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Systematic review of how eco-environmental transformation due to urbanization can be investigated in the sustainable development of Indian cities

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ABSTRACT

The existing model of urban development is found responsible for growing environmental problems in the cities. This is due to the greater focus on the economic development at the cost of the environment. As a result, it led to some serious problems like air, water, soil pollution in the cities. It urged for a better ecologically based urban planning system wherein addressing the transformation from the natural landscape to the urbanscape is essential for effective management. However, still, in developing countries like India, no significant attention is given to environmental management in case of urban planning. The absence of specific directions to investigate the eco-environmental transformation in urban planning is one of the major reasons behind this. This study through the systematic review of 72 existing literature tried to identify the current theories and concepts to address the eco-environmental transformations in the urban areas. It found four different themes for investigating the said issues in the urban centres. These are land use & land cover prediction, green space, ecosystem services, and perception study. Lots of articles are available on the first three issues. But, the fourth theme contains a comparatively less number of articles. In fact, most of the works on this theme were carried out in the recent past. This study tried to summarize all the facts associated with these themes through intense revision. Finally, it also tried to highlight the methods or ways that can be adapted to apply these in Indian cities.

1. Introduction

The role of humans in the present-day is so dominant that it is classified as a different geological age: Anthropocene (Nijhuis and Jauslin, 2015). One of the main features of Anthropocene is the rapid urbanization (Chwałczyk, 2020). Urban centres are considered as the main hub of human activities and, with rapid progress in life, peoples are getting more concentrated in the urban cities. Following an estimate, around 66 percent of the total world population will live in the cities by 2050 (World Urbanization Prospects, 2015). However, in recent past, significant numbers of research works have emerged out highlighting the side-effects of uncontrolled rapid urbanization (Garrett,2010; Uttara et al., 2012; Nguyen et al., 2019). Cities are considered one of the most important sources of greenhouse gasses that ultimately results in climate change (Kennedy et al., 2009). Besides, increase in impervious surface by removing the vegetation cover resulted in urban heat islands. Fragmentation and modification in natural cover threatens biodiversity, species dispersal, energy flow, and cycling of nutrients. This is reflected in low return of ecosystem service values (ESVs) (Das and Basu, 2020; Mitchell et al. 2015).

All the features of agenda 21 under the United Nations Brundtland Commission in 1987 have provided the direction of achieving urban sustainable development. A lot of research work was also carried out in this regard (Wu, 2013). However, the present model of urban growth is found unsustainable and ultimately degraded the ecosystem significantly (Millennium Ecosystem Assessment, 2005). The major drawback of this model was giving less weightage towards the role of landscape in urban development. Landscape resides at the interaction point of man and nature, which delivers different services to mankind such as urban cooling, stormwater control, food production, recreation, and aesthetic benefits (Wu, 2013). In a study on Australian cities, it is observed that 10 percent increases in tree canopy can reduce the urban heat effect by 19 percent (Osmond and Sharifi, 2016). Therefore, it is quite clear that the incorporation of environmental issues is essential in the planning and design of urban areas for sustainable development.

India, the second-most populous country in the world, has witnessed a rapid rate of urbanization since the 1990s. In India, the development plans and policies for the urban centres are mainly driven based on the economic opportunities. Very little attention is given to the protection of urban environmental landscape. As a result, the urban centres grew haphazardly and the peri-urban environment has suffered the most

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(Das and Das, 2019). Several recent studies have reported significant deterioration of the environment due to uncontrolled urbanization of Indian cities (Mondal et al., 2017; Ghosh and Das,2019). Loss of natural vegetation cover and valuable wetlands are the most prominent. Despite all of these, still, there is no systemic direction of how environmental transformation and protection can be addressed in the sustainable management of Indian Cities.

In recent years, it is noticed that the Government of India has started to emphasize the development of eco-friendly smart cities throughout the country. Pioneering work in this end was carried out by TERI with the help of the Royal Embassy of Denmark and International Urban Co-operation (IUC) Programme of the European Union in the form of policy dialogues on 'Making Liveable Cities: Challenges and Way Forward for India'. It aims to create 'people-centric' sustainable urbanization in India (Singh et al., 2018). Several other researchers have also carried out studies aimed to highlight sustainable liveability in the rapidly growing urban centres (Hanjabam, 2020; Saitluanga, 2014). However, the notable gap is that very little attention is provided to the eco-environmental condition of the cities for the sustainable management of the cities. Few pieces of research were performed at a local scale following a particular city to address the environmental issues for urban sustainability (Yedla, 2006; Rahman, 2011; Ziaul and Pal, 2017). A broad summary of systemic investigation of environmental issues in Indian cities is yet to be synthesized. Hence, this study tried to present a systematic way of investigating and incorporation of environmental issues in the sustainability of urban areas.

This study is conducted based on the following research questions: (i) what are the major eco-environmental issues that emerged out due to rapid urban growth? (ii) How different researchers have tried to address these issues in the sustainability of urban development?. This study examined the previous researches and presented the process of incorporation of urban eco-environmental transformation in a comprehensive compiled way. The findings of this study will help the researchers to address the environmental issues and management in case of different Indian cities using systematic and sophisticated methods.

2. Materials and methodology

This study performed a systematic review of existing literature to address the research questions of this study. Following Pickering and Byrne (2014), the focus was given to make this study a systematic, quantitative, comprehensive, and structured review. The present study is conducted systematically because all the existing articles are surveyed and finally included in a manner that they can be reproduced. This study is quantitative because it quantifies the research where there are gaps that exist. The method of this study is comprehensive because it included studies covering different locations and variables. Further, it summarized the findings of these researches. Finally, the method adopted in this study is structured as it included several steps to collect and analyze the existing literature (Hazemba and Halog, 2021). The successful investigation of the key areas of eco-environmental transformation due to urban expansion depends on the understanding of the current investigations and methods in this field (Iyer and Steele, 2015). Therefore, it includes identifying what needs to be addressed and diagnosed. It can be built off following 1. scope and problem definition, 2. Selection of search string, and 3. screening of researches.

2.1. Scope and problem definition

The objective of this study is to identify the environmental issues associated with urban development and their practical management in promoting urban sustainability. The goal is to compile different researches in a systematic way to set the basis of environmental management. It is tried to make this study as objective as possible without favouring any specific perspective. Since the issue of environmental degradation due to urban growth is a recent and burning one, the audience for this study will be broad covering all disciplines that are affected by the urban development. An initial search disclosed a large number of research papers in this field. However, for better illustration and representation, several representative samples are required. The samples are acquired following the subsequent steps.

2.2. Selection of search string

This step is performed to search the specific researches relating to the objectives of this study (O'Brien and Mc Guckin, 2016). Since the study deals with the eco-environmental transformation due to urban expansion, keywords like environmental degradation, environmental landscape, urban development are used. The details of the database search string are shown in Table 1.

It is important to mention that only the pieces of literature written in English are taken into consideration following the lingual capacity of the authors. Besides, the works that have been carried out in the 21st century (2001–2020) are taken due to having recent and updated methods.

2.3. Screening of researches

Using keywords, a total number of 729 research articles are discovered. Later on, these huge volumes of articles were screened out by a two-step process. In the first step, the descriptive articles are omitted by reading the abstract and title of the research. Following this, the number of articles reduced down to 228. The second level of screening is done to select the quality articles. In academics, cite score and impact factor are the two main criteria that are considered for quality assessment. In this study, the cite score and impact factor of the mother journal of the articles are evaluated to perform the second level of screening. At this stage, the studies with similar methodology are screened out to attain a less number of articles following the cite score and impact factor of the published journal. Finally, after two levels of screening, 72 research articles are included for the assessment. It is further important to mention that the objective of this study is to address only the studies that deal with the eco-environmental transformations in urban areas. Therefore, passive negative environmental effects such as different forms of pollution and land surface temperature effects are not incorporated in this study. Fig. 1 represents the stepwise screening process of the articles.

3. Results and discussion

A large number of articles were selected for this study, which was carried out at different locations between 2001 and 2020. However, the year 2015 is marked as the pivot point from when greater focus on sustainable development was given (Hazemba and Halog, 2021). Table 2 summarizes the findings of all the selected articles in a single form.

A detailed investigation of the selected literature revealed that rapid urban expansion has led to several environmental problems such as loss of natural cover, a significant decrease in ecosystem service values (ESVs), fragmentation and loss of green space, and deterioration of neighborhood environmental quality. Loss of valuable wetlands and natural vegetation cover mainly in the peri-urban region due to urban expansion is very common in case of Indian cities (Das and Basu, 2020; Ghosh and Das, 2019). Several studies showed that deterioration and reduction in environmental covers due to uncontrolled urbanization reflected in low ESVs (Das and Das, 2019; Wan et al., 2015; Zang et al., 2011). Furthermore, several studies reported that increased built-up structure at the cost of natural environmental cover resulted in low satisfaction of the residents and suggested deterioration of neighborhood environmental quality (Lanrewaju, 2012).

Finally, reading the selected articles has identified four main areas of investigation in the field of urban growth-induced eco-environmental transformation. These are (i) land use & land cover (LULC) change and

Table 1
Details of database search string or keywords.

Database Field	String of Search	Initial artcles found	Date
Scopus	"Environment management + Urban growth" or "Environment degradation + Urban growth" or "Natural cover loss + sustainable urban development" or "Environmental health + Urban" or "Environment efficiency + urban growth"	106	30.12.2020 to 31.12.2020
Web of Science	"Environment deterioration + Urban expansion" or "Environment degradation + Urban expansion" or "Loss of natural cover in urban areas + sustainable development" or "Environmental health + Urban" or "Environment efficiency + urban growth"	79	01.01.2021 to 02.01.2021
Science Direct	"Environment deterioration + Urban expansion" or "Environment degradation + Urban expansion" or "Loss of natural cover in urban areas + sustainable development" or "Environmental fragmentation + Urban expansion" or "Environment health + urban expansion"	94	03.01.2021 to 04.01.2021
Google Scholar and Google Search Engine	"Environment deterioration + Urban expansion" or "Environment degradation + Urban expansion" or "Natural cover loss + sustainable urban development" or "Environmental fragmentation + Urban expansion" or "Environment health + urban expansion" or "Environmental efficiency + Urban development"	450 (Originally > 450)	05.01.2021 to 08.01.2021
All	Total	729	

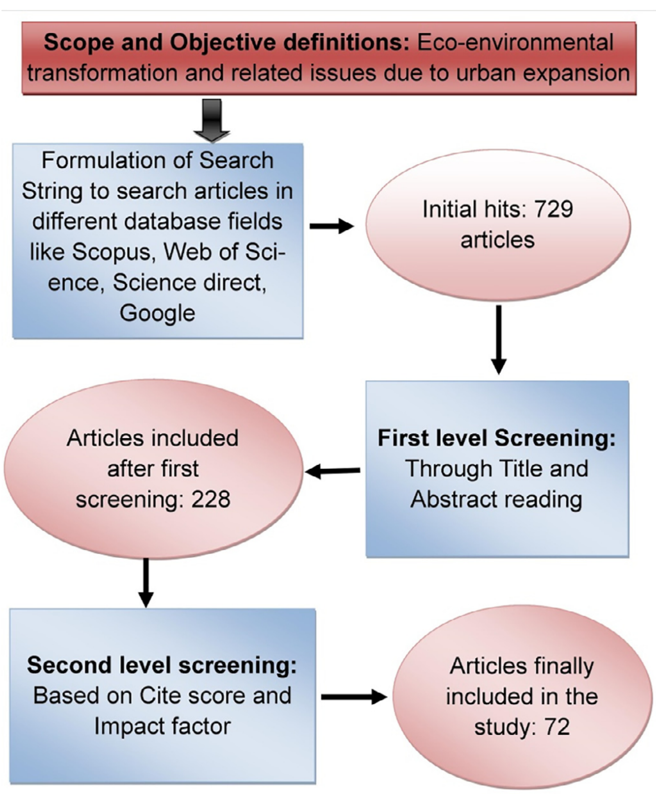

Fig. 1. Methodological flow-chart showing the selection of articles in this study.

scenario design; (ii) Assessment of ecosystem service values (ESVs); (iii) Urban green space structure and its relation with urban heat island; (iv) Perception survey on neighborhood environmental quality. The following sub-section highlighted the insight facts of these studies and tried to show how these can be implemented in Indian cities.

3.1. LULC change and scenario design

An intense review of the literature has disclosed that LULC change is the common form of analysis of urban development-induced eco-environmental transformation. LULC change can relate successfully the expansion of urban area with the loss of natural cover by depicting the contribution of each LULC type in urban expansion. For example, Previous studies on LULC change successfully demonstrated that the Howrah Municipal Corporation in West Bengal, India has expanded by around 30 km^2 in the past 40 years (1975–2015) at the cost of vegetation (−7.05 km^2), waterbody (−5.99 km^2), and agriculture land (−11.96 km^2) (Patra et al., 2018). A similar study also highlighted the expansion of Delhi metropolitan city in India by highlighting the net loss of each specific LULC (Jain et al., 2016). It helps to highlight the specific LULC that is most vulnerable to urbanization. Therefore, a specific land use management policy can be implemented to guide sustainable urbanization. It is observed that studies have favoured analysis of LULC of more than 20 years that starts from the 1990s and ends in the recent past (Vivekananda et al., 2020; Naikoo et al., 2020; Alawamy et al., 2020). To classify the satellite images, maximum likelihood classification is found as the easiest (Erasu, 2017; Mondal et al., 2017; Rahman et al., 2011) and random forest as the effective one (Hernandez and Shi, 2017; Eisavi et al., 2015; Das and Basu, 2020; Chang et al., 2020). Herein, the main focus lies on the rate of changes in the area of different LULC between specific time intervals. A high rate of negative changes in the areas of different natural cover signifies environmental degradation. In the context of Indian cities, earlier, the scope to have very high-resolution satellite images for the desired period is limited due to inadequate funds. However, recently, changes in the data policy were made, wherein the National Remote Sensing Centre (NRSC) started to provide high-resolution data at a very low cost to the academicians, researchers, and students. Furthermore, moderate resolution satellite product is made freely available in the public domain of NRSC. Besides, the Landsat satellite products with moderate resolution can be downloaded from the official website of USGS earth explorer (https://earthexplorer.usgs.gov/) for any cities of India for the past 20 or more. These are freely available and, recently, level-2 Landsat products are also made publicly available. In case of the satellite image classifications, spectral signature collection and processing through maximum likelihood classification or random forest can be performed following Basu et al. (2021) (Video tutorials of supervised image classification in ArcGIS: https://www.youtube.com/watch?v=-a_jEhMVF60 and Video tutorial on random forest classification in R: https://www.youtube.com/watch?v=fal4Jj81uMA).

In recent studies, it is observed that the horizon of LULC analysis expanded further and researchers tried to foresee the future LULC pattern of the desired area based on historical LULC transition and factors influencing these transitions (Rimal et al., 2018; Huang et al., 2008; Samal and Gedam, 2015). This has brought a revolution in the study

Table 2
Summary of the 72 research articles selected for this study.

Source	Topic	Spatial Scale	Location	Method
Alawamy et al. (2020)	Detection of LULC change	County to urban cities	Libya	Image classification by maximum likelihood
Batisani and Yarnal (2009)	Landscape transformation due to urban expansion	County	United States of America	CLUE-S model for future land use pattern
Bose and Chowdhury (2020)	Modeling urban expansion and LULC change	Urban Centre	India	Markov Chain for future LULC pattern
Braimoh and Onishi (2007)	Determining the variables of LULC Change	Metropolitan Region	Nigeria	Binary logistic regression to show the relation between LULC change and variables
Chang et al. (2020)	Urban land use mapping	Urban Centre	China	Image Classification by Random Forest
Chim et al. (2019)	LULC change detection and prediction	River basin	Cambodia	LULC prediction by MLPNN-Markov Chain
Costanza et al. (2014)	Ecosystem Service estimation	Global	Global	Coefficients determination for ESVs estimation
Dadashpoor et al. (2019)	Prediction of future urban growth	Metropolitan area	Iran	SLEUTH model for prediction
Das and Basu (2020)	Ecological degradation assessment through perceived value	Urban and peri-urban region	India	Perceived degradation assessment by Importance-Performance Analysis
Das and Das (2019)	Impact of urbanization on ESVs	Urban Centre	India	Temporal ESVs estimation
Daw et al. (2016)	Elasticity in ecosystem services	Conceptual framework		Ecosystem elasticity index to explore the relationship between ecosystem and human well-being
Dewan and Yamaguchi (2009)	LULC change analysis for sustainable urbanization	Metropolitan Region	Bangladesh	Image Classification by Supervised algorithm
Dubovyk et al. (2011)	Assessment of informal settlement development as a decision-making tool	District	Turkey	Spatial modeling of informal settlement development and future prediction by logistic regression
Eisavi et al. (2015)	LULC mapping	Urban Centre	Azerbaijan	LULC change mapping by random forest
Ghosh and Das (2019)	Wetland Vulnerability due to urban expansion	Metropolitan region	India	LULC mapping and vulnerability assessment by Fuzzy approach
Hamad et al. (2018)	LULC analysis and prediction	Region	Iraq	LULC prediction by Cellular Automata (CA)-Markov Chain
Helbich (2019)	Green space measurement	Rural and urban area	Netherland	Green space health study by Normalized Difference Vegetation Index (NDVI)
Hernandez and Shi (2017)	Detection of LULC change	Urban area	Mexico	LULC classification by random forest
Hu et al. (2008)	Impact of LULC change on ESVs	Township	China	Spatial and temporal ESVs estimation
Hu and Lo (2007)	Modeling urban growth	Urban area	United States of America	Future urban growth probability mapping by logistic regression
Hua and Chen (2019)	Understanding peoples' perception regarding the quality of Ecosytem services	Urban region	China	Prioritizing Ecosystem services based on importance-performance analysis
Huang et al. (2010)	Spatial-temporal assessment of rural-urban land conversion	Urban Centre	United States of America	Analysis of land use change and probable conversion by logistic regression
Huang et al. (2008)	LULC change to show urban expansion	Metropolitan Region	China	Image classification by maximum likelihood
Johmson et al. (2014)	Environmental perception among residents	Urban Centre	Argentina	Perception survey
Klompmaker et al. (2018)	Green space assessment	Neighborhood	Netherland	NDVI
Kyttä et al. (2011)	Perception of environmental quality for decision-making	Towns	Finland	Internet questionnaire and analysis by softGIS
Lahoti et al. (2019)	Green space mapping methodology and distribution assessment	City	India	Digitization, extraction, and compilation from the high-resolution data source
Lanrewaju (2012)	Impact of urbanization on environmental degeneration	National	Nigeria	assessing the relation between housing quality and environment condition by using secondary data
Li et al. (2019)	Impact of LULC change on ESVs	Five Countries	Central Asia	Spatial-temporal changes in ESVs as estimated following Costanza et al. (1997)
H. Liang, Chen, and Zhang et al. (2017)	Assessment of urban green space distribution	Megacity	China	Green space distribution characteristics by landscape metrics
H. Liang et al. (2017)	Assessment of green space quality	Urban city	China	Green space quality measurement by unmanned aerial vehicle data
Liu and Zhou (2005)	Land use change and urban growth trajectory	Megacity	China	Urban growth modeling using GIS technique
M'Ikiugu et al. (2012)	Urban green space analysis and its expansion potential	City	The Republic of Kenya	Green space characteristics and possible expansion area identification by GIS and landscape metrics
Maimaitiyiming et al. (2014)	Effect of green space on land surface temperature (LST)	City	China	Association between green space and LST through landscape metrics
Masoudi et al. (2019)	Cooling effect of green space on LST	Four Asian cities	Asia	Association between green space and LST through correlation and regression

(*continued on next page*)

Table 2 (*continued*)

Source	Topic	Spatial Scale	Location	Method
Mitchell et al. (2015)	Effect of landscape fragmentation on ecosystem services	Opinion		Framework to analyze the effect of landscape fragmentation on ecosystem services
Mondal et al. (2017)	Urban expansion and wetland shrinkage	Metropolitan City	India	Urban growth modeling to simulate the future wetland transition by SimWeight model
Naeem et al. (2018)	Association between green space characteristics and LST	Metropolitan city	Pakistan and China	Impact of green space on LST through landscape metrics, green space cool islands, and LST factors
Naikoo et al. (2020)	LULC change and built-up expansion	Metropolitan city	India	Spatial-temporal analysis of LULC change
Nasehi and Imanpour namin (2020)	Green space fragmentation analysis	City	Iran	Assessment of fragmentation in green space using landscape metrics
Nguyen et al. (2019)	Environmental effects of urban development	City	Vietnam	Association between NDBI, NDVI, and LST
Nurdin and Wijayanto (2020)	Green space distribution	City	Indonesia	NDVI measurement from Landsat OLI
Perveen et al. (2017)	Developing policy scenario for sustainable urban growth	Region	Australia	Scenario-based urban growth based on Delphi approach
Pramanik and Punia (2019)	Assessment of green space effects on urban cooling	Metropolitan city	India	Natural cover characteristics identification by landscape metrics and its association with LST
Rahman et al. (2011)	Urbanization and environmental quality	City	India	Determining the relationship between urbanization and environmental degradation using remote sensing and GIS
Rimal et al. (2018)	LULC change and urban expansion	City	Nepal	Modeling urban expansion by cellular automata and Markov Chain
Samal and Gedam (2015)	Land use change associated with urbanization	Region	India	GIS-based LULC change detection
Shi et al. (2020)	Urban green space accessibility and distribution	City	China	Questionnaire star survey platform to determine the accessibility and distribution
Sinha et al. (2015)	Improved LULC classification techniques	Region	India	Combined used of thermal and spectral signature for better LULC classification and understanding the LULC dynamics
Sivakumar (2014)	Urban mapping and growth prediction	City	India	Modeling urban expansion by Markov Chain algorithm
Sudhira et al. (2004)	Urban sprawl dynamics	Region	India	Urban sprawl dynamics by landscape metrics
Talukdar et al. (2020)	Dynamics of ESVs in response to LULC change	Region	India	Ecosystem elasticity analysis to explore the relationship between ecosystem services and LULC change
Taylor and Hochuli (2017)	Defining green space	Global	Global	Recommended a definition that is both qualitative and quantitative
Thapa and Murayama (2012)	Spatial urban growth modeling	City	Nepal	Modeling of urban growth using MLPNN-Markov Chain
Uttara et al. (2012)	Impact of urbanization on environmental degeneration	Cities	India	Supporting data to show environmental degradation due to urbanization
Tian et al. (2014)	Assessing the quality of urban green space	Region	Hong Kong Islands	Green space extraction from high-resolution image and quality measurement by landscape metrics
Vargas-Hernández et al. (2018)	Green space as a component of an ecosystem	Global	Global	Community involvement in sustainable management of green space
Vermeiren et al. (2012)	Scenario-based urban growth modeling	City	Uganda	GIS and Logistic regression for spatial modeling
Vivekananda et al. (2020)	LULC classification and change detection	Region	India	Spatial-temporal analysis of LULC change to understand its dynamics
Wang et al. (2018)	Quantifying and characterizing the urban green space	City	China	Patch level analysis to understand the green space changes over time
Wan et al. (2015)	Effect of urbanization on ecosystem services	City	China	Entropy value method and estimation of ESVs
Weng (2007)	urbanization and changes in landscape pattern	City	United States of America	Spatial-temporal analysis and application of landscape metrics
Wu et al. (2009)	Projection of land use change pattern	City	Canada	Kernel logistic regression
Wu (2013)	Ecosystem services and human well-being	Global	Global	Methods to establish the relation between ecosystem services and human well-being
Wu and Zhang (2012)	Land use dynamics and built-up area expansion	City	China	Spatial-temporal built-up expansion and analysis of driving variables
Wu and Kim (2021)	Equality in assessing the green space	Cities	China	A comparative study among 341 cities using Gini coefficient
Wüstemann et al. (2017)	Access to public green space	Cities	Germany	Green space inequality measurement using Gini coefficient
J. Xiao et al. (2006)	Urban expansion and land use change	City	China	Spatial-temporal analysis of LULC change and its driving factors
Xu et al. (2018)	Spatial variation of green space equity	City	Germany	Spatial inequality assessment by Gini coefficient
Kong et al. (2014)	Impact of green space on LST	Metropolitan area	China	Green space characteristics by landscape metrics and association with LST
Zang et al. (2011)	Impact of urbanization on ESVs	Region	China	Spatial-temporal LULC change and ESVs estimation
Ziaul and Pal (2017)	Impact of urbanization on the peri-urban environment	City	India	Possible environment degradation identification by devising insecurity index

Table 3
Variables that are found by different researchers across the globe as urban growth influential.

Category	Variables	Description	Studies that incorporated
Socio-Economic factors	Population Density	Numbers of people reside per sq. km or in specific grids. Population density and urban growth is positively related.	Batisani and Yarnal, 2009; Wu and Zhang, (2012); Wu et al., (2009); Dubovyk et al., (2011); Xiao et al. (2006); Huang et al. (2010)
	Gross Domestic Product (GDP)	GDP is incorporated as per unit area basis. Here, high GDP suggests good for urban expansion.	Dewan and Yamaguchi (2009); Sudhira et al. (2004); Seto et al. (2011); Jiang et al. (2013)
	Worker	Proportion of workers per unit area is adopted as proxy to the economic conditions, where income data is not available.	Das and Basu (2020); Basu et al. (2021)
Proximity factors	Distance to City Centre	Location of the city Centre is demarcated from the urban planning map of the respective city and, then, distance map is generated using GIS softwares like ArcGIS. Greater distance from city Centre discourages urban expansion on that direction.	Vermeiren et al. (2012); Li et al. (2013); Braimoh and Onishi (2007)
	Distance to Major Roads and Railway station	All the major roads and railway station within a city can be acquired from the city planning map or google earth. Proximity to the major roads and railway station increases the accessibility and serves as the urban expansion drivers.	Liu and Zhou (2005); Müller et al. (2010); Hu and Lo (2007)
Physical factors	Slope and Elevation	The slope and elevation of an area can be obtained from the digital elevation model (DEM) which is freely available at the USGS Earth Explorer. Slope and elevation are negatively associated with urban expansion.	Bose and Chowdhury (2020); Thapa and Murayama (2012); Tian et al. (2012)
	Flood prone zone / Distance to drainage	Most of the cities in the world are located beside any river. Delineation of the flood-prone region through temporal satellite image analysis is also found an important negatively associated indicator for urban expansion.	Park and Lee, (2019); Handayani et al., (2020); (Liu et al., 2018)
Neighborhood factors	Neighbourhood urban area	Proportion of urban area/underdeveloped area (agriculture/fallow land) in the neighborhood unit area (pixels) is estimated mainly using the 'Block Statistics' tool in ArcGIS using (3 km/pixels × 3 km/pixels) surrounding units. A high proportion indicates favourable conditions for urban expansion.	Das and Basu, (2020); Luo and Wei (2009); Müller et al. (2010)
	Neighborhood underdeveloped area		
Land use Planning map	Future land use planning map	The existing land use planning map serves as an important basis for guiding urban expansion in future.	Thapa and Murayama (2012); Tian et al. (2005); Long et al. (2012)

of LULC analysis, which enables the researchers to estimate the effect of urban development on the natural covers in the upcoming future. Prediction of future conditions requires two LULC of two different periods and a set of explanatory variables. Still, there is no common form of explanatory variables that can be incorporated right away for the analysis. This study compiled all the possible explanatory variables that are depicted as influencing factors of urban growth by different studies (Table 3). It is important to mention that the set of variables responsible for the urbanization of different cities varies from place to place. Therefore, it is not possible to present a general set of variables that will be suitable for all the cities. However, this study tried to show the individual variables that are adopted commonly by several studies.

Researchers found that the prediction of the accurate future condition is very difficult due to the uncertain response of certain factors and situations (Perveen et al., 2017). Therefore, the prediction of LULC under multiple scenarios was found much useful to understand the future condition (Dadashpoor et al., 2019). The three common scenarios that are used by the researchers are "Business as usual" (Das and Basu, 2020), "Environment scenario" (Perveen et al., 2017), and "Planning scenario" (Thapa and Murayama, 2012). The business as usual scenario deals with the future prediction where the changes are expected to take place in the same way following the current LULC transition. No special modification in the modeling is required in case of this scenario. The environment scenario deals with the prediction of future LULC protecting the natural elements. In this case, minimum weights are allocated to the pre-defined natural covers that make these less transition potential. The planning scenario tries to predict the future LULC following the existing planning map of the region. All the land uses of the planning maps are incorporated in this scenario as explanatory variables that allow the model to predict following this land uses. There are several commonly used models for LULC prediction such as the Markov Chain model (Sivakumar, 2014), Cellular Automata model (Sinha et al., 2015); Cellular Automata-Markov chain model (CA-Markov) (Hamad et al., 2018), Multi-Layer Perceptron Neural Network- Markov chain model (MLPNN-Markov) (Chim et al., 2019).

3.2. Assessment of ecosystem service values (ESVs)

The term 'Ecosystem Service' refers to all the material and non-material benefits that can be acquired directly or indirectly from the environment or ecosystem Hu et al., 2008). The quantification of these services in monetary terms is known as ecosystem service values (ESVs) (Li et al., 2019). In recent years, spatial-temporal estimation of ESVs has gained wide applicability to assess the quality of the environment. A study on HaDaQi industrial corridor in China showed that an uncontrolled increase in an urban area during the period (1990–2005) has resulted in 29 percent loss of ESVs (2.26% annually) indicating severe ecosystem degradation (Zang et al., 2011). Similar effects of urbanization were observed in the tropical ecotone area of Brazil. Here, uncontrolled urbanization has removed 41% of arboreal vegetation from 1989 to 2014. It ultimately resulted in a loss of 89% ESVs during the same period (Ferreira et al., 2019). A decrease in ESVs over time signifies the degradation of the natural environment and suggests the necessity of environmental management (Talukdar et al., 2020; Das and Das, 2019). A systematic review of existing research articles showed that the best way of ESVs estimation is the application of global coefficients as provided by Costanza et al. (1997). Costanza et al. (2014) updated the global coefficient at a later period and the new coefficients served as the basis of ESVs estimation in recent studies. The simple way of ESVs estimation can be documented following Eqs. (1) and ((2).

$$ESV = \sum (A_k \times VC_k) \tag{1}$$

$$ESV_f = \sum (A_k \times VC_{fk}) \tag{2}$$

Where 'ESV' depicts the Ecosystem service value for a specific year; A_k = Area of LULC class 'k' in hectare; VC_k = Coefficient ($/ha/year) as provided by Costanza et al. (1997) or Costanza et al. (2014) for LULC class 'k'; ESV_f = Ecosystem service value of LULC class 'k' for function 'f'; VC_{fk} = Coefficient ($/ha/year) as provided by Costanza et al. (1997) or Costanza et al. (2014) for function 'f' of LULC class 'k'.

Apart from ESVs estimation, few studies have tried to estimate ecosystem service elasticity to establish the relationship between human well-being and ecosystem service. The main aim is to identify how changes in ecosystem services can lead to changes in human well-being. The estimation of overall ecosystem service elasticity can be performed following Daw et al. (2016).

3.3. Urban green space structure and its relation with urban heat island

The word 'green space' refers to the natural vegetation, gardens, parks, etc. within and around a city (M'Ikiugu et al., 2012). Moreover, it is mainly associated with the proportion of trees or vegetation (Taylor and Hochuli, 2017). Vegetation is considered one of the most important environmental elements. It provides different services to the human such as food, climate regulation, esthetic, recreation, minimizing the heat effect, etc. (Das and Das, 2019). Several researchers have tried to present the loss of natural vegetation cover by showing the conversion of the eco-environmental landscape into the built-up structure. In this regard, they performed an analysis of the characteristics and structure of the green spaces. The analysis of green space structure is divided into two steps. The first step is associated with the identification of green space and the second step is associated with the study of the characteristics of green space at patch level (Wang et al., 2018; H. Liang et al., 2017). Normalized Difference Vegetation Index (NDVI) is the common approach that is adopted by the researchers to identify the green spaces in the cities (Helbich, 2019; Nurdin and Wijayanto, 2020; Engemann et al., 2019). However, few researchers have tried more advanced steps by highlighting the green spaces from different sources like Google earth, city land use map, etc., and, then, demarcating them in the satellite images (Lahoti et al., 2019; Shi et al., 2020). It delivered better accuracy in the delineation of green spaces (Klompmaker et al., 2018). In case of structure analysis, researchers have favoured landscape metrics to identify the fragmentation in the green spaces. In these regards, the commonly used landscape metrics are NP (number of patches), PLAND (Percentage of landscape), LPI (Largest Patch Index), PD (Patch Density), COHESION (Patch cohesion index), AI (Aggregation index), etc. (Weng, 2007; H. Liang, Chen, and Zhang et al., 2017; Nasehi and Namin, 2020; Qian et al., 2019). Table 4 represents a summary of five commonly used indices.

Besides this, few studies were also found that tried to show the spatial inequality in green space distribution. The most popular approach in this regard is the application of the Gini Coefficient (Wüstemann et al., 2017; Xu et al., 2018; Wu and Kim, 2021). It is applied across the ward level/grid level to show the inequality in the availability of green space. A high value of the Gini coefficient indicates greater spatial variation in the distribution of green space. Besides, it also indicates unequal access of citizens to the green space across the city (Wüstemann et al., 2017), which in turn put a negative impact on the livable condition of the city (Fu et al., 2019). In Indian context, there are also some open-source websites (https://github.com/datameet/Municipal_Spatial_Data) from where the ward level shapefiles can be downloaded directly. However, the number of available cities is limited on these websites. For the rest of the cities, the ward map can be obtained from the local municipal offices. Landscape metrics analysis can be performed using Fragstat software. For the application of the Gini Coefficient, specific R commands (https://www.r-bloggers.com/2012/02/gini-index-and-lorenz-curve-with-r/) can be used to generate the coefficient values and Lorenz curve.

It is a well-established fact that natural vegetation cover helps to mitigate the heat effect (Vargas-Hernández et al., 2018). Focusing on this principle, researchers have tried to establish the link between the green space and land surface temperature (LST) following a spatial-temporal investigation (Maimaitiyiming et al., 2014; Naeem et al., 2018; Yin et al., 2019; Masoudi et al., 2019; Pramanik and Punia, 2019). Through their outcome, they showed the necessity of the management of green spaces for better urban livability. Within the cities, it is observed that the areas with a greater proportion of green spaces contribute little to the effect of heat island over time. Contrary to this, the bare areas with an increase in the cover of concrete contribute maximum to generate the heat island. Systematic review highlights that grid-wise (100 × 100 m; or 60 × 60 m; or 30 × 30 m) analysis delivers better results while showing the relation between green space and LST as compared to the analysis following administrative boundaries. To establish the relationship between these two, researchers used correlation and regression. Here, the LST of a grid is selected as a dependent variable and the proportion of green space of the same grid is selected as an independent variable.

3.4. Perception survey on neighborhood environmental quality

In most countries, as well as India, the primary way of executing any environment management plan follows the top-down approach. However, although a few at present, researches is emerging out showing the benefits of a bottom-up approach. The main agenda of these studies was to identify the environmental issues associated with eco-environmental transformations based on the perception survey of the residents (Das and Basu, 2020; Hua and Chen, 2019; Kyttä et al., 2011; Ngesan et al., 2013; Johnson et al., 2015). For example, Das and Basu (2020) formulated the index of perceived degradation based on the perception of the residents. Following this, they calculated more than 65% degradation of the peri-urban wetland due to urbanization. This helps to identify the problems in a much better way and ultimately helps to take up effective strategies to mitigate those issues. It is important to mention that several studies took few environmental indicators to determine the quality of life in the urban areas. The main objective of these studies was to determine the quality of life or liveability in urban areas and is less associated with environmental issues. Therefore, these studies are not included in this section. Out of total of 72 selected articles, only 5 are associated with this section. All the articles followed a questionnaire survey approach to record the perception of the residents. The number of questions and types varied based on the objective and study unit of each article. The final output is presented as a perception index by processing all the recorded perception scores in a composite form. Besides this, few studies also used importance-performance analysis (IPA) to show the performance of different environmental units. In Indian context, this kind of study can be performed following three steps. These are general identification of the problem, preparation of a list of questionnaire associated with it, and development of a composite index to show the outcome in a composite form.

4. Challenges and suggestions for sustainable urban development in India

India is a developing country. Therefore, economic growth automatically comes at the topmost priority of the nation. The natural environment suffers most in the situations where development plans take place having zero coherence across institutions regarding the environment (Bass et al., 2010). Besides, the main focus of specific ministry also remains on that specific factor (Nunan et al., 2012). No strategies

Table 4
Few commonly used landscape metrics.

Metrics	Definition	Unit	Range	Description
PLAND	$PLAND = \frac{\sum_{y=1}^{n} r_{xy}}{TA}(100)$ Here, x = patch type; y= 1,..., n patches; TA= Total area	Percentage	0 < upto ≤ 100	Depicts the area of landscape in percent. More value means more area covered by the landscape
PD	$PD = \frac{np_i}{TA}(10,000)(100)$ Here, np_i= number of patches; TA= Total Area	Patches (quantity) per 100 hectare	The value of PD is > 0.	Depicts patches per 100 hectares. High PD describes the existence of several patches in a relatively small area.
LPI	$LPI = \frac{\max_{y=1}^{np}(r_{xy})}{TA}(100)$ Here, np= number of patches; r_{xy} = Area of patch xy	Percentage	0 < upto ≤ 100	Highlights the patch having largest area in a landscape.
COHESION	$COHESION = 1 - (\frac{\sum_{j=1}^{n} p_{ij}}{\sum_{j=1}^{n} p_{ij}\sqrt{a_{ij}}}) * (1 - \frac{1}{\sqrt{Z}})^{-1} * 100$ Here, p_{ij} = perimeter; a_{ij} = Area; Z = number of cells	Percentage	0 < upto <100	Helps to describe the connectedness within the patches of the landscape. High connection among the patches is essential for sustainability and it is represented in the form of high cohesion value.
AI	$AI = [\frac{c_{ii}}{\max c_{ii}}](100)$ c_{ii}= adjacencies (joins) among pixels in patch i admiring single-count method max-c_{ii} = maximum adjacencies (joins) among pixels in a patch type i admiring single-count method.	Percent	0 < upto ≤ 100	Describes the aggregation and compactness within the patches. Relatively high value of AI reflects the high aggregation and compactness within the patches.

involve developing environmental plans strengthening capacity and getting investments for environmental management (Assey, 2007). Lack of political will to address the long-term benefits of environmental management also hinders progress in this regard.

Urban planning generally passes through three different phases. It starts from strategic planning and then moves into the implementation phase and finally ends into the evaluation stage. Strategic planning involves synergies among the different strategic frameworks (Ferry et al., 2018). Urban built-up expansion and loss of natural cover is a major environmental issue in India. Scenario-based urban growth modeling and LULC change trajectory can provide a direction regarding the possible impact of urban expansion on the natural cover. In this case, the identification of a suitable set of explanatory variables is a prerequisite to get the optimum result. Further, instead of using a single machine learning model, comparative analysis of 2 or 3 models is ideal to get better accuracy. It will help to establish a trade-off between loss of natural cover and built-up expansion. Studies revealed that green space provides a cooling effect in the cities and mitigates the heat island effect. Therefore, identification of the characteristics of green space over time and establishing its relation with LST serves as an important development indicator. Compact green space cover with less heat island effect suggests a more ecofriendly and livable city. In this case, the identification of green space is the main challenging task. It is observed that digitization and then extraction of green space areas from high-resolution imageries like Google Earth, Aerial photo, and city planning map can deliver better accuracy.

In a democratic country like India, all public investments should enclose its raison d'être by highlighting immediate results. The total benefits and usefulness of a specific public investment in urban development can be judged concerning spatial-temporal ESVs estimation. Further investigation can also determine the future loss of ESVs if the LULC trajectory remains in the same direction (Basu et al., 2021). Generally, the ESVs are estimated based on the global coefficient of Costanza et al. (1997). However, several studies estimated the coefficient for their study area (Xie et al., 2008). A similar approach can be taken to obtain the coefficients in case of Indian cities to get the most accurate ESVs. It can help to understand the possible environmental degradation due to urban planning and the gain or loss that is ultimately achieved by the community. Integration of environment and development is considered part of a long-term sustainable urban development. Therefore, sustainable urban development requires the involvement of all stakeholders that are associated with the development process. In this regard, evaluation can be performed whether the ongoing urban development is sustainable and ecofriendly or not. The perception of the local people becomes the key element in this case. It can identify the drawbacks in urban planning and helps to develop more liveable cities. Perception analysis can reveal the environmental need by the direct involvement of the stakeholders. In this way, it can facilitate a bottom-up approach wherein environmental aspects can be considered into the development process following the demand of residents. However, a proper set of questionnaires that can address the issue properly is required for a successful perception study. Besides, preliminary analysis needs to be done like analysis of variation to depict whether the set of responses is sufficient enough to carry out the study.

5. Conclusion

Urbanization is the main feature of this geological age where human dominates the whole landscape. Despite this, a sustainable balance between the natural and urban landscape is essential for the benefit of all. Since the very beginning, very little attention is paid to ecologically efficient urban planning. As a result, it led to several environmental issues in the urban areas that resulted in low urban livability. Therefore, recently, all the countries have started to devote more attention to environmental management in the cities. However, in developing countries like India, there is no study that can guide the researchers to follow the current trend of analysis in addressing the eco-environmental transformation in urban areas. This study is conducted to examine the recent processes of highlighting the eco-environmental transformation-induced issues to address sustainable urban development. Later on, a short discussion is also carried out to show the way of application of these methods in the Indian case. A systematic review of the existing literature has been carried out and, after screening, a total of 72 articles are selected for the assessment. Detailed and intense literature review disclosed four different ways of addressing eco-environmental transformation due to rapid urban development. In this regard, the use of satellite products has gained wide application. It is also observed that the use of sophisticated techniques like LULC prediction using scenario design, ecosystem service values, and green space assessment has gained momentum during the last decade. Few studies also emerged out in the recent past that showed the involvement of the residents in the effective management of environmental issues. Finally, it can be said that the incorporation of environmental issues in urban design and planning needs better knowledge of the functions and services of environmental units. The outcome of this study can deliver a clear direction to the researchers on the current trend of researches in this field.

Declaration of Competing Interest

There is no potential conflict of interest.

References

Alawamy, J.S., Balasundram, S.K., Mohd. Hanif, A.H., Boon Sung, C.T., 2020. Detecting and analyzing land use and land cover changes in the region of Al-Jabal Al-Akhdar, Libya using time-series landsat data from 1985 to 2017. Sustainability 12 (11), 4490. doi:10.3390/su12114490.

Assey, P., 2007. Environment at the heart of Tanzania's Development: lessons from Tanzania's national strategy for growth and reduction of poverty, MKUKUTA (No. 6). IIED.

Bass, S., Annandale, D., Nam, H.A., Van Binh, P., Dong, T.P., 2010. Integrating Environment and Development in Viet Nam: achievements, Challenges and Next Steps (No. 2). IIED.

Basu, T., Das, A., Pham, Q.B., Al-Ansari, N., Linh, N.T.T., Lagerwall, G., 2021. Development of an integrated peri-urban wetland degradation assessment approach for the Chatra Wetland in eastern India. Sci. Rep. 11 (1), 1–22.

Batisani, N., Yarnal, B., 2009. Urban expansion in Centre County, Pennsylvania: spatial dynamics and landscape transformations. Appl. Geogr. 29 (2), 235–249.

Bose, A., Chowdhury, I.R., 2020. Monitoring and modeling of spatio-temporal urban expansion and land-use/land-cover change using markov chain model: a case study in Siliguri Metropolitan area, West Bengal, India. Model. Earth Syst. Environ. 6, 2235–2249. doi:10.1007/s40808-020-00842-6.

Braimoh, A.K., Onishi, T., 2007. Spatial determinants of urban land use change in Lagos, Nigeria. Land Use Policy 24 (2), 502–515.

Chang, S., Wang, Z., Mao, D., Guan, K., Jia, M., Chen, C., 2020. Mapping the essential urban land use in changchun by applying random forest and multi-source geospatial data. Remote Sens. 12 (15), 2488. doi:10.3390/rs12152488.

Chim, K., Tunnicliffe, J., Shamseldin, A., Ota, T., 2019. Land use change detection and prediction in upper siem reap river, Cambodia. Hydrology 6 (64), 1–23. doi:10.3390/hydrology6030064.

Chwałczyk, F., 2020. Around the anthropocene in eighty names—considering the urbanocene proposition. Sustainability 12 (11), 4458. doi:10.3390/su12114458.

Costanza, R., Arge, R., Groot, R., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260. doi:10.1038/387253a0.

Costanza, R., De Groot, R., Sutton, P., Van der Ploeg, S., Anderson, S.J., Kubiszewski, I., Farber, S., Turner, R.K., 2014. Changes in the global value of ecosystem services. Glob. Environ. Change 26, 152–158. doi:10.1016/j.gloenvcha.2014.04.002.

Dadashpoor, H., Azizi, P., Moghadasi, M., 2019. Analyzing spatial patterns, driving forces and predicting future growth scenarios for supporting sustainable urban growth: evidence from Tabriz metropolitan area, Iran. Sustain. Cities Soci. 47, 101502. doi:10.1016/j.scs.2019.101502.

Das, A., Basu, T., 2020. Assessment of peri-urban wetland ecological degradation through importance-performance analysis (IPA): a study on Chatra Wetland, India. Ecol. Indic. 114, 106274. doi:10.1016/j.ecolind.2020.106274.

Das, M., Das, A., 2019. Dynamics of urbanization and its impact on Urban Ecosystem Services (UESs): a study of a medium size town of West Bengal, Eastern India. J. Urban Manag. 8 (3), 420–434. doi:10.1016/j.jum.2019.03.002.

Daw, T.M., Hicks, C., Brown, K., Chaigneau, T., Januchowski-Hartley, F., Cheung, W., Rosendo, S., Crona, B., Coulthard, S., Sandbrook, C., Perry, C., Bandeira, S., Muthiga, N.A., Schulte-Herbrüggen, B., Bosire, J., McClanahan, T.R., 2016. Elasticity in ecosystem services: exploring the variable relationship between ecosystems and human well-being. Ecol. Soc. 21 (2), 11. doi:10.5751/ES-08173-210211.

Dewan, A.M., Yamaguchi, Y., 2009. Land use and land cover change in Greater Dhaka, Bangladesh: using remote sensing to promote sustainable urbanization. Appl. Geogr. 29 (3), 390–401.

Dubovyk, O., Sliuzas, R., Flacke, J., 2011. Spatio-temporal modelling of informal settlement development in Sancaktepe district, Istanbul, Turkey. ISPRS J. Photogramm. Remote Sens. 66 (2), 235–246.

Eisavi, V., Homayouni, S., Yazdi, A.M., Alimohammadi, A., 2015. Land cover mapping based on random forest classification of multitemporal spectral and thermal images. Environ. Monit. Assess. 187 (5), 1–14. doi:10.1007/s10661-015-4489-3.

Engemann, K., Pedersen, C.B., Arge, L., Tsirogiannis, C., Mortensen, P.B., Svenning, J.-.C., 2019. Residential green space in childhood is associated with lower risk of psychiatric disorders from adolescence into adulthood. Proc. Natl Acad. Sci. 116 (11), 5188–5193. doi:10.1073/pnas.1807504116.

Erasu, D., 2017. Remote sensing-based urban land use/land cover change detection and monitoring. J. Remote Sens. GIS 6, 196. doi:10.4172/2469-4134.1000196.

Ferreira, L.M.R., Esteves, L.S., de Souza, E.P., dos Santos, C.A.C., 2019. Impact of the urbanisation process in the availability of ecosystem services in a tropical ecotone area. Ecosystems 22 (2), 266–282.

Ferry, M., Kah, S., Bachtler, J., 2018. Integrated territorial development: new instruments—New results? IQ-Net Themat. Pap 42, 1–57.

Fu, B., Yu, D., Zhang, Y., 2019. The livable urban landscape: GIS and remote sensing extracted land use assessment for urban livability in Changchun Proper, China. Land Use Policy 87, 104048.

Garrett, T., 2010. Effects of urbanization on environmental parameters in aquatic systems along an urban-rural gradient in northeastern Illinois. All Capstone Projects 26. http://opus.govst.edu/capstones/26.

Ghosh, S., Das, A., 2019. Urban expansion induced vulnerability assessment of East Kolkata Wetland using fuzzy MCDM method.. Remote Sens.Appl.: Soc. Environ., 13, 191–203. doi:10.1016/j.rsase.2018.10.014.

Hamad, R., Balzter, H., Kolo, K.Y.O., 2018. Predicting Land use/land cover changes using a CA-Markov Model under two different scenarios. Sustainability 10 (10), 1–23. doi:10.3390/su10103421.

Handayani, W., Chigbu, U.E., Rudiarto, I., Putri, I.H.S., 2020. Urbanization and increasing flood risk in the Northern Coast of Central Java—Indonesia: an assessment towards better land use policy and flood management. Land 9 (10), 343. doi:10.3390/land9100343.

Hazemba, M., Halog, A., 2021. Systematic review of how environmental management policies are incorporated into national development plans in order to achieve sustainable development. Environ. challenges 3, 100041.

Helbich, M., 2019. Spatiotemporal contextual uncertainties in green space exposure measures: exploring a time series of the normalized difference vegetation indices. Int J Environ Res Public Health 16 (5), 852. doi:10.3390/ijerph16050852.

Hernandez, I.E.R., Shi, W., 2017. A Random Forests classification method for urban land-use mapping integrating spatial metrics and texture analysis. Int. J. Remote Sens. 39 (4), 1175–1198. doi:10.1080/01431161.2017.1395968.

Hu, H., Liu, W., Cao, M., 2008. Impact of land use and land cover changes on ecosystem services in Menglun, Xishuangbanna, Southwest China. Environ. Monit. Assess. 146, 147–156. doi:10.1007/s10661-007-0067-7.

Hu, Z.Y., Lo, C.P., 2007. Modeling urban growth in Atlanta using logistic regression. Comput. Environ. Urban Syst. 31 (6), 667–688.

Hua, J., Chen, W.Y., 2019. Prioritizing urban rivers' ecosystem services: an importance-performance analysis. Cities 94, 11–23.

Huang, B., Zhang, L., Wu, B., 2010. Spatiotemporal analysis of rural–urban land conversion. Int. J. Geogr. Inf. Sci. 23 (3), 379–398.

Huang, W., Liu, H., Luan, Q., Jiang, Q., Liu, J., Liu, H., 2008. Detection and prediction of land use change in beijing based on remote sensing and GIS. The International Archives of the Photogrammetry. Remote Sens. Spatial Inf. Sci. XXXVII Part B6b. Beijing.

Iyer, D., Steele, A., 2015. UNDP-UNEP Poverty-Environment Initiative - 2015 - stgwedocs.unep.org.

Jain, M., Dawa, D., Mehta, R., Dimri, A.P., Pandit, M.K., 2016. Monitoring land use change and its drivers in Delhi, India using multi-temporal satellite data. Model. Earth Syst. Environ. 2 (1), 19.

Jiang, L., Deng, X., Seto, K.C., 2013. The impact of urban expansion on agricultural land use intensity in China. Land Use Policy 35, 33–39.

Johnson, B.G., Faggi, A., Voigt, A., Schnellinger, J., 2015. Environmental perception among residents of a polluted watershed in Buenos Aires. J. Urban Plann. Dev. 141 (3), A5014002. doi:10.1061/(ASCE)UP.1943-5444.0000250.

Kennedy, C., Steinberger, J., Gasson, B., Hansen, Y., Hillman, T., Havranek, M., Pataki, D., Phdungsilp, A., Ramaswami, A., Mendez, G.V., 2009. Greenhouse Gas Emissions from Global Cities. Environ. Sci. Technol. 43, 7297–7302.

Klompmaker, J.O., Hoek, G., Bloemsma, L.D., Gehring, U., Strak, M., Wijga, A.H., van den Brink, C., Brunekreef, B., Lebret, E., Janssen, N.A., 2018. Green space definition affects associations of green space with overweight and physical activity. Environ. Res. 160, 531–540. doi:10.1016/j.envres.2017.10.027.

Kong, F., Yin, H., James, P., Hutyra, L.R., He, H.S., 2014. Effects of spatial pattern of greenspace on urban cooling in a large metropolitan area of eastern China. Landsc. Urban Plan. 128, 35–47.

Kyttä, M., Kahila, M., Broberg, A., 2011. Perceived environmental quality as an input to urban infill policy-making. Urban Des. Int. 16, 19–35. doi:10.1057/udi.2010.19.

Lahoti, S., Kefi, M., Lahoti, A., Saito, O., 2019. Mapping methodology of public urban green spaces using GIS: an example of Nagpur City, India. Sustainability. 11 (7), 2166. doi:10.3390/su11072166.

Lanrewaju, A.F., 2012. Urbanization, housing quality and environmental degeneration in Nigeria. J. Geogr. Reg. Plan. 5 (16), 422–429.

Li, J., Chen, H., Zhang, C., Pan, T., 2019. Variations in ecosystem service value in response to land use/land cover changes in Central Asia over 1995-2035. PeerJ Preprints 7, e27645v1. doi:10.7287/peerj.preprints.27645v1.

Li, X.M., Zhou, W.Q., Ouyang, Z.Y., 2013. Forty years of urban expansion in Beijing: what is the relative importance of physical, socioeconomic, and neighborhood factors? Appl. Geogr. 38, 1–10.

Liang, H., Chen, D., Zhang, Q. , 2017. Assessing Urban Green Space distribution in a compact megacity by landscape metrics. J. Environ. Eng. Landsc. Manag. 25 (1), 64–74.

Liu, H., Zhou, Q., 2005. Developing urban growth predictions from spatial indicators based on multi-temporal images, Computers. Environ. Urban Syst. 29 (5), 580–594.

Liu, H., Wang, Y., Zhang, C., Chen, A.S. and Fu, G., 2018. Assessing real options in urban surface water flood risk management under climate change. Nat. Hazards, 94(1), pp. 1–18. doi:10.1007/s11069-018-3349-1.

Long, Y., Gu, Y., Han, H., 2012. Spatiotemporal heterogeneity of urban planning implementation effectiveness: evidence from five urban master plans of Beijing. Landsc. Urban Plan. 108 (2–4), 103–111.

Luo, J., Wei, Y.H.D., 2009. Modeling spatial variations of urban growth patterns in Chinese cities: the case of Nanjing. Landsc. Urban Plan. 91 (2), 51–64.

M'Ikiugu, M.M., Kinoshita, I., Tashiro, Y., 2012. Urban green space analysis and identification of its potential expansion areas. Procedia - Soc. Behav. Sci. 35, 449–458. doi:10.1016/j.sbspro.2012.02.110.

Maimaitiyiming, M., Ghulam, A., Tiyip, T., Pla, F., Latorre-Carmona, P., Halik, Ü., Sawut, M., Caetano, M., 2014. Effects of green space spatial pattern on land surface temperature: implications for sustainable urban planning and climate change adaptation. ISPRS J. Photogramm. Remote Sens. 89, 59–66. doi:10.1016/j.isprsjprs.2013.12.010.

Masoudi, M., Tan, P.Y., Liew, S.C., 2019. Multi-city comparison of the relationships between spatial pattern and cooling effect of urban green spaces in four major Asian cities. Ecol. Indic. 98, 200–213. doi:10.1016/j.ecolind.2018.09.058.

Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Synthesis. Island Press, Washington, DC, USA.

Mitchell, M.G., Suarez-Castro, A.F., Martinez-Harms, M., Maron, M., McAlpine, C., Gaston, K.J., Johansen, K., Rhodes, J.R., 2015. Reframing landscape fragmentation's effects on ecosystem services. Trends Ecol. Evol. 30 (4), 190–198. doi:10.1016/j.tree.2015.01.011.

Mondal, B., Dolui, G., Pramanik, M., Maity, S., Biswas, S.S., Pal, R., 2017. Urban expansion and wetland shrinkage estimation using a GIS-based model in the East Kolkata Wetland, India. Ecol. Indic. 83, 62–73. doi:10.1016/j.ecolind.2017.07.037.

Müller, K., Steinmeier, C., Kuchler, M., 2010. Urban growth along motorways in Switzerland. Landsc. Urban Plan. 98 (1), 3–12.

Naeem, S., Cao, C., Qazi, W.A., Zamani, M., Wei, C., Acharya, B.K., Rehman, A.U., 2018. Studying the association between green space characteristics and land surface temperature for sustainable urban environments: an analysis of Beijing and Islamabad. ISPRS Int. J. Geoinf. 7 (2), 38. doi:10.3390/ijgi7020038.

Naikoo, M.W., Rihan, M., Ishtiaque, M., Shahfahad, 2020. Analyses of land use land cover (LULC) change and built-up expansion in the suburb of a metropolitan city: spatio-temporal analysis of Delhi NCR using landsat datasets. J. Urban Manag. 9 (3), 347–359. doi:10.1016/j.jum.2020.05.004.

Nasehi, S., Imanpour namin, A., 2020. Assessment of urban green space fragmentation using landscape metrics (case study: district 2, Tehran city). Model. Earth Syst. Environ. 6, 2405–2414. doi:10.1007/s40808-020-00809-7.

Ngesan, M.R., Karim, H.A., Zubir, S.S., Ahmad, P., 2013. Urban community perception on nighttime leisure activities in improving public park design. Procedia - Soc. Behav. Sci. 105, 619–631. doi:10.1016/j.sbspro.2013.11.065.

Nguyen, T.M., Lin, T.-.H., Chan, H.-.P., 2019. The environmental effects of urban development in Hanoi, Vietnam from satellite and meteorological observations from 1999 to 2016. Sustainability 11 (6), 1768. doi:10.3390/su11061768.

Nijhuis, S., Jauslin, D., 2015. Urban landscape infrastructures: designing operative landscape structures for the built environment. Res. Urban. Ser. 3, 13–34. doi:10.7480/rius.3.874.

Nunan, F., Campbell, A., Foster, E., 2012. Environmental mainstreaming: the organisational challenges of policy integration. Public Admin. Dev. 32 (3), 262–277.

Nurdin, E.A., Wijayanto, Y., 2020. The distribution of green open space in Jember City area based on image landsat 8 – OLI. IOP Conf. Series: earth and Environmental Science 485, 012016. doi:10.1088/1755-1315/485/1/012016.

O'Brien, A.M., Mc Guckin, C., 2016. The Systematic Literature Review Method: Trials and Tribulations of Electronic Database Searching at Doctoral Level. SAGE Publications, London, UK ISBN 9781473949713.

Osmond, P., Sharifi, E., 2016. Guide to Urban Cooling Strategies. Low Carbon Living CRC, Sydney, Australia.

Park, K., Lee, M.-.H., 2019. The development and application of the urban flood risk assessment model for reflecting upon urban planning elements. Water. 11 (5), 920. doi:10.3390/w11050920.

Patra, S., Sahoo, S., Mishra, P., Mahapatra, S.C., 2018. Impacts of urbanization on land use/cover changes and its probable implications on local climate and groundwater level. J. Urban Manag. 7 (2), 70–84.

Perveen, S., Kamruzzaman, M., Yigitcanlar, T., 2017. Developing policy scenarios for sustainable urban growth management: a Delphi approach. Sustainability 9, 1787. doi:10.3390/su9101787.

Pickering, C., Byrne, J., 2014. The benefits of publishing systematic quantitative literature reviews for PhD candidates and other early-career researchers. High. Educ. Res. Dev. 33 (3), 534–548. doi:10.1080/07294360.2013.841651.

Pramanik, S., Punia, M., 2019. Assessment of green space cooling effects in dense urban landscape: a case study of Delhi, India. Model. Earth Syst. Environ. 5, 867–884. doi:10.1007/s40808-019-00573-3.

Rahman, A., Kumar, Y., Fazal, S., Bhaskaran, S., 2011. Urbanization and quality of urban environment using remote sensing and GIS techniques in East Delhi-India. J. Geogr. Inf. Syst. 3, 61–83. doi:10.4236/jgis.2011.31005.

Rimal, B., Zhang, L., Keshtkar, H., Haack, B.N., Rijal, S., Zhang, P., 2018. Land use/land cover dynamics and modeling of urban land expansion by the integration of cellular automata and Markov chain. ISPRS Int. J. Geoinf. 7 (4), 154. doi:10.3390/ijgi7040154.

Saitluanga, B.L., 2014. Spatial pattern of urban livability in Himalayan region: a Case of Aizawl City, India. Soc. Indic. Res. 117, 541–559. doi:10.1007/s11205-013-0362-3.

Samal, R.D., Gedam, S.S., 2015. Monitoring land use changes associated with urbanization: an object based image analysis approach. Eur. J. Remote Sens. 48, 85–99.

Seto, K.C., Fragkias, M., Güneralp, B., Reilly, M.K., 2011. A meta-analysis of global urban land expansion. PLoS One 6 (8), e23777.

Shi, L., Halik, Ü., Abliz, A., Mamat, Z., Welp, M., 2020. Urban green space accessibility and distribution equity in an arid oasis city: urumqi, China. Forests. 11 (6), 690. doi:10.3390/f11060690.

Singh, R., Panda, A., Thaker, P., 2018. Making Liveable Cities: Challenges and Way Forward For India. https://www.teriin.org/policy-brief/making-liveable-cities-challenges-and-way-forward-india

Sinha, S., Sharma, L.K., Nathawat, M.S., 2015. Improved Land-use/Land-cover classification of semi-arid deciduous forest landscape using thermal remote sensing. Egypt. J. Remote Sens. Space Sci. 18 (2), 217–233. doi:10.1016/j.ejrs.2015.09.005.

Sivakumar, V., 2014. Urban mapping and growth prediction using remote sensing and GIS techniques, Pune, India. In: ISPRS – International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XL-8(December), pp. 967–970. doi:10.5194/isprsarchives-XL-8-967-2014.

Sudhira, H.S., Ramachandra, T.V., Jagadish, K.S., 2004. Urban sprawl: metrics, dynamics and modelling using GIS. Int. J. Appl. Earth Obs. Geoinf. 5 (1), 29–39.

Talukdar, S., Singha, P., Shahfahad, Mahato, S., Praveen, B., Rahman, A., 2020. Dynamics of ecosystem services (ESs) in response to land use land cover(LU/LC) changes in the lower Gangetic plain of India. Ecol. Indic. doi:10.1016/j.ecolind.2020.106121.

Taylor, L., Hochuli, D.F., 2017. Defining greenspace: multiple uses across multiple disciplines. Landsc. Urban Plan. 158, 25–38. doi:10.1016/j.landurbplan.2016.09.024.

Thapa, R.B., Murayama, Y., 2012. Scenario based urban growth allocation in Kathmandu Valley, Nepal. Landsc. Urban Plan. 105, 140–148. doi:10.1016/j.landurbplan.2011.12.007.

Tian, G., Qiao, Z., Zhang, Y., 2012. The investigation of relationship between rural settlement density, size, spatial distribution and its geophysical parameters of China using Landsat TM images. Ecol. Modell. 231, 25–36.

Tian, Y., Jim, C.Y., Wang, H., 2014. Assessing the landscape and ecological quality of urban green spaces in a compact city. Landsc. Urban Plan. 121, 97–108.

United Nations, Department of Economic and Social Affairs, Population Division, 2015. World Urbanization Prospects: The 2014 Revision, Highlights. United Nations, New York, NY, USA.

Uttara, S., Bhuvabdas, N., Aggarwal, V., 2012. Impacts of urbanization on environment. IJREAS 2 (2), 1637–1645.

Vargas-Hernández, J.G., Pallagst, K., Zdunek-Wielgołaska, J., 2018. Urban green spaces as a component of an ecosystem. In: Dhiman, S., Marques, J. (Eds.), Handbook of Engaged Sustainability. Springer, Cham doi:10.1007/978-3-319-53121-2_49-1.

Vermeiren, K., Van Rompaey, A., Loopmans, M., Serwajja, E., Mukwaya, P., 2012. Urban growth of Kampala, Uganda: pattern analysis and scenario development. Landsc. Urban Plan. 106 (2), 199–206.

Vivekananda, G.N., Swathi, R., Sujith, A.V.L.N., 2020. Multi-temporal image analysis for LULC classification and change detection. Eur. J. Remote Sens. doi:10.1080/22797254.2020.1771215.

Wan, L., Ye, X., Lee, J., Lu, X., Zheng, L., Wu, K., 2015. Effects of urbanization on ecosystem service values in a mineral resource-based city. Habitat Int. 46, 54–63.

Wang, J., Zhou, W., Qian, Y., Li, W., Han, L., 2018. Quantifying and characterizing the dynamics of urban greenspace at the patch level: a new approach using object-based image analysis. Remote Sens. Environ. 204, 94–108. doi:10.1016/j.rse.2017.10.039.

Weng, Y.-.C., 2007. Spatiotemporal changes of landscape pattern in response to urbanization. Landsc. Urban Plan. 81 (4), 341–353. doi:10.1016/j.landurbplan.2007.01.009.

Wu, B., Huang, B., Fung, T., 2009. Projection of land use change patterns using kernel logistic regression. Photogramm. Eng. Remote Sens. 75 (8), 971–979.

Wu, J., 2013. Landscape sustainability science: ecosystem services and human well-being in changing landscapes. Landsc. Ecol. 28, 999–1023. doi:10.1007/s10980-013-9894-9.

Wu, K.-.Y., Zhang, H., 2012. Land use dynamics, built-up land expansion patterns, and driving forces analysis of the fast-growing Hangzhou metropolitan area, eastern China (1978–2008). Appl. Geogr. 34, 137–145.

Wu, L., Kim, S.K., 2021. Exploring the equality of accessing urban green spaces: a comparative study of 341 Chinese cities. Ecol. Indic. 121, 107080. doi:10.1016/j.ecolind.2020.107080.

Wüstemann, H., Kalisch, D., Kolbe, J., 2017. Access to urban green space and environmental inequalities in Germany. Landsc. Urban Plan. 164, 124–131. doi:10.1016/j.landurbplan.2017.04.002.

Xiao, J., Shen, Y., Ge, J., Tateishi, R., Tang, C., Liang, Y., Huang, Z., 2006b. Evaluating urban expansion and land use change in Shijiazhuang, China, by using GIS and remote sensing. Landsc. Urban Plan. 75 (1–2), 69–80. doi:10.1007/s10980-019-00932-6.

Xie, G.D., Zhen, L., Lu, C.X., Xiao, Y., Chen, C., 2008. Expert knowledge based valuation method of ecosystem services in China. J. Nat. Resour. 23 (5), 911–919.

Xu, C., Haase, D., Pribadi, D.O., Pauleit, S., 2018. Spatial variation of green space equity and its relation with urban dynamics: a case study in the region of Munich. Ecol. Indic. 93, 512–523. doi:10.1016/j.ecolind.2018.05.024.

Yedla, S., 2006. Dynamics of environmental problems in Mumbai. Clean. Tech. Environ. Policy 8, 182–187. doi:10.1007/s10098-005-0030-7.

Zang, S., Wu, C., Liu, H., Na, X., 2011. Impact of urbanization on natural ecosystem service values: a comparative study. Environ. Monit. Assess. 179 (1), 575–588.

Ziaul, Sk., Pal, S., 2017. Estimating wetland insecurity index for Chatra wetland adjacent English Bazar Municipality of West Bengal. Spat. Inf. Res. 25, 813–823. doi:10.1007/s41324-017-0147-x.