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Assessing Smart Growth Implementation and its Impact on Urban Sprawl: A Content and GIS-Based Analysis

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Abstract

Smart growth (SG) is a set of policies and regulations implemented to mitigate the expansion of urban sprawl. SG is a planning approach that prioritizes creating compact, mixed-use, and high-density urban areas to foster sustainable regional development. The Bodetabek region in Indonesia is seeing rapid growth. Nevertheless, amidst this exponential expansion, the extent to which the local government has embraced SG concepts in its regional development remains uncertain. The primary aim of this study is to assess the extent to which SG concepts have been implemented in the domain of urban planning within the Bodetabek region. The methods of this paper are divided into several stages. Firstly, an examination is conducted to determine the extent to which SG concepts have been incorporated into the planning policy of the Bodetabek area. Subsequently, an assessment is made of the urban sprawl that has occurred in the Bodetabek area for 20 years. Lastly, an analysis is performed to investigate the pattern of urban expansion in the Bodetabek. The findings in this research show that the SG idea has been implemented in the Bodetabek region. The correlation between the proportion of SG content in Bodetabek local laws and land cover changes is evident. There is an inverse relationship between the proportion of SG content in local legislation and the extent of urban development in the Bodetabek area. These findings provide preliminary evidence or indicators that can serve as a reminder of the potential of SG to curb urban sprawl, effectively aligning with established theoretical frameworks.

1. Introduction

The appearance of urban sprawl is a prominent effect of a lack of planned urban land development and population growth (Attino, 2018). The negative implications of urban sprawl are generally acknowledged, including transportation issues, environmental degradation, and its involvement in diminishing agricultural land, natural areas, and open spaces. Therefore, the concept of urban sprawl has come to be associated with detrimental effects on the long-term viability and sustainability of urban areas (Bhatta et al., 2010; Habibi & Asadi, 2011; Włoch-Szymla, 2019) and is a complex phenomenon (OECD, 2018). In response to the expansive pattern of urban development, concepts leading to land expansion management are compressed and integrated with the transportation system. The idea is considered more comprehensive and innovative, called smart growth (SG) to address the negative impact of urban sprawl (Addison et al., 2013; Burchell et al., 2000; Calthorpe, 1990; Harris & Evans, 2000; Włoch-Szymla, 2019). SG, which emerged in the 1990s in the United States, is a concept of managing urban growth through land-use efficiency, utilizing comprehensive public transportation systems,

exploiting and optimizing existing space functions, and encouraging communities to participate or participate in urban development (Chapin, 2012). Besides, SG is a potential movement representing architectural, social, and political change related to urban growth control (Kushner, 2002).

So far, the organization of growth management and urban scholars have suggested and implemented many sets of SG principles. For example, Smart Growth Network (ICMA & SGN, 2002) has enumerated the ten principles for SG, including (1) mixed land uses, (2) taking advantage of compact building design, (3) creating a range of housing opportunities, and choices, (4) create a walkable neighborhood, (5) foster distinctive and attractive communities with a strong sense of place, (6) preserve open space, farmland, natural beauty, and critical environmental areas, (7) strengthen and direct development towards existing communities, (8) provide a variety of transportation choices, (9) make a development, decisions predictable, fair and cost-effective, and (10) encourage community and stakeholders collaboration in development decisions. Downs (2005) identified six general principles of SG including making settlements more compact and preserving open space, increasing residential density, mixed land use and pedestrian-friendly, impacting the cost of new development, emphasizing public transport, and revitalizing the surrounding environment.

O'Connell (2009) divides SG policies into two categories: (1) land-preserving policies that include an urban growth boundary (UGB), a program for the purchase of developments, the transfer of development rights (TDR), zoning policies designed to encourage smaller lot size, and transit-oriented development (TOD), and (2) inner-city redevelopment policies that include infill or brownfield development, encourage reinvesting in or rehabilitation of existing buildings, and zoning policies to mixed-use development. Addison et al., (2013) collected several previous studies on growth management practices divided into two levels of government. The first is statewide growth management, UGB, and impact fees which are general regulatory tools used by various levels of government, then the second is new urbanism, TOD, and infill/urban revitalization at the neighborhood level. Appleyard et al (2019) explained that SG is often referred to as the integration or coordination of transportation and land use. The evaluation carried out by Appleyard to describe the coordination between transportation and land use is TOD.

By using SG principles in their urban planning policies, cities can more effectively or efficiently use their land (AlKhereibi et al., 2021; Litman, 2022), can potentially reduce urban development costs (Pierre Filion & McSpurren, 2007), make more efficient use of land resources and ensure more effective provision of public services (Mohammed et al., 2016), effectively increase density and shift investment to urban cores using growth limits (Mohammed et al., 2016), housing affordability (Addison et al., 2013; Aurand, 2010; Litman, 2022), environmental quality (Addison et al., 2013; Artmann et al., 2019; Litman, 2000), and social equity (Addison et al., 2013; Litman 2000), improve the attractiveness and quality of housing (Artmann et al., 2019), emphasis on high-quality green spaces (Artmann et al., 2019), reducing reliance on personal vehicles and improving mobility (AlKhereibi et al., 2021), and enhancing the value of surrounding real estate (AlKhereibi et al., 2021; Wang et al., 2021), natural lands and resources are properly preserved (Pierre Filion & McSpurren, 2007), significantly impact children's physical activity levels (Jerrett et al., 2013), employment opportunities and more union jobs (Litman, 2022), public health benefit and safety (Frederick et al., 2018; Litman 2022), shorter commute duration (Litman, 2022), non-drivers are provided with various transport options (Jabareen, 2006; Litman, 2022) and various housing choices are provided (Addison et al., 2013; Jabareen, 2006). More particular effects, however, may differ depending on the environment and implementation strategy chosen inside the city.

Several previous studies show that several countries have applied SG principles in urban planning documents and land management. Florida, Maryland, Oregon, and Washington have implemented growth management policies to varying degrees to manage their urban growth (Addison et al., 2013). In his research (Addison et al., 2013) discovered that many SG management strategies in major American cities do reduce housing affordability for low-middle class residents, displacement, gentrification, and other justice issues. Similar to the case in Isfahan (Iran) where urban growth policies have an impact on housing prices (Bagheri & Tousi, 2018). However, according to Mohammed et al. (2016), empirical evidence that SG policies have an impact on high house prices is still limited, so this claim is still debated. Portland (Oregon), Arlington (Virginia), Boulder

(Colorado), and Lancaster County (Pennsylvania) use The 2003 General Plan Guideline by the US State of California as a basis for determining the sustainable development of the SG policies they implement (promoting compact, infill and TOD, and conservation and protecting open spaces and natural areas) and there is evidence that SG policies can help in the goal of improving public transportation (Mohammed et al., 2016). So according to him, it is still possible for SG policies to contribute to achieving sustainable development goals.

In the medium-sized region, Brazilian City also includes policies regarding urban growth management in the 2005 Master Plan Zoning Guidelines document and shows that government territory and political dynamics influence the urban growth management strategy (Menzori et al., 2021). Cairo, Egypt, was identified as containing more than 50% compliance with SG in the Housing Plan, Planning Profile, and Infrastructure documents and can help improve the quality of life in its community (Ghalib, 2018). The City of Jeddah implements a compact city as a sustainable urban development tool to control urban sprawl and requires planning authorities to encourage more realistic and sustainable intensification policies (Shawly, 2022).

SG, which is believed to solve the problem of urban sprawl, has not been widely discussed in the context of case studies in Indonesia. Indeed, in the legislation documents related to urban planning or urban growth management in Indonesia does not use the term SG, but there are several policies on urban growth management in Indonesia that are relevant to the SG principle and have been embedded in the legislative document. Examples of SG principles embedded in city planning policies and directions include Transfer Right Development (TDR), Transit Oriented Development (TOD), urban infill/revitalization, and compact city. Regulation regarding TDR listed in the Act No. 11-2021 on the procedures for substances agreements at spatial planning regulation and detailed spatial planning regulation. Later, the regulation and technical guidelines of TOD was listed in the Presidential Decree No. 55-2018 about Bodetabek Transportation Master Plan. Then, area revitalization guidelines as well as other regulations drawn up for the preservation of the area and buildings listed on the Ministry of Public Works No. 18-2010.

Then, there are several studies that try to assess the implementation of concepts and policies related to urban growth management carried out as in research (Arifwidodo, 2012; Dewita et al., 2018; Harmain et al., 2020; Nugraha et al., 2023). Bandung uses the compact development policy contained in the Bandung Master Plan 2013, Bandung Long Term Development 2007, and West Java Master Plan 2025 to reduce urban problems and improve quality of life (QoL) (Arifwidodo, 2012). Then Dewita et al. (2018) measured the relationship using Data Envelopment Analysis (DEA) between housing-transportation affordability and urban compaction in twenty-two municipalities in Jakarta, Bandung, and Medan. It is known that these measurements support the argument that compact cities have the potential to increase affordability if there is a combination of housing and transportation. The integration of land use with transportation has also succeeded in encouraging socioeconomic activities as proven by Harmain et al (2020) di Jakarta. Urban compactness in Jakarta can also protect work and social life during the COVID-19 pandemic crisis (Nugraha et al., 2023). According to him, diversity of land use and road access is important to protect the community against disruption to work and social life during the pandemic.

Implementing SG policies is not an easy thing. Some of the obstacles and challenges faced are conventional urban planning, lack of incentive-based practices and resources, ad-hoc planning, and lack of integrated transportation and land use planning (Raparthi, 2015); weak political commitment and market pressures that prevent planners from creating accessible and open communities (Grant, 2009); depend on the activism of interest groups and their interaction with local political institutions (politics, economic, and social) (de la Cruz, 2009; Gray, 2007). Because SG is widely employed by urban planners and policymakers as the most environmentally friendly approach to city development, the measurements should be valuable to them (Gren et al., 2019). Therefore, to realize SG implementation, planning must strive to encourage more realistic and sustainable intensification policies (Shawly, 2022); carry out coordination and integration to achieve significant progress in transport and land use imbalances (Appleyard et al., 2019); city/town technical planning capability (PC) (Ali, 2015); there is a need to re-evaluate and redesign growth management practices, and to encourage comprehensive practices that simultaneously consider market issues, planning tools and the role of government

(Addison et al., 2013); and concern in individual traits (such as age and work type), family characteristics, and environmental characteristics that may have a role in the differentiation (Nugraha et al., 2023).

There haven't been many studies that specifically address whether Indonesian urban expansion planning and management has accepted and implemented SG policies. As a result, this study will demonstrate how deeply SG concepts are incorporated in both land growth management rules and policies in Indonesia. The assessment of the content of the SG principles was then contrasted with the conditions of urban sprawl that happened at the study site. The places analyzed were suspected of suffering urban sprawl, particularly Bogor City, Depok City, Tangerang City, and Bekasi City (named Bodetabek), all of which were impacted by Jakarta-related activities.

In 2005-2010, Jabodetabek showed that the growth of developed areas was more dominant than population growth (Hidajat et al., 2013) and experienced urban sprawl (Fitriani et al., 2018). According to Fitriani et al. (2018), the sprawl pattern that occurs in Bodetabek is the ribbon development type, which is a growth pattern that develops following the transportation network, then it shows a polycentric structure pattern in which Jakarta is the main center. Urban sprawl is characterized by changes in agricultural land or consumption of agricultural land and sensitive land, as well as dividing agricultural and natural areas (Abrantes et al., 2016; Baśnou et al., 2013; Freilich, 1999; Hidajat et al., 2013; Salvati et al., 2012). In the case of Jabodetabek, Fitriani et al. (2018) assume that the factor causing urban sprawl is high population growth, which affects the level of population density either through birth or population migration and is triggered by the role of Jakarta as the core of development, which then attracts people to move to the center and expand the urbanization process (Imam Buchori et al., 2017).

2. Data and Methods

2.1. Data Collecting

This study requires two sets of data (see Table 1). in line with the intended analysis. Firstly, data is needed for the extraction of maps, specifically Landsat imagery 7 TM (for the 2001 and 2011 periods) and Landsat 8 OLI (for the 2021 period), which are provided by the United States Geological Survey (USGS). The selected images were acquired during May and June, as the dry season is expected to occur from the end of May to the end of September according to the Meteorology, Climatology, and Geophysics Agency. Secondly, there is a requirement for spatial planning regulation documents within the Bodetabek area. These documents are essential for analyzing the SG principles embedded in the spatial planning regulation for the Bodetabek area. Furthermore, additional supportive data, such as population statistics and work programs, are also needed as they pertain to the SG principles.

Table 1. Data Requirement and Source

Type of Data Used	Scale/Resolution	Years	Source
Landsat 7 TM image	30m	2001, 2011	USGS
Landsat 8 OLI/TIRS	30m	2021	USGS
Administrative Boundary Map	1:25,000	2001	Geospatial Information Agency Indonesia
Statistic Data - Population	District Boundary	2001, 2011, 2021	Statistic Agency Indonesia
Spatial Planning Regulation (SPR)	Municipality Area of		Government
	Bogor	2011-2031	
	Depok	2012-2032	
	Tangerang	2012-2023	
	Bekasi	2011-2031	

Source: Author, 2023

2.2. Data Analysis

In this research, the analytical methods (Figure 1) employed will be tailored to the research objectives in two steps. First, to assess the phenomenon of urban sprawl, this study uses measurements of built-up area (BUA) and non-built-up area (NBUA) using GIS and Remote Sensing. The image classification in this study was carried out using ArcGIS 10.8 software (ESRI). Landsat imagery was used, and it was composited into natural colors, specifically the 3,2,1 band combination for Landsat 7 TM and the 4,3,2 band combination for Landsat 8 OLI, with a maximum allowable cloud cover of 30%. To obtain the Landsat images matching the study area, they were clipped accordingly and then classified using the maximum likelihood method. In the data processing, ten samples of BUA and NBUA areas were employed in each region as guidance. The classification output was provided as raster data. To calculate the area accurately, the next step involved converting the raster data into vector data. Once the vector data was generated and dissolved, the subsequent step was to overlay it with administrative boundary maps and population maps. The population map was generated by incorporating statistical population data into the base map, which comprised administrative boundaries.

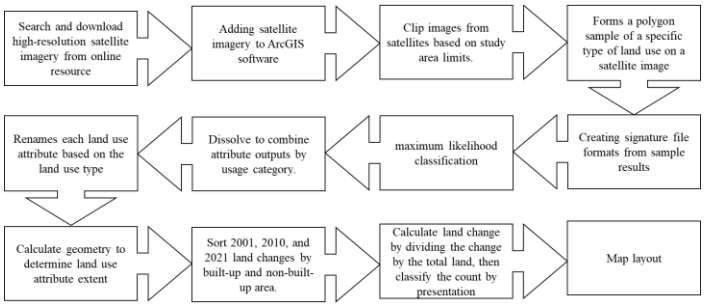
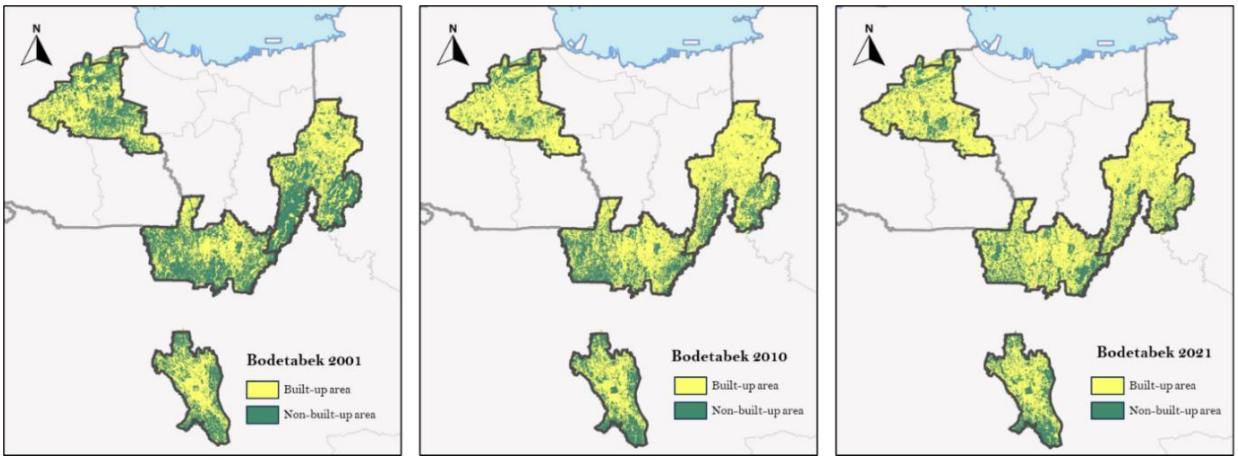


Figure 1. Methods of Measuring Built-up Area (BUA) and Non-built-up areas (NBUA)

In this research, analysis of Landsat 7 TM is done with satellite imagery for the years 2001, 2010, and 2021 to reveal built-up area (BUA) and non-built-up area (NBUA) conditions in Bodetabek (see Figure 2). Secondly, the analysis of SG principles (Table 2) is carried out in the SPR, as this document is consistently available for each study area. The primary objective of this analysis is to determine the extent to which the SPR within the study areas incorporates elements related to SG principles. Due to differing interests and requirements, terminologies for land control may differ among regions or countries. SPR provides a more general and comprehensive framework for regulating land use, infrastructure development, economic growth, and environmental conservation within a designated area. During the content analysis phase, a comprehensive explanation of the SG principle and its corresponding criteria is conducted.



Source: Author, 2023

Figure 2. BUA and NBUA Bodetabek in 2001, 2010, and 2021

Table 2. SG Principles and its Criteria

SG Principles	SG Principles Criteria
Mix Land Uses	[1A] Provide a more diverse and sizable population and commercial base for supporting viable public transit. [1B] Enhance an area's vitality and perceived security by increasing people's number and activity. [1C] Siting commercial areas close to residential areas.
Take Advantage of Compact Building Design	[2A] To support wider transportation choices and provide cost savings for localities. [2B] Preserves more open space, and individual buildings make more efficient use of land resources. [2C] Encouraging buildings to grow vertically rather than horizontally. [2D] Support wider transportation choices and provide cost savings for localities. [2E] To encourage transit use to reduce air pollution and congestion.
Create a Range of Housing Opportunities and Choices	[3A] Providing quality housing for people of all income levels. [3B] Create a wider range of housing choices by increasing housing supply in existing neighborhoods and on land served by existing infrastructure. [3C] Use infrastructure resources more efficiently, ensure a better job-housing balance, and generate a strong foundation of support for neighborhood transit stops, commercial centers, and other services. [3D] Integrating single- and multi-family structures in housing developments can support a more diverse population and allow a more equitable distribution of households of all income levels.
Create Walkable Neighborhoods	[4A] Goods (housing, office, retail) and services (transportation, schools, libraries) are located within an easy and safe walk. [4B] Make pedestrian activity possible. [4C] Creating a streetscape for a range of users-pedestrians, bicyclists, transit riders, and drivers. [4D] Regulation that prohibits mixed land uses results in longer trips and makes walking a less viable option.
Foster Distinctive, Attractive Communities with a Strong Sense of Place	[5A] Create interesting, unique communities that reflect the values and culture of the people who live there and foster physical environments that support a more cohesive community fabric. [5B] Promotes development that uses natural and man-made boundaries and landmarks to define neighborhoods, towns, and regions. [5C] Encourage the construction and preservation of buildings that are assets. [5D] Ensure that the value of infill and greenfield development is determined as much by its accessibility as its physical orientation to, and relationship with, other buildings and open space. [5E] Creating high-quality communities with architectural and natural elements.
Preserve Open Space, Farmland, Natural Beauty and Critical Environmental Areas	[6A] Bolstering local economies, preserving critical environmental areas, improving community quality of life, and guiding new growth into existing communities. [6B] Fund open space protection efforts (provides many fiscal benefits: increasing local property value, providing tourism dollars, and preventing local tax increases.
Strength and Direct Development Towards Existing Communities	[7A] Smart growth directs development towards existing communities already served by infrastructure, seeking to utilize the resources that existing neighborhoods offer, and conserve open space and irreplaceable natural resources on the urban fringe. [7B] Infill development.
Provide a Variety of Transportation Choices	[8A] To implement new approaches to transportation planning, such as better coordinating land use and transportation; Increasing the availability of high-quality transit services; creating redundancies; resilience and connectivity within the road network; and ensuring connectivity between pedestrians, bikes, transit, road facilities. [8B] Using a multi-modal approach to transportation with supportive development patterns, to create a variety of transportation options.
Make Development Decisions Predictable, Fair and Cost Effective	[9A] All concepts must be embraced by the private sector. [9B] Governments must have the right infrastructure and regulatory decisions. It will support fair, predictable, and cost-effective. [9C] The development industry must be highly regulated; the value of the property and the desirability of a place are affected by government investment in infrastructure and government regulation. [9D] Creating a supportive environment for the development of innovative, pedestrian-oriented, mixed-use projects.
Encourage Community and Stakeholder Collaboration in Development Decisions	[10A] Encouraging community and stakeholder collaboration can lead to creative, speedy resolution of development issues and greater community understanding of the importance of good planning and investment. [10B] Involving the community early and often in the planning process vastly improves public support for smart growth and often leads to innovative strategies that fit the unique needs of a particular community. [10C] In encouraging collaboration including developing an inclusionary process and a common understanding among diverse stakeholders, using effective and appropriate communication techniques, and working with local authorities.

Source: Analysis, 2023

3. Result and Discussion

3.1. Urban Growth in Bodetabek Region

Based on the acquired data, it is evident that there has been an expansion in the extent of urban land cover, elucidated by the observed augmentation of built-up areas within the Bodetabek region. A notable increase of 28% in BUA within Bodetabek from the year 2001 to 2021 (refer to Table 3). Following a more extensive investigation of each location, it is shown that Bekasi witnessed a significant rise in BUA of 44% between 2001 and 2010, but with a comparably small expansion of 6% between 2010 and 2021. Bekasi appears as the municipality with the most dramatic increase in total land coverage. For instance, between 2001 and 2021, Bekasi accommodated four districts—namely Medan Satria, Pekayon Jaya, Duren Jaya, and Kaliabang Tengah—with growth exceeding 40%, and an additional four districts—Jakasampurna, Margahayu, Harapan Jaya, and Bojong Rawalumbu— demonstrating growth surpassing 50%. Notably, one district, Pejuang, experienced an extreme alteration in land cover, amounting to 70%.

Table 3. BUA Growth in Bodetabek 2001, 2010, and 2021

Area	BUA Growth (ha)			Land Area (ha)
	2001	2010	2021	
Bogor	5.79	5.76	6.19	11.22
Depok	8.98	11.28	12.80	19.86
Tangerang	10.02	13.47	13.93	18.03
Bekasi	11.25	16.15	17.13	21.64

Source: Calculation by Author, 2023

Moving on, in Tangerang, a growth of 34% was observed during 2001-2010, followed by a marginal increase of 3% during 2010-2021. From 2001 through 2021, Tangerang comprised two districts that exhibited the most substantial augmentation in land coverage: Pasir Jaya, expanding by an extent of 445.7 ha or 55%, and Pajang, expanding by an extent of 390 ha or 63%. In the third ranking, Depok displayed an expansion of 26% in built-up areas, with the most significant increase occurring between 2010 and 2021, accounting for 13%. Within Depok, Sukamaju District underwent the most considerable change, expanding by 292.5 ha or 41%, closely followed by Tugu District, which experienced an expansion of 386.5 ha or 55%. Conversely, Bogor registered the least substantial increase in BUA, totaling only 4% between the years 2001 and 2021. The most notable alteration in land cover within Bogor was evident in Baranangsiang District, exhibiting a change of 25%, corresponding to an area of 179.4 ha. The second most significant change was observed in the Kebon Pedes District, indicating a change of 22%, equivalent to an area of 153.5 ha. The proportion of BUA and NBUA to the district area in Bodetabek is explicated through visualization as depicted in Figure 3.

Besides, population growth and density serve as a reason for the shift in NBUA to BUA. Based on the population growth data, a growth trend is evident across all areas of Bodetabek. Analysis of the data presented in Table 3. reveals a significant disparity in population growth between the periods of 2001-2010 and 2010-2021. Notably, for Bogor, Depok, and Tangerang, the population growth during these respective time intervals experienced a reduction in percentage growth. In contrast, Bekasi demonstrated an increase in population growth across the given time series. Nevertheless, it can be asserted that, overall, the population growth consistently exhibits positive increments within the temporal span from 2001 to 2021. Remarkably, Bekasi emerges as the municipality boasting the highest population and population density within the Bodetabek region, notwithstanding not necessarily recording the highest population growth rate (Table 4).

Table 4. Total Population and Density in Bodetabek 2001, 2010, 2021

Area	Population			Density		
	2001	2010	2021	2001	2010	2021
Bogor	762,667	960,985	1,099,422	64	81	93
Depok	1,186,684	1,535,297	1,882,010	59	77	94
Tangerang	1,354,226	1,720,121	1,770,587	82	105	108
Bekasi	1,941,144	2,127,428	2,471,752	92	101	117

Source: Indonesia Statistic Bureau with calculation by Author, 2023

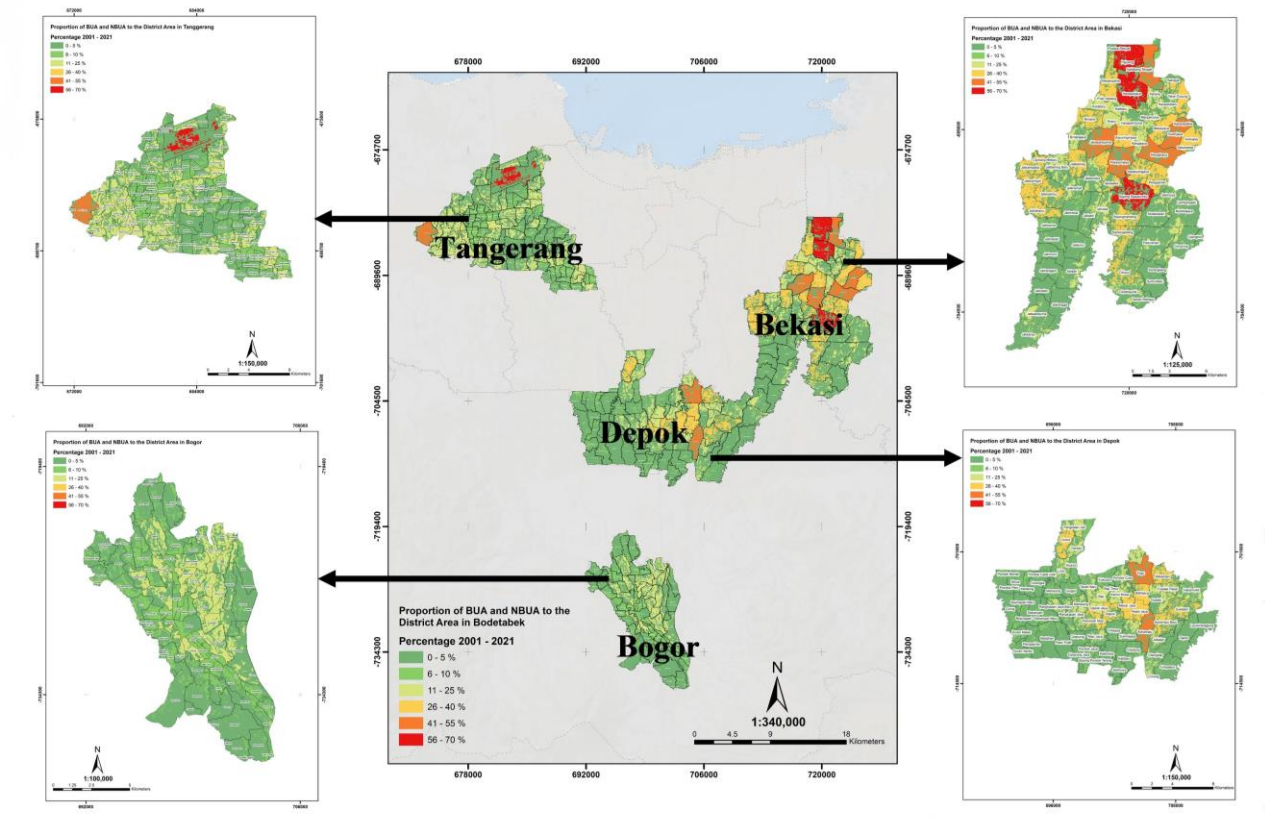


Figure 3. Proportion of BUA and NBUA to the District Area in Bodetabek (2001, 2010, and 2021)

Next, the analysis of the SG principles and whether is already contained in the spatial planning document. The analysis of SG principles is conducted within the SPR, as this document is consistently available for each study area (Table 5). The primary objective of this analysis is to ascertain the extent to which the SPR within the study areas encompasses elements pertinent to land management or land growth control. Due to distinct interests and needs, the terminologies employed for land control may vary across different municipalities, regions, or countries. A spatial Plan is a more general or comprehensive guidance and framework for regulating land utilization, infrastructure development, economic expansion, and environmental conservation within a given area.

Table 5. SG Principles Containing in SPR

No	SG Principles	SPR			
		Bogor	Depok	Tangerang	Bekasi
1	Mix Land Uses	A	A	A	N/A
2	Take Advantage of Compact Building Design	A	A	A	A
3	Create a Range of Housing Opportunities and Choices	A	A	A	A
4	Create Walkable Neighborhoods	A	A	A	N/A
5	Foster Distinctive. Attractive Communities with a Strong Sense of Place	A	A	N/A	A
6	Preserve Open Space. Farmland. Natural Beauty and Critical Environmental Areas	A	A	A	A
7	Strengthen and Direct Development Towards Existing Communities	A	A	N/A	A
8	Provide a Variety of Transportation Choices	A	A	A	A
9	Make Development Decisions Predictable. Fair and Cost Effective	A	A	A	A
10	Encourage Community and Stakeholder Collaboration in Development Decisions	N/A	N/A	N/A	A
The adopted principles in total		**9/10**	**9/10**	**7/10**	**7/10**

A: Available; N/A: Not available
Source: Analysis, 2023

Based on content analysis, it is evident that the SPR in the study area has incorporated SG principles. Based on the weighting results shown in Table 6, it was found that the SPR in Bodetabek with the most comprehensive inclusion of SG principles was those of Depok and Bogor, with a total weight of nine of ten SG principles. Tangerang and Bekasi received a weight of 7 SG principles. The tenth SG principle, which pertains to "community and stakeholder collaboration", is not included in the SPR of all cities. However, upon closer examination, numerous planning activities and programs in Indonesia are collaborative, and research addressing "community and stakeholder collaboration" is prevalent. Consequently, despite not being explicitly addressed in the SPR, the principle of "community and stakeholder collaboration" is, in essence, acknowledged and implemented in land growth management or control measures in several regions of Indonesia. One of Bogor's spatial plan regulations has incorporated the collaboration principle, as evident in the regulation concerning the "management of green open spaces", where a specific article defines the roles of the community and the private sector in green space management efforts. Another form of community participation in transportation matters is the Bogor and Bekasi Spatial Plan. These regulations involve oversight and input from the public regarding the provision of mass public transportation services to ensure service quality adheres to minimal standards.

Table 6. Policies and Regulations that Embody with SG Principles

No	SG Principles	Criteria	SPR			
			Bogor	Depok	Tangerang	Bekasi
1	Mix Land Uses	1A	1	0	1	0
		1B	0	1	0	0
		1C	1	0	1	0
2	Take Advantage of Compact Building Design	2A	0	0	0	0
		2B	0	1	1	0
		2C	1	1	1	1
		2D	0	0	0	0
		2E	0	0	0	0
3	Create a Range of Housing Opportunities and Choices	3A	0	1	0	1
		3B	0	0	1	0
		3C	1	1	0	1
		3D	0	0	0	0
4	Create Walkable Neighborhoods	4A	0	1	0	0
		4B	1	1	1	0
		4C	0	0	0	0
		4D	1	0	0	0
5	Foster Distinctive, Attractive Communities with a Strong Sense of Place	5A	1	1	0	1
		5B	1	1	0	0
		5C	0	0	0	0
		5D	0	1	0	0
		5E	0	0	0	0
6	Preserve Open Space, Farmland, Natural Beauty and Critical Environmental Areas	6A	1	0	0	1
		6B	1	1	1	0
7	Strenghten and Direct Development Towards Existing Communities	7A	1	1	0	1
		7B	0	0	0	0
8	Provide a Variety of Transportation Choices	8A	1	1	1	1
		8B	0	0	1	1
9	Make Development Decisions Predictable, Fair and Cost Effective	9A	0	0	0	0
		9B	0	0	0	0
		9C	1	1	1	1
		9D	0	0	0	0
10	Encourage Community and Stakeholder Collaboration in Development Decisions	10A	0	0	0	0
		10B	0	0	0	0
		10C	0	0	0	0

Score: 0: not contained, >1: contained

Source: Analysis, 2023

Furthermore, the implementation of SG principles in Bogor, Depok, and Tangerang also exemplifies the realization of the tenth principle, as these programs aim to enhance collaboration between the community and the government in the development process (Table 7). 'Community and stakeholder collaboration in development decision-making' (the tenth principle) is stipulated in the Detailed SPR of Bekasi, which affirms the community's right to participate in space utilization and management. In the realm of transportation, community involvement is addressed, allowing for knowledge-sharing and input regarding traffic management and public transportation, as elucidated in Bekasi's Spatial Plan concerning Traffic Management and Public Transportation. The selection of principles based on the above table is contingent upon the presence or absence of a given criterion within the SPR.

Table 7. Several Implementation of SG Principle in Bodetabek

Criteria	Bogor	Depok	Tangerang	Bekasi
2C	Vertical housing development for low-income (Ramadhan, 2022)	The integration of commuter line stations with the construction of residential units. (Fadli & Alexander, 2022)	Apartment construction increased in 2019-2022 with the addition of around 18,582 units (Salsabila, 2019).	Apartment construction is increasing from 2010 – 2023. In 2013 there were 18,123 units, in 2015 it became 21,408, and in 2023 it will reach 49,895 apartment units (Fauzi, 2016; Sari, 2018)
	The increase in residential building activity during the third quarter of 2017, the second quarter of 2018, and the fourth quarter of 2019 (Rumah.com, 2021a)		There was an increase in the property supply index reaching 2.5% on a quarterly basis (Rumah.com, 2021b)	
8A	Development of integration between online transportation, terminals, and stations through cooperation with online transportation providers.	Development of integration between online transportation, terminals, and stations through cooperation with online transportation providers.	Development of integration between online transportation, terminals, and stations through cooperation with online transportation providers.	Development of integration between online transportation, terminals, and stations through cooperation with online transportation providers.
	Many masses transportation options such as commuter lines, BRT, cross-city buses, LRT, and traditional micro mobility.		Improving BRT services through digitalization of payment systems (TNG, 2023)	Provision of Light Rail Transit (LRT) and construction of LRT Station with TOD concept.
	Provision of integrated and reliable urban transportation with the concept of Bus Rapid Transit (BRT) in 2021 (Ronal, 2021)		Construction of TOD nodes to connect activity centers between cities and within cities (BPTJ, 2018)	Development of commuter line services
	Construction of the Bodebek Light Rail Transit (LRT) and will be operational in 2023 (Sulistyawaty et al., 2023)		Procurement of public transportation in the form of Bus Rapid Trans Tangerang Ayo (BRT Tayo) starting in 2019 and Si Benteng City Transportation since 2021(TangerangSatu.co.id)	Provision of intercity and provincial buses.
	City and sub-city scale TOD (commuter line terminals and stations) (Republika.id, 2021)			
9C	Industrial estate regulation	Industrial estate regulation.	Arrangement of the creative industry industrial park.	Issuance of Bekasi City regional regulations regarding the implementation of space utilization permits
				Arrangement and function of certain areas to be developed into national-scale industries

The provided table depicts SG principles and criteria, which are following the articles outlined in the SPR of the Bodetabek area. It is worth mentioning that in the Bodetabek region, a minimum of three common criteria have been generated from the implemented SG concepts. These criteria can be attributed to the principles mentioned in Table 8. i.e. Compact Buildings, criteria 2C (encouraging vertical rather than horizontal

building),Transportation Choices, criteria 8A (implementing innovative approaches in transportation planning), Criteria 9C (developer companies must be strictly regulated, government investments influence property values and the attractiveness of a place in infrastructure and government regulations).

The Bodetabek region has not fully embraced all the criteria, which is influenced by the area's specific social, economic, environmental, political, and legal circumstances. Multiple scholarly sources in the literature suggest that numerous elements exert an effect on the decision-making process of four local governments when it comes to adopting sustainable development concepts as a framework. The application of criteria in SG principle in the Bodetabek region demonstrates a shared characteristic, which involves the adoption and prioritization of programs related to Transit Oriented Development (TOD) and the establishment of vertical housing structures alongside complementary amenities that align with this concept. In addition, to determine the region that primarily embraces the SG principle criteria in its SPR computation is conducted for each chosen criterion concerning the overall criteria within a given principle.

Table 8. Percentage of Criteria Content on SG Principles in Spatial Planning Policies in Bodetabek

SG Principles	SPR Weight of Criteria Content in Each Principle (%)			
	Bogor	Depok	Tangerang	Bekasi
Mix Land Uses	66.67	33.33	66.67	0
Take Advantage of Compact Building Design	20	40	40	20
Create a Range of Housing Opportunities and Choices	25	50	25	50
Create Walkable Neighborhoods	50	50	25	0
Foster Distinctive, Attractive Communities with a Strong Sense of Place	50	50	25	50
Preserve Open Space, Farmland, Natural Beauty and Critical Environmental Areas	40	60	0	20
Strengthen and Direct Development Towards Existing Communities	66.67	33.33	33.33	33
Provide a Variety of Transportation Choices	50	50	0	50
Make Development Decisions Predictable, Fair and Cost Effective	50	50	100	100
Encourage Community and Stakeholder Collaboration in Development Decisions	0	0	0	0
Average	41.83	41.67	31.50	27,33

Source: Analysis, 2023

Based on the findings, it can be observed that Bodetabek's SPR includes criteria based on the SG principle. These criteria account for around 27-42% of the total criteria included in the regulation. Bogor and Depok's cities demonstrate the highest adoption rates of SG concepts. The results indicate that the average proportion of material remains below 50%. This study has revealed that the SPR in the Bodetabek region have incorporated the principles of SG as part of its developmental plans.

3.2. Discussion

SG is an urban planning and development approach that focuses on creating more sustainable, livable, and economically viable communities. It aims to combat urban sprawl, promote efficient land use, and improve the quality of life for residents. SG is believed to be an innovative and comprehensive solution to urban sprawl (Addison et al., 2013; Burchell et al., 2000; Calthorpe, 1990; Harris & Evans, 2000; Włoch-Szymla, 2019). The comprehensive measurement is not only measured from economic factors but also ecological, spatial, and social considerations (Berke et al., 2006; I Buchori et al., 2021; Włoch-Szymla, 2019).

The results of land cover classification using the maximum likelihood method in the Bodetabek area show that Bekasi saw the most significant growth in land cover change, followed by Tangerang, Depok, and Bogor. Based on the findings, it can be inferred that Bekasi exhibits the most pronounced urban sprawl in comparison to other cities within the Bodetabek region. Bekasi underwent a notable alteration in its land cover,

amounting to a 27% shift between the years 2001 and 2021. This change was particularly significant in nine urban villages inside the city, namely Medan Satria, Pekayon Jaya, Duren Jaya, Kaliabang Tengah, Jakasampurna, Margahayu, Harapan Jaya, Bojong Rawalumbu, and Pejuang, where the percentage of land cover change exceeded 40%. In line with population growth in Bekasi which also experienced growth of up to 27% from 2001 to 2021. After Bekasi, Tangerang ranks as the second urban area with the most pronounced expansion, as seen by a land cover alteration rate of 3% between 2001 and 2021. It is also in line with its population growth which increased by 31% from 2001 to 2021. Then, the city that experienced the third NBUA to BUA change after Tangerang was Depok with a change of 19% despite experiencing the highest population growth of 59% from 2001 to 2021. Meanwhile, Bogor experienced the lowest land change of only 4% of its total land area, although Bogor's population growth was quite high at 44%. This condition is still in line with research by Fitriani et al. (2018) which identified the level of ribbon development type urban sprawl with data from 2005-2010 in Bodetabek as a result of massive activity in Jakarta.

Furthermore, according to the content analysis results in the SPR document in Bodetabek, no more than 50% of SG principles are incorporated in spatial planning papers. It is known that the city that embeds the SG principle the least is Bekasi (27.33%). Then the second lowest city is Tangerang (31.50%). While the city that embeds the SG principle the most is Bogor (41.83%), and the second is Depok (41.67%). If this condition is juxtaposed with the results of the land cover classification using the maximum likelihood method in the Bodetabek, it looks quite interesting. The results of the pairing show that it is in line with the basic concept of SG. Bogor, which has 41.83% SG principle content in the SPR, shows that Bogor has the lowest land use change conditions (4%).

Bogor City is not directly affected by activities or activities in Jakarta, because Bogor City has developed itself due to massive agricultural activities. Over time, Bogor became a developing area and succeeded in becoming a modern urban area. Now Bogor focuses more on mixed-use development (66.67% of the principle of mix land uses contained in the Bogor SPR), and provides many apartment dwellings that are integrated with other land uses. This can certainly be more effective and efficient in utilizing land owned (AlKhereibi et al., 2021; Litman, 2022). The Bogor City Government dreams of holding the title of a walkable city, so the Bogor SPR document contains 50% about 'create walkable neighborhoods'. Now the policy is implemented with the addition and revitalization of pedestrian ways, as well as focusing on stations that are planned as TOD areas. To support the success of the TOD, Bogor is one of the cities that focuses on improving public transportation and providing many mass transportation options so that at least Bogor has achieved the implementation of SG in the transportation sector. SG can indeed help in the goal of improving public transportation (Mohammed et al., 2016). The integration of land with the transportation system (macro-mobility and micro-mobility) implemented in Bogor is relevant to the SG concept conveyed by Appleyard et al. (2019), where SG is a form of integration between transportation and land. Although Bogor does not explicitly state that its city growth management carries SG, Bogor quite accommodates and implements SG principles.

Furthermore, in the second place of cities that contain many SG principles in their SPR documents is Depok (41.67%). When juxtaposed with the results of land cover classification, Depok experienced a land cover change of 19% (the second place of the cities that experienced the least land cover change). Activities that are relevant to the SG principle that is favored by the Depok government are local economic development and improving the quality of life of its people. According to the Indonesian Digital Creative Industry Society (MIKTI), Depok is one of the cities with the highest number of start-ups in Indonesia in 2021 (Lantara, 2023). The number of start-ups is quite large, it can provide job opportunities for the community. This is relevant to the concept of SG conveyed by (Litman, 2000) that if SG is applied effectively it can improve welfare and social equity. In addition, the implementation realized by the Depok government is by providing housing choices for the people of Depok, such as the construction of flats integrated with stations (Fadli &; Alexander, 2022). However, on the one hand, the provision of transportation options in Depok has not been successfully implemented properly. So far, Depok has not shown mass transportation options that can support integration with land. Even though Depok has good potential to implement a compact city when viewed from the aspect of

land use and transportation systems (Ratnaningtyas et al., 2022). As in Jakarta, the integration between land use and transportation has succeeded in encouraging socio-economic activities (Harmain et al., 2020).

Then, in third place, the city that embeds the SG principle on its SPR document is Tangerang (31.50%). The value of Tangerang's land cover change itself is the second highest that experienced a change in BUA from 2001-2021 (22%). An interesting condition that occurs in Tangerang is that although the SPR document does not embed the principle of development supported by the private sector, large-scale development and residential areas in Tangerang are controlled by many private sectors. Apartment construction increased in 2019-2022 with the addition of around 18,582 units, the majority of which were carried out by private developers (Salsabila, 2019) and quarterly there was an increase in the property supply index to reach 2.5% (Rumah.com, 2021b). The provision of housing and transportation options is realized in Tangerang (see Table 7). However, the impact of the 'freedom' of private developers in building housing has given Tangerang the label 'private city'. The trend of mixed-use development that does not benefit from compact building design is felt to occur in Tangerang, so it is far from efficient and effective land use. Even though SG itself has a concept that is expected to streamline land use, reduce development costs, and use land resources effectively (AlKhereibi et al., 2021; Filion & McSpurren, 2007; Litman, 2022; Mohammed et al., 2016).

Similar to Tangerang, Bekasi appears to be predominantly influenced by private developers. Currently, it is known that the Bekasi SPR document only embeds the SG principle at 27.33%. Bekasi ranks last in cities that embed the SG principle between Bogor, Depok, and Tangerang. When viewed from the land cover change that occurred in Bekasi, Bekasi shows as the city that has experienced the most changes from NBUA to BUA (27%). What is interesting is where the principle of 'mix land uses' which is not listed in the Bekasi SPR has been implemented. For example, large-scale housing development carried out by private developers with the concept of mixed land use (consisting of housing, retail, schools, hospitals, and offices). Bekasi itself has a history of large-scale housing development that is quite high.

The urban sprawl circumstances seen in the Bodetabek region align with the extent of SG principal criterion content found in the local rules of these cities, as indicated by the findings of the analysis of spatial plan content. Finally, this research can contribute to the conclusion that the adoption of the SG principal in urban planning policy documents in Indonesia effects the urban sprawl phenomena, even though the rules and policies do not utilize the term SG in the policy. This is a novel idea that This is a novel idea that developed through urban sprawl study in Indonesia. While it is necessary to conduct additional research and account for other contributing variables to urban sprawl, the findings of this study can serve as a catalyst or a reminder of the significance of implementing sustainable growth principles especially in Indonesia. According to Kushner (2002), it is anticipated that SG will concentrate its infrastructure subsidies on certain growth regions, prioritizing projects that promote infill development, neighborhood repair, and revitalization, rather than focusing on new suburban development. The results of this study serve as preliminary evidence suggesting that the SG principle may have the potential to impede the progression of urban expansion.

A challenge in implementing SG principles in urban planning policy is reliance on interest group activism and their interaction with local political institutions (de la Cruz, 2009; Gray, 2007) and market pressures that may hinder planners (Grant, 2009), or may countries be faced with conventional urban planning (Raparthi, 2015). So sometimes not all SG principles can be simultaneously embedded in the SPR document. It is known that cities that almost achieve all SG principles are Bogor and Depok, which are nine out of ten existing principles. While Tangerang and Bekasi accommodate seven principles out of ten principles. The SG concept in Indonesia has not been comprehensively assembled in a single regulation but is still general, disseminated, and following the political needs of the region. In addition, regional autonomy also makes each city entitled to determine how the management of city or regional growth is regulated, so as not to form harmony between regions.

One weakness of this work pertains to the lack of complete temporal alignment between the data sources utilized. Specifically, the local regulatory papers on urban planning included in this analysis do not entirely correspond with the time series of Landsat TM7 images that were utilized. There exists a temporal discrepancy

between the duration of validity for the planning papers employed and the time series utilized to discern the phenomenon of urban sprawl in the Bodetabek region. The study utilizes local rules to establish and implement a policy framework spanning from 2011/2012 to 2031/2032. Additionally, the time series of TM7 Landsat pictures employed in the analysis covers the period from 2001 to 2021. This implies that there exists an indeterminate discrepancy in the number of years, as the efficacy of the policy outlined in the rule has not been conclusively demonstrated through its execution. This research highlights the necessity of considering additional aspects that can provide further evidence regarding the veracity of the impact resulting from the implementation of the SG principle. Furthermore, a notable constraint evident in this study is the absence of supplementary material or data of local legislation that may already encompass SG principles. This includes programs, derivative policies, and derivative regulations stipulated in other documents. The accommodation of the 10th principle, which pertains to fostering community and stakeholder involvement in decision-making processes, might have been addressed in alternative papers.

4. Conclusion

SG is referred to as a more comprehensive and innovative urban planning concept in overcoming the phenomenon of urban sprawl and its negative impacts. Some of the SG principles that are prioritized to overcome urban sprawl problems include urban planning that focuses on land use efficiency, preservation and empowerment of natural resources and existing communities, integrating land and transportation, attractive communities, and relying on predictable, fair, and cost-effective development decisions. Although there are many pros and cons in the development of the theory, SG is still a promising concept as an alternative to solve the problem of urban sprawl.

The results showed that, although spatial planning regulations and policies in Indonesia do not use the term SG, several SG principles have been included in SPR documents in several cities used as case studies in this study. In the results of content analysis conducted on the SPR document, it is known that the city that applies the SG principle the most is Bogor City. While the lowest city embedding the SG principle in the SPR document is Bekasi City. Furthermore, if juxtaposed with the results of land cover change analysis using a combination of Landsat 7 TM and Landsat 8 OLI, it is known that the more the government uses policies and regulations that are relevant to the SG principle, it can affect the characteristics of urban sprawl that occurs in the region. Although this study has some limitations in a more in-depth study and several data series that have a difference in years with city SPR documents, it can provide a big picture that the SG principle is proven to affect the phenomenon of urban sprawl, especially in Indonesia. Implementation of SG principles can be recommended of course by adding incentive-based practices and resources, optimizing integration planning between land and transportation, as well as increasing political commitment and reducing market pressure so as not to prevent planners from creating accessible and open communities.

Furthermore, this research can be continued or developed into more detail by adding several other factors, such as population density, community commuting patterns, community lifestyles, and decision making in settlement. Meanwhile, in the analysis of the phenomenon of urban sprawl, other factors that are more diverse can be added to measure more concrete regional expansion.

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