parts of Delhi, which are on verge to devastating if not provided with immediate attention.

In Chap. 8, a quantitative assessment of Dhundsir Gad (Gad means stream) watershed has been carried out to study the relationship between hydrological characteristics, lithological, and structural antecedents for management, planning, and conservation activity. The data for morphometric parameters is extracted from remotely sensed images and processed in geographical information system (GIS) platforms for quantitative analysis. Geological field investigation of the watershed is done to investigate inter-relationship between the hydrological characteristics, lithology, and structural attributes. Morphometric characterization was measured from linear, relief, and areal aspects for four sub-watersheds of Dhundsir Gad. The prioritization of the sub-watershed has been done after evaluating and ranking morphometric parameters. Regional patterns of hypsometric integral (HI) and hypsometric curves in the watershed have also been computed to understand the role of tectonics and soil erosion in shaping the relief of the watershed.

In Chap. 9, a study has been carried out to identify the groundwater prolific zones using remote sensing (RS) and geographical information system (GIS) in Kamina sub-watershed of Bhima river basin, Shirur Taluka of Pune District, Maharashtra, India. Several thematic maps were generated to identify the potential zones. Analytical hierarchy process (AHP) is used for the delineation of groundwater potential zones. The AHP proposes a weight for each evaluation criteria according to the decision maker's pairwise comparisons of the criteria. The groundwater potential zone map so generated is divided into four classes (very low, low, moderate, and high) depending on the possibility of groundwater potential. The highest potential area is located toward eastern and southern region of Ghod River and thick soil cover. The findings of the study can help in the formulation of an efficient management plan for sustainable development of the area.

In Chap. 10, a study indicates the effectiveness of remote sensing (RS) and geographic information system (GIS)-based morphometric analysis of a sub-watershed of Damodar river basin in Ramgarh district, Jharkhand, India. The sub-watershed and drainage texture of the study area are extracted by ASTER DEM and topographical map in the GIS environment. Morphometric parameters such as stream order, stream length, bifurcation ratio, drainage density, stream frequency, form factor, and circulatory ratio are calculated. The sub-watershed's total drainage area is 46.71 km^2 and shows a dendritic drainage pattern that designates homogeneous lithology, gentle regional slope, and lack of structural control. The study area is designated as the fifth-order basin with a drainage density (D_d) value range 9.91 km/km^2. Results of the study have immense significance for engineers, managers, and planners for management of soil and water and provide watershed prioritizing management activities in the area.

In Chap. 11, the use of emerging technologies, early warnings, immediate incidence response, and post-recovery activities can well be employed to mitigate the losses that the disaster would lead to. One such emerging technology is the Internet of Things (IoT). This can help in monitoring for the purpose of early warning of disasters. The potential of IoT is described in order to provide rescue, response, mitigation, and preparedness to manage a disaster. This chapter explains the role of IoT in disaster management along with proposing a generic model having distinct layers through well-defined functionality. The chapter also explains the integration of cloud and IoT that could improve the efficiency of IoT applications in disaster management.

In Chap. 12, a work is carried out for developing a framework of systematic analysis to explain e-participation of citizens in India. The paper tries to identify and measure key indicators of e-participation in India. Survey of 200 respondents is analyzed from four smart cities across India. The work applies regression and concludes that all the indicators have a significant impact on e-participation of citizens in smart cities. The study finds that though the government is investing a huge amount of funds in smart cities development but still a lot is to be done. Also, the concept of participatory approach is currently not a prominent research theme among scholars. So, the current work will address this gap to unravel the conceptual framework of e-participation of citizens in smart cities in India.

In Chap. 13, a present study is performed to understand the spatial-temporal variability of LULC of Nagpur city, Maharashtra, from 2000 to 2020. The LULC classification is performed considering four different classes, i.e., barren land, built-up, agriculture, and water bodies. The LULC results show that the built-up area is increased by 26.62% from 2000 (41.24%) to 2020 (67.86%), and with a slight increase in water bodies, 0.19% is also evident. On the other hand, the area covered with vegetation is decreased by 15.93 % from 2000 (30.17%) to 2020 (14.24%), and barren land is reduced by 10.88%. The present study also predicted the LULC scenario using artificial neural network (ANN)-based cellular automata (CA) model with the help of different driving parameters. The prediction model showed an overall accuracy of 81.23% in predicting the 2025 LULC maps with the help of 2015 and 2020 LULC data. The results of the prediction model evident a maximum growth of 30.88% in the built-up area as compared to year 2020.

In Chap. 14, the research attempts to categorize the slums based on living standards, which will help to formulate the sustainable development techniques for better implementation of slum improvement projects. Data about the socioeconomic and physical condition of the slums has been collected using field surveys. For clustering slums in different categories, a $2 \times 2 \times 2$ matrix is formed. For creating an indicative matrix, essential inputs were identified, and an overall matrix table for all the slums with their scores was prepared. A georeferenced very high-resolution satellite imagery with a ward boundary map was used to create a base map. Different maps were generated showing current slum distribution and also the spatial distribution of varying slum categories. Maps were validated with field survey and with field photographs.

In Chap. 15, the study aims to analyze urban growth and sprawl in Dehradun city of Uttarakhand, which is one of the cities in government's smart city project list. The urban sprawl of Dehradun can be analyzed by using the Shannon's entropy approach. As per the result, the entropy value obtained for the year 2008 is 0.877 and 2016 is 1.598, in which the value of 2016 is near to the value of upper limit of log n (i.e., 1.591) which depicts more urban sprawl in 2016 than in 2008. The present study effectively used the Landsat TM data of year 2008 and 2016. This study can help for better planning and sustainable management of resources of a certain region and can help government officials and planners to monitor and analyze current urbanization and plan for future growth and requirements. This particular study can be helpful to understand the urbanization pattern in the city.

In Chap. 16, a study aims to map and analyze the dynamics of land-use/land cover changes using IRS LISS-III data for the years 2011–2012 and 2015–2016 of Andhra Pradesh state, India. On-screen visual interpretation techniques have been used to delineate the land-use/land cover classes in ArcGIS environment and cross-tabulation used for quantifying the changes in land-use pattern. The study reveals that built-up area, agriculture land, and water bodies have been increased about 0.21% (343.06 km^2), 0.11% (176.21 km^2), and 0.02% (32.08 km^2), respectively, while area under other land categories such as forest area, wastelands, and wetlands have decreased about 0.02% (107.44 km^2), 0.20% (333.38 km^2), and 0.07% (110.53 km^2), respectively. The results of this study would be helpful for planners, decision makers, and administrators to plan and implement appropriate decisions in order to sustainable resource utilization.

In Chap. 17, the current work tried to envisage the study on urbanization transitions due to launch of metro rail network in the NCR region. The metro network influenced the periphery and rural areas of Delhi and also contributing toward linear development or development of parallel infrastructures along the metro network. Cities of nearby states have become major intersections of metro network. Thereby, the current work tries to intend to establish the urbanization along with the social scenario, as it has a massive network of nearly 288 km length comprising of six different lines. This study proposes to identify the push and pull to further analyze the urbanization pattern due to the expansion of the network in the region, as the growing population in region requires further expansion. Hence, metro projects are expanding continuously and providing a new stimulus toward the increasing urbanization.

In Chap. 18, the spatiotemporal effects of UHI in Rajkot city has been assessed using Landsat 5 TM and Landsat 8 OLI remote sensing data. The land-use/land cover (LULC) classification is performed using maximum livelihood method on Landsat images for the year 2009 and 2017. Normalized difference vegetation index (NDVI) and land surface temperature (LST) were derived using mono-window algorithm. Subsequently, ambient air temperature was scrutinized and isotherm was derived for three locations in Rajkot city. On the basis of various results derived and analysis of temperature trend of past 60 years, it was determined that UHI effect was more prominent in the Central Business District (CBD) area of the selected regions. The results also revealed that the study region has experienced an increase of 0.3 °C in ambient air temperature in past 60 years. The built-up area and LST for LULC classes have also increased by 8.42% between 2009 and 2017 in Rajkot.

In Chap. 19, various rural towns are developing into urban towns, and hence, for a balanced and a proper development, a planning is required. Remote sensing is the acquiring of the data about the item without contacting it or without physically being present there. Due to advanced technology and new innovations, satellite imaging has enabled to collect and interpret various data which earlier was done physically and consumed a lot of time. A surface analysis is conducted with the help of remote sensing which gives a lot of information regarding various aspects, whereas it also interprets the physical data with other socioeconomic data. This interpretation helps in getting a link to the planning process. The information collected through satellites helps planning in various formats such as time, efficiency, and other ways.

In Chap. 20, a study was carried out to assess green spaces in Vijayawada's Urban Local Body. Because of better economic opportunities, the city has seen a surge in population inflow. As a result, there has been a decrease in urban green spaces from 2012 to 2020. The results show that there exists a negative correlation of -0.46 between per capita green and population; therefore, with every 1 unit increase of population, the demand for built up and urban amenities will increase, thereby impacting the per capita green and overall greenness index of the city negatively. In this study, transformed difference vegetation index (TDVI) has proven to be superior to normalized difference vegetation index (NDVI) for urban green analysis. NDVI shows vegetation of 21.25 km^2, whereas TDVI shows vegetation of 16 km^2. There has been an increase of merely 2% of vegetation in past 8 years span in the Vijayawada city.

In Chap. 21, magnetic susceptibility measurements were carried out of agricultural soil which was collected from 23 locations from Kopargaon area of Ahmadnagar district, Maharashtra State of India, using AGICO-MFK1-FA Multifunction Frequency Kappabridge KLY4S with low-frequency susceptibility (F1) 976 Hz and high-frequency susceptibility (F2) 15616 Hz. The magnetic susceptibility values were observed at low and high frequencies. This significant magnetic enhancement is an indication of the presence of ferromagnetic minerals in agricultural soil from the studied area. Heavy metals in soil samples were analyzed by using double-beam atomic absorption spectrophotometer. The evaluation of anthropogenic influence and contamination with trace elements in soil from study area was carried out using geo-accumulation index. The interpretation of the obtained field measurements and the laboratory analyses indicate that Cd, Pb, and Ni provide the potential risk, while the other heavy metals are in the safe limits.

This edited book entitled *Geospatial Technology for Landscape and Environmental Management—Sustainable Assessment and Planning* comprises the chapters written by scholarly academicians, well-known researchers, and experts. The primary motivation of this book is to fill the gap in the available literature on the subject by bringing together the concepts, theories, and experiences of the specialists and professionals in this field.

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