HOW SMART GROWTH CAN CURB URBAN SPRAWL: A CASE STUDY OF A RAPIDLY URBANIZING CITY IN KERALA, INDIA

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Commission III

KEYWORDS: Urban sprawl, Smart Growth, Sustainability, Remote sensing, LULC, Change detection, GIS

ABSTRACT:

Cities begin to spread at an alarming rate as the world's urban population grows, resulting in a slew of socioeconomic, environmental, and ecological challenges. Urban sprawl, defined as low-density, non-contiguous, unplanned, unregulated, and uncoordinated outer expansion of cities, is associated with various negative consequences, including loss of arable land, environmental destruction, increased transportation costs, deterioration of the city center, and many others. Smart growth can be considered a potential remedy for the negative impacts of urbanization. The smart growth idea is centered on creating more lively, competitive, and habitable cities to address the deterioration and decay in urban systems caused by urban land sprawl. This article discusses the possibilities of smart Growth approaches as a tool for reducing undesirable urban sprawl. Furthermore, this study aims to capture the land use land cover (LULC) dynamics of Kozhikode Urban Agglomeration (KUA) from 1991-to 2021 using remote sensing and GIS techniques. This study aims to identify potential smart growth locations in KUA using Geographic Information System (GIS)-based modeling methods to mitigate the effects of uncontrolled urban sprawl. To get the most out of smart growth possibilities and effective sprawl reduction, future development activities should focus more on the identified potential hotspots of Smart Growth. The study demonstrated the application of the Smart Growth techniques in a sprawling tier-2 city of Kerala. The city planning authorities can use this technique for effective sprawl management and sustainable city planning.

1. INTRODUCTION

According to the United Nations Population Division's 2019 version of World Population Prospects, the world's urban population will increase to 4.9 billion by 2030, while the global rural community is expected to fall by 28 million between 2005 and 2030. On a worldwide scale, all future population growth will occur in towns and cities, the majority of which will appear in developing countries (World Urbanization Prospects, 2018). The tremendous increase in the urban population may trigger uncontrolled growth of urban areas known as urban sprawl.

The urban sprawl phenomenon presents severe difficulties in service provision and living circumstances, along with financial, environmental, cultural, and aesthetic impacts on natural assets. As the developing nations have less income to spend on urban maintenance and service provision, cities are becoming centers of massive sprawl and severe environmental issues. A thorough and balanced strategy is needed to address the problems of city sustainability. To make urban growth viable and urban development sustainable, the phenomenon of urban sprawl must be avoided. For urban development to be sustainable, there must be control over the urban sprawl of undesired types. Fortunately, uncontrolled urban sprawl can be prevented or limited to a great extent by adopting smart growth principles which focus on the future change of current sprawl (Gray, 2007).

This paper deals with various potential and prospects of smart growth policies for controlling urban sprawl of undesired type. The principles of smart growth, its policy tools for managing urban sprawl, comparison of sprawled Growth and smart Growth, etc., are discussed in this paper. It also outlines a case study of spatiotemporal mapping of land cover classes in Kozhikode Urban Agglomeration (KUA), Kerala, India, from 1991-to 2021 and Smart Growth techniques in the study area for effective sprawl control. Smart growth initiatives recognize the connection between development trends and quality of life by adopting new strategies and practices encouraging better homes, transportation, economic development, and environmental quality conservation. The smart growth idea calls for compact, transport- and pedestrian-friendly city planning that is more sustainable and less polluting than current models of urbanization.

2. SMART GROWTH PRINCIPLES

The Smart Growth movement that emerged in the mid-1990s can be considered an alternative growth paradigm and an antidote to the cancerous growth of cities. Regardless of the proliferation of numerous Smart Growth definitions, a universally accepted definition doesn’t exist (Downs, 2001; Gearin, 2004; Levy, 2008). As per the American Planning Association (APA, 2002) “*Smart Growth is the planning, designing, development, and revitalization of cities, outskirts, and rural regions to generate and encourage social equity, a sense of place and community, and to preserve culture as well*

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https://doi.org/10.5194/isprs-archives-XLIII-B3-2022-1355-2022

as natural resources. It boosts both short-term and long-term ecological integrity. It enhances the quality of life for all by extending a variety of transportation, employment, and housing choices available to a region in a fiscally responsible way." A clear understanding of various definitions makes us aware that the supreme goal of Smart Growth is to maximize the quality of life. Four key components that embody smart growth are liveability, affordability, efficiency, and environmental protection. It is evident from these terms that smart growth relates to a set of overall values or objectives that direct planning efforts, strategies, and practices not only to slow or mitigate urban sprawl, but the issues connected with urban sprawl are often the primary motive for smart growth initiatives (Perovic and Kurtovic, 2012).

In the year 2005, Downs put forward nine smart growth principles aimed to eliminate the menace of unplanned uncontrolled city growth. They are:1)Compact development, 2)Increase in housing density, 3)Mixed land-use with pedestrian-friendly designs, which gives importance to walkability, 4) Imposing effective charges on consumers to cover the public costs of new development, 5) Limit the usage of private cars and improve public transportation.6) Revitalize existing old neighbourhoods, 7)Create affordable housing, 8) Reduce barriers to developer's rights, and 9) Increase the number of laws governing aesthetics, road layouts, and building (Downs, 2005).

In 2006, the Smart Growth Network developed the key features that make communities successful and set the following ten fundamental principles:
***i)Mix land uses*:** High-density mixed-use development promotes the inclusion of mixed uses in communities as a critical element of smart growth and improves social inclusion, quality of life, and interconnections, providing different social classes with access to various services.
ii)Take advantage of compact building design: Instead of a conventional land consumptive sprawled development pattern, communities should search for means to become more compact in the design of buildings and streets. Examples of smart growth policy tools promoting high-density development are Transferable Development Rights (TDR), urban growth boundaries (UGBs), etc.
iii)Create a variety of housing alternatives and choices*:* To ensure equality and balanced asset allocation, various housing options should be available for different households with varying income levels. This will assist in enhancing the neighbourhood's economy, promoting environmental justice, and eventually helping in reducing social segregation.
iv) Create walkable neighbourhoods: Smart Growth seeks to create walkable communities where citizens can reside, work, learn, play, and worship within walking range.
v)Foster distinct, appealing neighbourhoods with a strong feeling of place: Nurturing societies with a powerful feeling of place gives rise to cultural awareness and a feeling of belonging among people, which in turn helps them engage more interactively in improving the standard of life of the society, participating in decision making, as well as in protecting the local assets.
vi) Open space, farms, natural beauty, and essential environmental areas should all be preserved: Preserving open space and farmlands promotes smart growth objectives by preserving delicate environmental areas, boosting local markets, improving social interactions and the standard of life of the community, and paving light to new developments in current populations.
vii) Strengthen and direct development towards existing communities*:* Rather than creating new communities, it is always better to go for rehabilitation and infill development of existing communities. It aims to use the resources provided by existing communities, encourages investment in blighted regions, improves the quality of life of residents from various social classes, and aids in the preservation of open spaces and valuable natural resources on urban outskirts.
viii)Provide a variety of transportation choices: Smart Growth seeks to provide people with equal access to multiple transport sources, facilities, employment, recreation, accommodation, and lastly, to improve social equity. A wide variety of transport choices, such as bicycle routes, safe and secure footpaths, and comfortable transit centers, are essential.
***ix) Make development decisions predictable, fair, and cost-effective*:** The primary idea is to create self-sustaining societies that promote investment and offer a suitable living standard.
x) Encourage community and stakeholder collaboration in development decisions: Since the citizens know their neighbourhoods very well, they can bring about innovative alternatives to complicated issues in their communities**.**

3. COMPARISON OF SPRAWLED GROWTH AND SMART GROWTH

Smart growth is considered an antidote or response to sprawl (Ismael, 2021). Urban sprawl can be regarded as an inefficient use of land wherein open spaces, natural areas, and farmlands seem to disappear quickly. Due to the rising cost of housing, high traffic density, and unnecessary infrastructure costs, sprawl has been criticized by numerous researchers worldwide (Ahani and Dadashpoor, 2021). The main objective of smart growth is to establish an equilibrium between people's requirements for employment and economic development, thereby enhancing the quality of life (Mahmoud et al., 2019). Table 1 summarizes the significant differences between sprawled growth and smart growth to build a community with a distinctive sense of place and focus on the limited dependence on the car.

Index	**Sprawl**	**Smart Growth**
Density	scattered development at a low density	Compact development with high density
Growth pattern	along urban fringes	infill and renovation of existing regions.
Type of land-use	Homogeneous land uses	Mixed-use development
Types of housing	Single-family housing in larger lots	Vibrant, compact housing units which promote mixed uses
Public Service (Shops, schools And Park)	Less. Need access to a car	more and more consistent Pedestrian access
Transport options	Automobile dependent transportation	Multimodal transport. Promotes walking, cycling, mass transit, etc
Streets	A hierarchical network of roads without end, separate paths, and sidewalks.	Active well-connected streets with different modes of activities
Planning	Unplanned, uncoordinated development with little/no stakeholder involvement	Well planned and co-ordinated with active stakeholder involvement
Public realm	Privacy is given	Vibrant public realm

https://doi.org/10.5194/isprs-archives-XLIII-B3-2022-1355-2022 |

	utmost importance with less emphasis on the public realm	with parks, sidewalks, public facilities, etc

Table 1: Comparison of sprawled growth and smart growth

The social, economic, and cultural elements of sustainability will benefit from the proper execution of smart growth policies. The appropriate implementation of smart growth policies will reduce development, service, and transportation costs. It helps to protect open spaces and farmlands by limiting urban development. There will be overall savings in the price, which results from aggregation. The societal benefit of smart growth includes better opportunities and improved varieties of housing, enhanced quality of life, more safety and security, strong and vibrant neighbourhood with improved transportation options, and preservation of unique historical and traditional cultural aspects. Smart growth proves to be very much beneficial for protecting environmental sustainability. This comprises reducing air and water pollution, preservation of green spaces and native species, an overall reduction in pollutants and greenhouse gases, etc.

4. CASE STUDY: CURBING URBAN SPRAWL USING SMART GROWTH SITE SUITABILITY ANALYSIS

4.1 General

Smart Growth arose as a new paradigm in urban planning to curb the disadvantages of uncontrolled urban sprawl (Khodeir, et al., 2016). For a developing country like India, with unchecked population growth and an unprecedented rate of urbanization, smart growth strategies are considered a vital tool for sprawl control. Hence, it is the need of the hour to identify the most suitable site which promotes smart growth. GIS is considered one of the most efficient applications for analyzing land-use suitability for various applications and its effective mapping (Collins et al., 2001). The traditional overlay mapping and modeling approaches are the frequently used methods for land-use suitability analysis in the GIS environment (Malczewsk, 2004). This study identifies the most appropriate smart growth suitable areas by using computer-assisted overlay mapping in GIS for future developments based on specific smart growth indicators. This study aims to identify possible Smart Growth favorable locations inside the Kozhikode Urban Agglomeration (KUA) by utilizing the potential of the Geographic Information System (GIS). The results of this study will be helpful for urban planners, real estate developers, decision-makers, and all interested persons in city planning and policymaking.

4.2 Study area

The study area chosen for this analysis is Kozhikode Urban Agglomeration (KUA), the 2nd largest urban agglomeration in Kerala, India. According to the Kerala Town Planning department, the percentage of the urban population in KUA is 67.15%, compared to 47.72% of the state. Between 2001 and 2014, KUA witnessed yearly population growth of 7.6%, urban area expansion of 15.2%, and total built-up area growth of 14.8 %. As per the Census 2011, KUA includes Kozhikode Corporation, Municipalities like Vatakara, Payyoli, Koyilandy, Koduvally, Ramanattukara, and Mukkom, together with some census towns and outgrowths. Figure 1 shows the map of the study area.

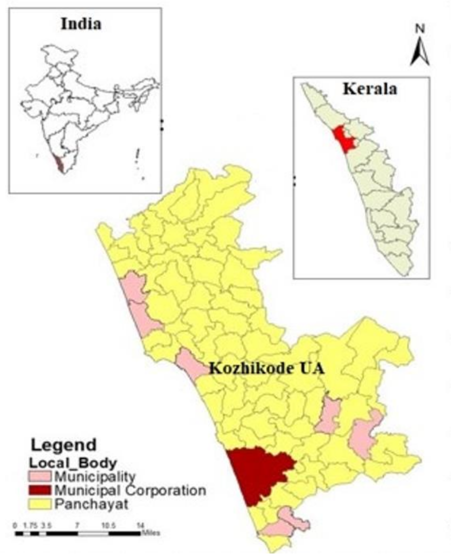

Figure 1: Location map of the study area

4.3 Methodology

The study involves two main steps a) LULC map preparation of Kozhikode Urban Agglomeration (KUA) to visualize urban growth over three decades and b) Mapping of potential smart growth locations In KUA for effective sprawl control. The overall methodology is summarised as a flow chart (Figure 2).

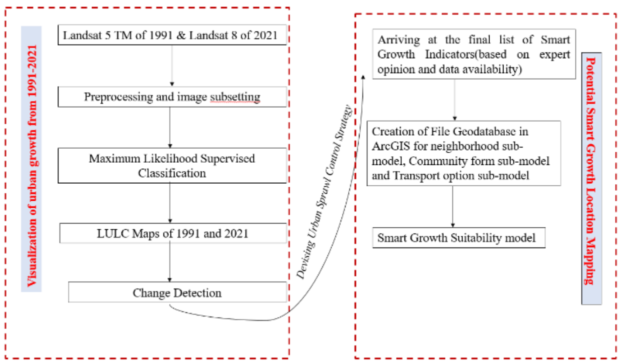

Figure 2: Flow chart of the methodology

4.3.1 Preparation of LULC Map

Landsat images of 30m spatial resolution downloaded from the USGS website are used in the study. The path and row of the study area are 145/052. The first image was captured on 3rd March 1991 with the sensor Landsat-5 TM, and the final image was captured on 10th March 2021 using the sensor Landsat-8 Initial pre-processing of the required bands was carried out using Erdas Imagine software. The study extent was clipped to the boundary of KUA using the subset tool. Next Maximum Likelihood Supervised Classification was applied over the pre-processed imageries of 1991 and 2021. The entire landscape was classified into three distinct land cover features: waterbody, built-up, and vegetation. Accuracy assessment was done to ensure the acceptability of the classified maps. Finally, post-classification change detection is carried out to quantify the landscape changes for different land cover classes.

4.3.2 Mapping of potential smart growth locations for sprawl control

Firstly, most critical smart growth indicators are picked up after an exhaustive literature survey, expert panel discussion, and data availability. The final list of smart growth indicators can be termed feature classes, and they are comprised of neighbourhood, community, and transport sub-models. Here, there are 17 different feature classes. The datasets used for smart growth mapping were obtained from the Department of Town Planning, Government of Kerala. Other shapefiles of roads, bus stops, buildings, etc., were derived from the website of Open Street Map (OSM). An expert panel discussion is then carried out to assess the level of importance of each feature class derived. Each feature class was given a weightage value ranging from 1 to 3, with 3 being the best-suited feature for smart growth zones. Using ArcGIS, a file geodatabase is created with four feature datasets: neighbourhood, transport option, community form, and the Smart Growth suitability model. Finally, by merging the outputs from the neighbourhood sub-model, community form sub-model, and transport option sub-model, a Smart Growth Suitability Model with the most suitable lands for future Smart Growth regions is generated. Figure 3 summarizes the details of feature classes used in each sub-model.

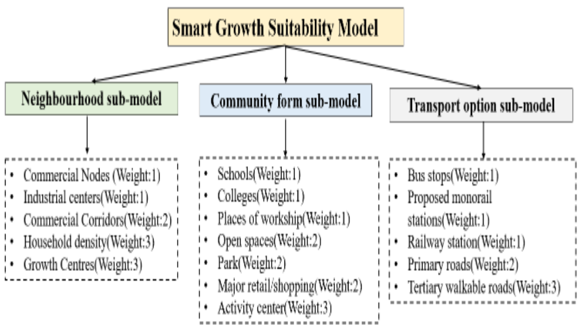

Figure 3: Smart growth suitability sub-models with feature classes

There are 17 feature classes for the three smart growth suitability sub-models. The neighbourhood sub-model has a maximum suitability value of 10, whereas the community form sub-model's maximum suitability value is 12, and the transport option sub-model's maximum suitability value is 8. The maximum appropriateness value for the final smart growth suitability model is 30. The suitability values are then classified into three groups. Values ranging from 1 to 10 are considered the best locations for smart growth. Values spanning from 11 to 12 are deemed smart growth places soon, and those with suitability values of 21 to 30 are considered promising smart growth locations in the far future. Areas with smart growth suitability values less than or equal to 10 can be seen as locations lacking basic smart growth features. According to the expert's opinion, the community forms sub-model is of the highest significance in the smart growth suitability analysis of KUA, followed by neighbourhood features sub-model and transport options sub-model.

4.4 Results and Discussions

There are two results from this study. The first result is the land use/land cover change for 1991 and 2021. The second outcome is the map showing potential smart growth locations in KUA. These are highlighted in sections 4.3.1 and 4.3.2.

4.4.1 Land use/ land cover changes in KUA

The Landsat satellite imageries of 1991 and 2021 were classified into three distinct classes using maximum likelihood supervised classification. The classified land cover classes are water bodies, built-up, and vegetation. The overall classification accuracy for 1991 was 88.80, with overall Kappa statistics as 0.8755. For 2021, overall classification accuracy was 93.30%, and overall Kappa statistics were 0.9151. Generally, an accuracy of 80% is considered to be good. Here, both classified images showed more than 80% accuracy, so the maps and results are reliable. Figures 4(a) and 4(b) show the classified images of 1991 and 2021.

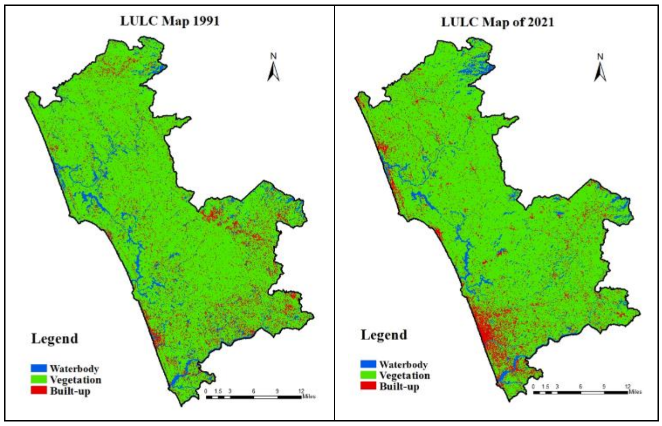

Figure 4(a) Landcover map of 1991, (b) Landcover map of 2021

Figure 5 shows the change in the area of each landcover class over the years. The total area of KUA is 1650km^2.In 1991, the majority of the landscape was occupied by vegetation cover (Approximately 86.5%), and at the same time, the built-up cover was only 5.5%. After three decades, there was a dramatic change in the landscape composition. The vegetation cover was reduced to 62.5%, with a rapid and steady increase in built-up cover of about 30%. The waterbody class also showed a marked reduction in area from 7.8% to 7.1% from 1991-to 2021.

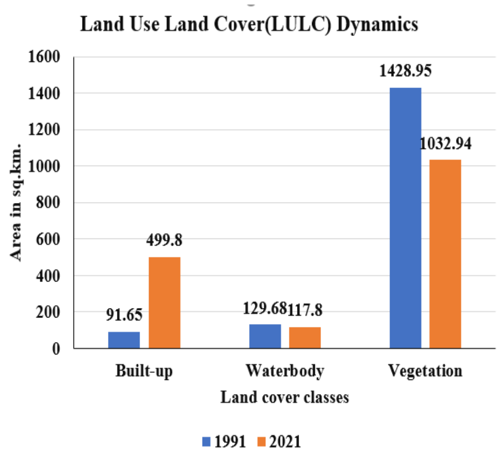

Figure 5: Land use land cover dynamics during 1991-2021

In this transformation, we may see an uncontrolled increase of built-up regions, which is otherwise seen as a proxy for uncontrolled urban sprawl. Hence, we can conclude that the study region under consideration has been experiencing haphazard urban sprawl during the last three decades. It is necessary to devise sprawl control strategies for this region.

4.4.2 Potential smart growth locations in KUA

i)Neighbourhood Sub-model: Within the file geodatabase, factors that encourage mixed-use and high-density land types are grouped as neighbourhood submodels. It includes growth centers, commercial nodes, corridors, industrial centers, and household density. Figure 6(a) shows the suitability values from the neighbourhood sub-model for the study area. The land-use suitability values vary from 1 to 10, with 10 being the most promising location and 1 representing an area with limited attributes for smart growth development. Figure 6(a) highlights the most suitable locations in red and brown colors, with suitability values spanning from 8 to 10. Kozhikode corporation area, neighbourhoods of Vadakara, Koyilandy, Feroke, and Kunnamanagalam regions show significant potential for being transformed into smart growth regions.

ii)Community forms Sub-model: These are the characteristic feature and highlights of smart growth. This sub-model includes seven community types with classes that utilize the public space to benefit the community. Its value ranges from 1 to 12, wherein the most potential locations scored 12. Figure 6. (b)shows the most favorable areas based on community form criteria.

iii)Transport options: The transit sub-model considers alternative and sustainable transportation methods for future smart growth. One of the prime features of smart growth is a walkable neighbourhood. The five feature types addressed in this sub-model are bus stops, projected monorail stations, railway stations, primary highways, and walkable tertiary roads. Figure 6. (c) shows the transit suitability map from the transit sub-model for KUA. Here, areas with values 1 to 8 are considered to satisfy some/many smart growth features in view of transport options.

iv)The smart growth suitability model

This research aimed to develop a methodology for identifying ideal places for smart growth development within KUA. All three sub-models are integrated into a single model to create the final smart growth suitability model. The final model can have 30 points, with 10 points for neighbourhood features, 12 points for community forms, and 8 points for transportation options. Those regions with a suitability value of zero have none of the characteristics of possible smart growth destinations. The highest recorded value was 28, although the maximum allowable value was 30. Figure 6(d) depicts the final suitability map with smart growth suitability values ranging from 1 to 28. The suitability values are then classified into three groups. Values ranging from 1 to 10 (shown in red in Figure 6(d)) are considered the best locations for smart growth. Values spanning from 11 to 12(shown in light pink color in Figure 6(d)) are deemed smart growth places soon, and those with suitability values of 21 to 30 are considered promising smart growth locations in the far future. Areas with a suitability value of zero lack the essential characteristics of smart growth.

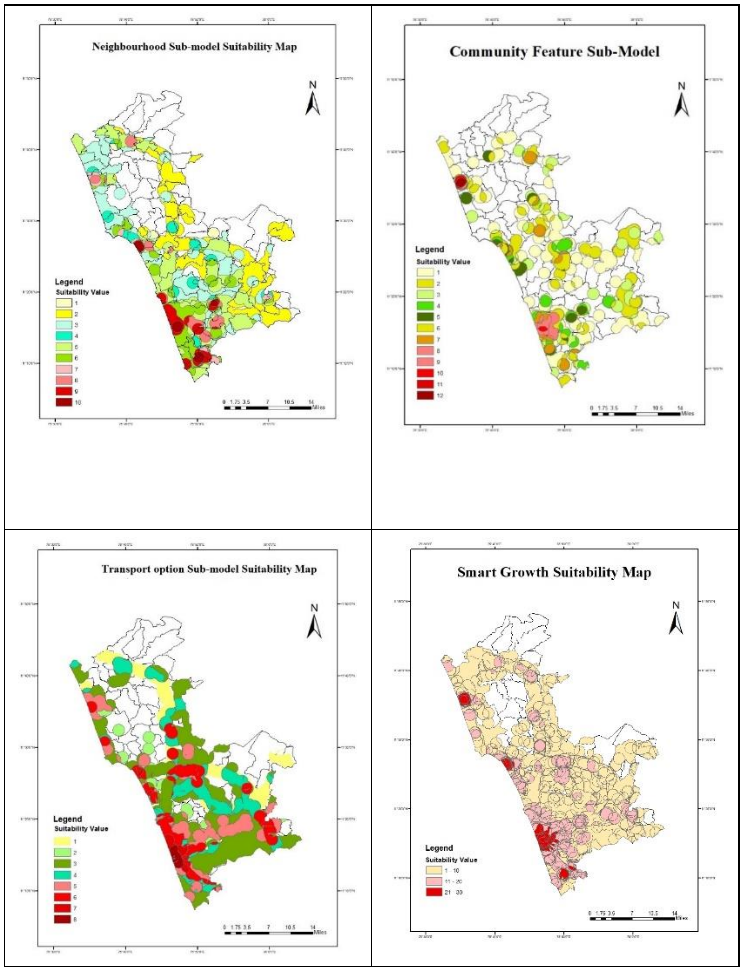

Figure 6. (a) Neighbourhood features Suitability map of KUA, (b) Community forms Suitability map of KUA, (c) Transport options Suitability map of KUA, and (d) Smart growth suitability map of KUA.

The total study area under consideration is about 1650km^2. A detailed analysis of potential smart growth locations revealed that nearly 110.55km^2 area could be regarded as the most favorable locations with a suitability value greater than 20. These include Kozhikode City Corporation, Vadakara, Koyilandy, Ramanattukara, and Feroke. Almost 445km^2 of the area falls under locations with moderate features to be smart, with suitability values ranging from 11-20. A significant portion of KUA (611.35km^2) falls under less suitable areas for smart growth, with values ranging from 1 to 10. However, with the help of competent planning tools and land management approaches, low-suitability places can be quickly turned into smart growth-friendly locations. Nearly 55.8km^2 area of KUA is devoid of any features and necessary infrastructure favorable for smart growth. Hence, when planning development activities, the emphasis should be on places where Smart Growth capabilities can be maximized, thereby reaching the Smart Living target. Places designed according to smart growth principles help in safeguarding communities where their citizens can live safely-help everyone in the society to lead a healthy life, making smart living a reality (Smart Growth Network, 2006).

5. CONCLUSION

Smart growth solutions which focus on compact development patterns can be seen as a superior solution against urban sprawl of undesired type. Smart growth promotes a compact urban development with a higher density that will renew the metropolitan area within its reach by combining urban development and environmental protection as an alternative to sprawled urban growth, which is expensive in terms of economy, environment, and society. The paper presented a brief overview of smart growth principles, policy tools, etc., for combating urban sprawl of undesired type. The case study presented in the article focuses on quantifying spatiotemporal LULC dynamics of KUA from 1991-to 2021 and identifying the most appropriate smart growth suitability areas by using computer-assisted overlay mapping in GIS for future developments based on specific smart growth indicators. The results of LULC dynamics highlighted that the study area has been experiencing a rise in built-up growth during the last three decades (1991-2021). During this period, a drastic decrease in vegetation cover (approximately 396.01km^2) and a rapid increase in built-up (408.15km^2) cover occurred. This shows the necessity of devising suitable methods for combating uncontrolled urban growth. Hence, this study aimed to develop a smart growth suitability model that identifies the best-suited land for possible smart growth development by merging the land-use sub-model, community sub-model, and transportation sub-model outputs. From the results obtained from the final smart growth suitability model, we can quickly identify locations with the features of smart growth and areas that lack qualities for becoming "smart" in city growth. Those locations that currently lack smart growth features can be changed into Smart Growth locales in the future by employing appropriate planning and land management approaches. Development activities must focus more on Smart Growth potential places to maximize Smart Growth capabilities and to meet the Smart Living target. Places designed with smart growth ideas, such as walkable neighbourhoods, safe bicycling, and so on, would protect dynamic natural assets for the successful functioning of our communities, assisting in the establishment of a sprawl-free city.

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