IJCSE International Journal of Computer Sciences and Engineering Open Access
Research Paper Vol.6, Issue.10, Oct. 2018 E-ISSN: 2347-2693

Urban Sprawl Monitoring with the help of Remote Sensing & GIS Techniques

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Available online at: www.ijcseonline.org

Accepted: 16/Oct/2018, Published: 31/Oct/2018

Abstract— The present study examines the use of Remote Sensing and GIS techniques in the mapping of urban sprawl (2001-2011) and land use/land cover change detection. The Year of 2001 and 2011 has been taken to detect the urban sprawl. An urban area is the most powerful territory on the earth. As we know in the last decade, the size of the urban areas has been continuously increased, and it will go for in the future. In the present day, urban growth is a big problem. For better livelihood, the urban areas are expanding rapidly. Remote Sensing and GIS techniques can define the process of urban sprawl. In the present study, Landsat ETM Plus satellite imageries and Google Earth Pro has been used to identify the urban sprawl of the study area.

Keywords— Remote Sensing, GIS, Urban Sprawl, Land Use Change Detection

I. INTRODUCTION

The social centers of our modern life are cities or urbanized areas. The urban area provides all of our daily needs. They provide safety, welfare, and commitment to a place where people can get a better lifestyle than rural areas [1]. For batter good living, education and income, the migration of the rural population towards the cities has increased [2]. In the year 2030, the population of the worlds is expected to 72 % increase with 175% upturn in urban areas [3]. The growing of the urban is linked with the economic development, which makes an increasingly higher contribution to the national economy. It also conducts to the rough development with the conversion of urban periphery land to build- up the settlement [4]. Urban sprawl directly or indirectly affecting the ecosystem by diminishing cropland, water bodies, and forest area [1]. It also connected with environmental hazards such as waterlog or floods, biodiversity loss, and energy crisis, etc. [5]. Especially, in developing countries like India, in the year 2030, 60% of the total population is expected to live in urban regions, which can have devastating effects on ecosystems and biodiversity [6]. Without exception, such research is beneficial for developing countries like India [7-11].

In this study, we had identified the urban sprawl and land-use land-cover change between the year of 2001 and 2011. To define the urban sprawl and land use change remote sensing, and GIS techniques have been used. The urban sprawl has been studied to find a relation between urban sprawl and population. In this study, we had demonstrated how satellite imagery could be displayed and analyzed using digital techniques in a popular digital image processing software Erdas Imagine 9.2 and GIS software ArcGIS 10.3, Apack 2.23.

The Midnapore Municipality was established in the year 1865. It is situated in West Bengal (Figure-1), India. The town is the headquarters of the Paschim Medinipur district. In the year 2002, Medinipur district has been divided into east and west Medinipur. But The Midnapore municipality comes under Paschim Medinipur District. Its consists total 24 wards with an area of 18.65 Sq. Km. According to the year 2011 census, the municipality has 169,127 population. The Municipality geographically located between 87°17'05" E to 87°20'45" E and 22°26'40'N to 22°23'50"N. The Kangsabati River flows the south side of the municipality and these municipality situated 23 meters above from the mean sea-level. The municipality has excellent communication with roads and railway network. Not only in the municipal area, but the municipality also has good communication systems with the other small town and villages in the district. The Midnapore Railway Station is well connected with the Howrah station. The station is on the Howrah-Adra, and Howrah-Purulia expresses train routes. Many major express trains pass through Midnapore including the Delhi-Puri Nilachal Express, Howrah-Lokmanya Tilak Samarsatta Express, Puri-Patna Express and New Delhi-Bhubaneshwar Rajdhani Express.

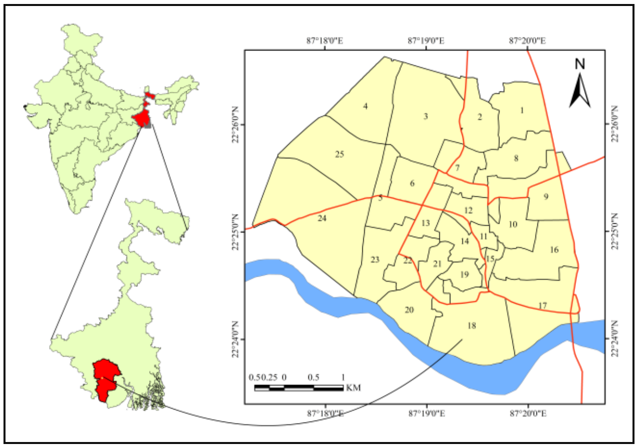

Figure1: Location Map of the Study Area

II. Related Work

Remote sensing technology is a cost-effective technique which can analyze the urban sprawl [12-14]. Over the past few decades remotely sense images has been used for urban change detection [15-17]. In this study have been used a post-classification comparison or an image-to-image comparison. Also statistical and remote sensing techniques have been used combined for identification of urban sprawl [12]. Urban sprawl studies have been pretended in different developed countries [18-19]. Multivariate regression has been used to delineate the relationship between impervious area and different urban parameters like population density, land use land cover, road density, etc. [12]. To understand the relation between the environment and human activities, Land-use Land-cover is a very important exhibitor, which is identified by the satellite imageries through classification methods. These are especially effective for developing countries such as India, where ground visit data are rare and Impassable [20-21]. The landscapes metrics can quantify the urban pattern, spatial features, physical characteristics features and their forms. It derives from remotely sensed data [22-23].

III. DATA & DATA SOURCE

In our current study, both primary and secondary data (Table-1) has been collected from different sources. Primary data, we used Enhanced Thematic Mapper (ETM+) images with 30 m spatial resolution covering the temporal scenes from 2001 and 2011 (Table-1). The satellite images have been downloaded from the United States Geological Survey (USGS) portal (24) in Geo-TIFF format and geo-referenced using the World Geodetic System WGS) 1984 coordinate reference system. The data were initially geo-corrected and rectified, and cropped to the study area. A complete methodology has been presented in Figure-2.The image pre-processing was performed using in Erdas Imagine software 9.2. The municipality ward boundary map has been collected from Midnapore Municipality. The secondary population data has been obtained from the Census Bureau (Census of India) for the year of 2001 & 2011 respectively. The communication systems such as the road network and railway, water bodies, settlements have been digitized from Google earth.

Table 1. Different type of data used

Type of Data Used	Year	Source
Landsat ETM+ image (WRS-2 / 139 / 44)	2001,2011	United States Geological Survey (USGS)
Google Earth Engine	2011	www.google.co.in/earth/explore/showcase/ocean.html
Municipality Ward Map	2011	Midnapore Municipality
Population Data	2001, 2011	Census of India

IV. Methodology

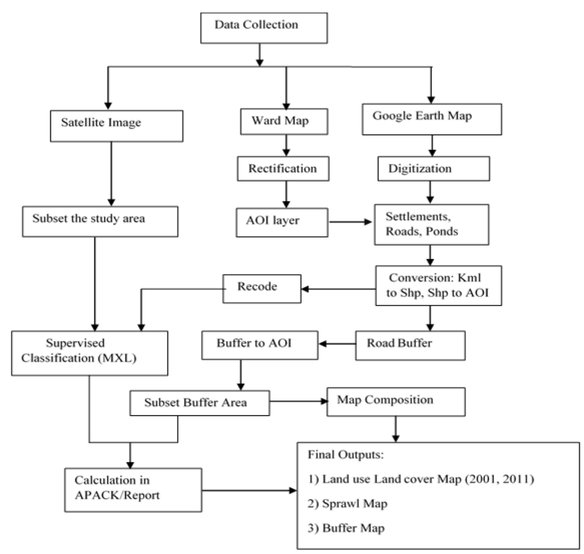

Figure2: Overall flow chart of the methodology

Layer stacking process has been performed with different bands of the satellite images using Erdas Imagine software. To subset our interest area from satellite images, in Erdas software the AOI tools have been used. In this study, the supervised classification has been used to define the land-use land-cover (Table-2) type for both years. For supervised classification, maximum likelihood algorithm has been chosen. In this classification method, the user has to select a training site (Signature) for the land use type. Finally, the classifications give the land-use land-cover image of the study area to investigate the changing scenario.

Table 2. Land use and land cover (LULC) nomenclature

LULC Classes	Land Use include in this class
Vegetation	Plantation and Shrub
Water Body	Reservoir, Ponds, Open water
Dry Land	Ready for construction, and real estate plots, Sand
Rail	Railway track
Road	Major and Minor roads
Settlement	Built-up area
Non agriculture	Non-irrigated lands
Laterite Exposer	Lateritic Soil Cover land

Last one decade the land use has vastly changed in Midnapore town. The supervised classification images define the all information to realize the land use change of the study area. To create a Land-use Land-cover map, supervised classification method we have used after that also used the recode processing for water bodies, settlement, and roads. With the help of ERDAS Imagine software the "recode" process has been done. Change detection analysis has been used to explain and quantify the temporal difference between images of the same view. Two classified images have used to estimate the area of various land cover changes. This analysis is useful to identify the different land use change. To identify the land-use land-cover change, we have also use Area statistics in Apack Software.

V. RESULTS AND DISCUSSION

Land use Land cover Change Detection

The standard FCC (False Color Composite), ETM plus imagery (2001, 2011) of Midnapore town, has been classified (Figure-3) into eight distinct classes to delineate the urban sprawl. The segmented classes are Vegetation, Water body, Dry land, Rail Line, Road, Settlement, Non-Agriculture, Laterite Exposer, etc.

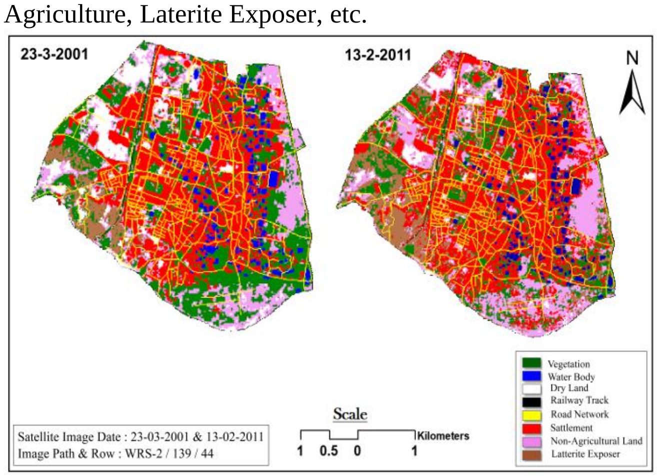

Figure3: Land use Land cover Map 2001 & 2011

The land-use land-cover map has been generated by using supervised classification process. In the year 2001, we can see the Midnapore town's most of the area surrounded by settlements, this covered with 668.6775 hectares. Vegetation covered by 495.4275 hectares, water body covered by 83.655 hectares, Dry land covered by 147.105 hectares, Non-agricultural covered by 285.795 hectares and Laterite exposer covered by 86.1075 hectares. The middle portion of the Midnapore town is concentrated by the settlement patches rest of the other part is covered by non-agriculture, dry land, laterite exposer, etc. But in the year 2011, there were lots of change in land-use of Midnapore town. But in the year 2011, there has lots of variation (Table-3) in land-use of Midnapore town. The settlement covered with 769.14 hectares, vegetation covered by 289.575hectares, water body covered by 83.655 hectares, dry land covered by 59.6025 hectares, agricultural fallow covered by 334.26hectares, and laterite exposer covered by 231.525 hectares.

Table 3. Aerial Extent of Different Land Cover

Class Name	2001 (Hectares)	2011 (Hectares)
Vegetation	495.4275	289.575
Water Body	83.655	83.655
Dry Land	147.105	59.6025
Rail	5.6475	5.6475
Road	174.8025	174.8025
Settlement	668.6775	769.14
Non agriculture	285.795	334.26
Laterite Exposer	86.1075	231.525

The bar graph (Figure-4) showing the area changes of different features or classes. As we can see that the vegetation in 2001 (495.4275 hectares) was high, but in 2011 (289.575hectares) it has been decreased. In the year 2001, the dry land (86.1075 hectares) was very high, but in 2011 (59.6025 hectares) it has been reduced because lots of settlement have built. The Settlement increased in 2011 compared to 2001, from 668.6775 hectares to 769.14 hectares. In non-agriculture land or agricultural fallow and laterite exposer, the area has been increased from 2001 (285.795, 86.1075hectares) to 2011 (334.26, 231.525 hectares) respectively. By image classification, it is easier to understand that the settlement from 2001 to 2011 has increased near about 15.024%, non-agriculture or agricultural fallow land has also increased by 16.95%. But the vegetation and dry land have been decreased near about 41.55% & 59.48%.

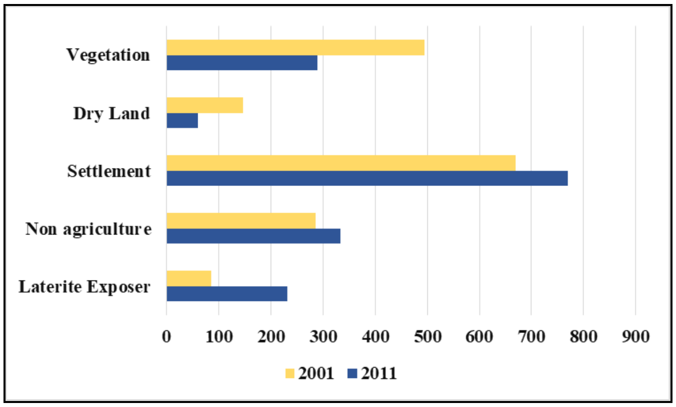

Figure4: Area change of different Land cover

Apack Ecological Metrics

Landscape ecologists rely on landscape metrics to compare, evaluate temporal changes, and predict landscape pattern effects (24). Our objective was to develop a computationally efficient program to calculate landscape metrics. APACK is an analysis package designed to meet these needs. It is a standalone program written in the Command Prompt to calculate landscape metrics on raster files. Data formats supported include ERDAS GIS files and output data consists of a text file. Here some useful metrics are represented graphically. Area statistics (AR) define simple area of the landscape (Figure-5). It is indicated for the landscape as a whole as well as for each attribute class present in the input map.

AR= (Cell of i Class) × (Area of one Cell)

Where, AR stand for Area Statistic, i stand for each class.

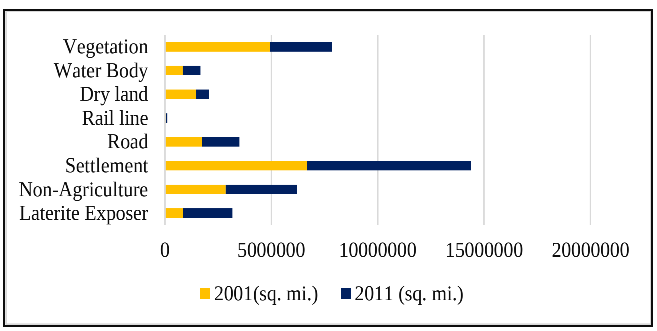

Figure5: Area Statistics of 2001 and 2011

Urban Sprawl Change Detection

The word of sprawl used by the land developer, planners, and government institutions refers to changes in land use trends and demographic changes across the entire geography. It defines the development rate of outside the urban center, especially the settlement area. The rate of population increase plays a key role in urban sprawl, and it caused considerable changes in the center of the municipality. Therefore the central part of the municipality is complicated to live. Thus, the adjacent part of the municipality has increased. Urban sprawl destroys our environment such as the cropland, vegetation cover land, fallow land, etc. In other words, as a result of population growth, the area also expands of any urban area, this growth is considered as urban sprawl. The following maps (Figure-6) are showing the urban sprawl from 2001 to 2011.

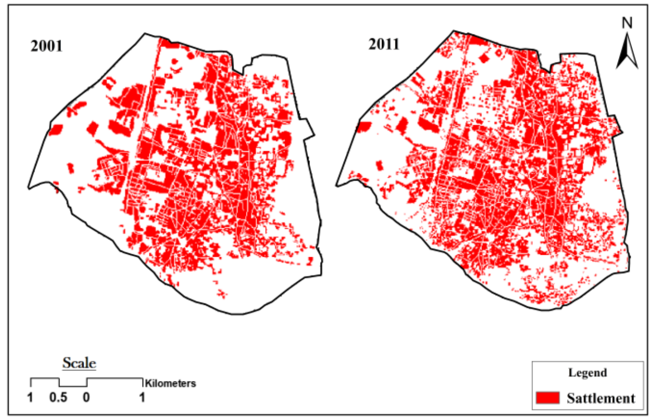

Figure6: Urban Sprawl Map

From the sprawling map (Figure-6), we can to explicitly that the increase in the settlement is going on jet speed. From the year 2001 to 2011 the urban sprawl in Midnapore Town depends on different causes. In the sprawling map, we can see the Ward No.9, 6, 15, 18, 19, 20 and 21 the settlement has sprawled from 2001 to 2011. The growth rate of urban from 2001 to 2011 is very high compared with previous years. The settlement growth (Figure-7) of Midnapore town is highly rated because of some the relevant factors. Migration is one of the primary causes for the vast increase of settlement. It assumed that from Keshpur most of the population settled in Midnapore town due to some political issues. Jungle Mahal is another area from where most of the community migrated to the Midnapore town because of Maobadi problems. In Midnapore town, there is the number of colleges, schools, and different types of occupation, which the reason large no. of the population from the village has shifted to the town for their career and better livelihood.

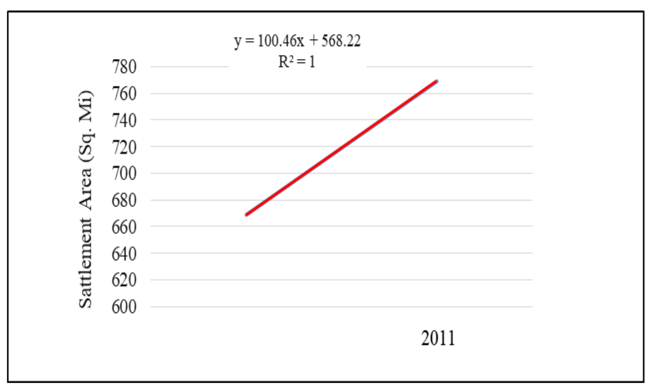

Figure7: Trend of Settlement Growth

Urban Sprawl Change Detection

In this study, has been tried to find out the settlement change in the major road side of 2001 and 2011 through buffer analysis. Buffering, in general, refers to the creation of a zone of a specified width around a point or a line or a polygon area. It is also referred to as a zone of a specified distance around coverage features. In this study, we have select 50, 100, & 200-meter (Figure-8) buffer area from the road. This area has been subsetted from satellite images (2001, 2011) and calculated the Area Statistics (AR). From 2001 to 2011, we can see there have been many changes in the settlement area (Table-4) (Figure-9).

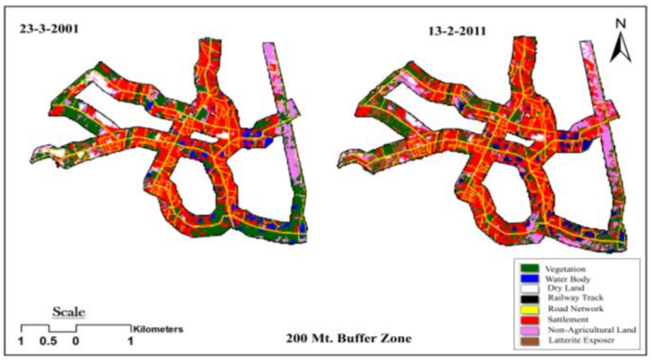

Figure8: 200 Meter Buffer area from State Highway

Table- 4 Settlement Growth in Buffer zone

Buffer Area (Mt)	Settlement (sq. m) 2001	Settlement (sq. m) 2011	Percentage (%)
50	991800	1126800	13.61161525
100	1887525	2074275	9.89390869
200	3351375	3622725	8.096676737

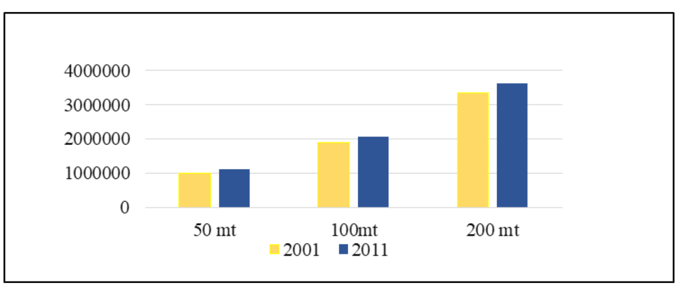

Figure9: Settlement Growth in Buffer zone

VI. Conclusion and Future Scope

The municipality is the second largest town in Paschim Midnapore district after Kharagpur. Throughout the study, we can say the remote sensing and GIS techniques can accurately detect the urban growth and land-use land-cover changes. In this study, we can see the rate of urban change, which is the essential potential threats to the environment of sustainable development. The study has attempted to understand the change in land use land cover and urban sprawl from 2001 to 2011 in Midnapore town. Remote sensing and GIS techniques are one of the suitable methods to monitor such kind of changes and can extract the changing information from satellite image data. This satellite data play a crucial role in mapping and quantifying the temporal sprawl of urban area. The present study also ensures that the change of land-use land-cover has a negative impact on the environment. The LULC also help to monitor the demands of the growing population, which is associated with the dynamics of land use change. This is a very important thing for the urban planning authorities to implement a proper land use planning in developing countries where land use data generally are not sufficient. Remote sensing technology is indispensable for dealing with a dynamic phenomenon, like urban sprawl. Without remote sensing data, one may not be able to monitor and estimate the urban sprawl effectively over a period, especially for the elapsed period. The relation between urban growth and population growth is the population growth is a key role of urban sprawl. In Midnapore municipality from the year of 2001 to 2011 the population growth has been seen 12.92%.

Acknowledgment

I would like to thank the Department of Remote Sensing & GIS, Vidyasagar University, for its constant support and providing the wonderful platform for my research work. I heartily thankful to Google earth and Bhuvan for providing satellite data and secondary data.

References

[1] Stow, D. A., Hope, A., McGuire, D., Verbyla, D., Gamon, J., Huemmrich, F., ... & Hinzman, L. (2004). Remote sensing of vegetation and land-cover change in Arctic Tundra Ecosystems. Remote sensing of environment, 89(3), 281-308.

[2] Visalatchi, A., & Padmanaban, R. C. (2012). Land use and land cover mapping and shore line changes studies in Tuticorin coastal area using remote sensing. International Journal of Advanced Earth Science and Engineering, pp-1.

[3] Lambin, E. F., Turner, B. L., Geist, H. J., Agbola, S. B., Angelsen, A., Bruce, J. W., ... & George, P. (2001). The causes of land-use and land-cover change: moving beyond the myths. Global environmental change, 11(4), 261-269.

[4] Squires, G. D. (Ed.). (2002). Urban sprawl: Causes, consequences, & policy responses. The Urban Insitute.

[5] Cabral, P., Feger, C., Levrel, H., Chambolle, M., & Basque, D. (2016). Assessing the impact of land-cover changes on ecosystem services: a first step toward integrative planning in Bordeaux, France. Ecosystem Services, 22, 318-327.

[6] Cabral, P., Feger, C., Levrel, H., Chambolle, M., & Basque, D. (2016). Assessing the impact of land-cover changes on ecosystem

services: a first step toward integrative planning in Bordeaux, France. Ecosystem Services, 22, 318-327.
[7] Megahed, Y., Cabral, P., Silva, J., & Caetano, M. (2015). Land cover mapping analysis and urban growth modelling using remote sensing techniques in greater Cairo region—Egypt. ISPRS International Journal of Geo-Information, 4(3), 1750-1769.
[8] Cadenasso, M. L., Pickett, S. T., & Schwarz, K. (2007). Spatial heterogeneity in urban ecosystems: reconceptualizing land cover and a framework for classification. Frontiers in Ecology and the Environment, 5(2), 80-88.
[9] Zhang, Q., Wang, J., Peng, X., Gong, P., & Shi, P. (2002). Urban built-up land change detection with road density and spectral information from multi-temporal Landsat TM data. International Journal of Remote Sensing, 23(15), 3057-3078.
[10] Luck, M., & Wu, J. (2002). A gradient analysis of urban landscape pattern: a case study from the Phoenix metropolitan region, Arizona, USA. Landscape ecology, 17(4), 327-339.
[11] Cabral, P., Santos, J. A., & Augusto, G. (2010). Monitoring urban sprawl and the national ecological reserve in Sintra-Cascais, Portugal: Multiple OLS linear regression model evaluation. Journal of Urban Planning and Development, 137(3), 346-353.
[12] Sudhira, H. S., Ramachandra, T. V., & Jagadish, K. S. (2004). Urban sprawl: metrics, dynamics and modelling using GIS. International Journal of Applied Earth Observation and Geoinformation, 5(1), 29-39.
[13] Yang, X., & Liu, Z. (2005). Use of satellite-derived landscape imperviousness index to characterize urban spatial growth. Computers, Environment and Urban Systems, 29(5), 524-540.
[14] Haack, B. N., & Rafter, A. (2006). Urban growth analysis and modeling in the Kathmandu Valley, Nepal. Habitat International, 30(4), 1056-1065.
[15] Gomarasca, M. A., Brivio, P. A., Pagnoni, F., & Galli, A. (1993). One century of land use changes in the metropolitan area of Milan (Italy). International Journal of Remote Sensing, 14(2), 211-223.
[16] Green, K., Kempka, D., & Lackey, L. (1994). Using remote sensing to detect and monitor land-cover and land-use change. Photogrammetric engineering and remote sensing, 60(3), 331-337.
[17] Yeh, A. G. O., & Li, X. (2001). Measurement and monitoring of urban sprawl in a rapidly growing region using entropy. Photogrammetric engineering and remote sensing.
[18] Batty, M., Xie, Y., & Sun, Z. (1999). Dynamics of urban sprawl.
[19] Jantz, C. A., & Goetz, S. J. (2005). Analysis of scale dependencies in an urban land-use-change model. International Journal of Geographical Information Science, 19(2), 217-241.
[20] Sudhira, H. S., Ramachandra, T. V., & Jagadish, K. S. (2003). Urban sprawl pattern recognition and modeling using GIS. Proc. Map India—2003, New Delhi.
[21] Dewan, A. M., Yamaguchi, Y., & Rahman, M. Z. (2012). Dynamics of land use/cover changes and the analysis of landscape fragmentation in Dhaka Metropolitan, Bangladesh. GeoJournal, 77(3), 315-330.
[22] Herold, M., Goldstein, N. C., & Clarke, K. C. (2003). The spatiotemporal form of urban growth: measurement, analysis and modeling. Remote sensing of Environment, 86(3), 286-302.
[23] de Filho, F. J. B. O., & Metzger, J. P. (2006). Thresholds in landscape structure for three common deforestation patterns in the Brazilian Amazon. Landscape Ecology, 21(7), 1061-1073.
[24] Lee, D., & Choe, H. (2011). Estimating the impacts of urban expansion on landscape ecology: Forestland perspective in the greater Seoul metropolitan area. Journal of Urban Planning and Development, 137(4), 425-437.

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