

# STRUCTURAL ANALYSIS OF INFLUENCING FACTORS FOR SUSTAINABILITY OF URBAN GREEN SPACES (CASE STUDY: DEPOK CITY)

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## ABSTRAK

Kota Depok, yang terletak di bagian barat Provinsi Jawa Barat, telah mengalami pertumbuhan yang pesat selama beberapa dekade terakhir. Pertumbuhan ini terjadi seiring dengan urbanisasi yang kuat, perkembangan industri, dan peningkatan populasi. Selain dampak positif dengan tumbuhnya ekonomi dan berkembangnya infrastruktur, perkembangan yang cepat ini menyebabkan terjadinya kerusakan lingkungan dan kehilangan lahan terbuka hijau. Hal ini dapat berdampak negatif pada kualitas udara, air, dan tanah, serta mengancam keberlanjutan lingkungan. Tulisan ini mencoba menginventarisir faktor-faktor yang terlibat dalam keberlanjutan ruang hijau perkotaan secara sistematis dengan pendekatan struktural menggunakan *software Cross-Impact Matric Multiplication Applied to Classification (MICMAC)*. Dari 12 faktor yang dianalisis, terdapat 5 faktor mempunyai tingkat pengaruh kuat dan ketergantungan rendah dan 3 faktor yang mempunyai pengaruh kuat namun mempunyai ketergantungan tinggi. Faktor-faktor tersebut adalah: 1) kebijakan RTRW, 2) penegakan hukum, 3) pendidikan lingkungan hidup, 4) integritas pemangku kepentingan, dan 5) keterlibatan dan partisipasi masyarakat, sedangkan 1) konservasi keanekaragaman hayati, 2) nilai tanah, dan 3) pemeliharaan dan perlindungan lingkungan hidup merupakan faktor yang pengaruhnya kuat namun ketergantungannya juga tinggi. Hasil identifikasi faktor-faktor kunci tersebut dapat dimanfaatkan oleh para pemangku kepentingan sebagai pertimbangan untuk mengambil keputusan.

**Kata Kunci:** Keberlanjutan, MICMAC, Ruang Terbuka Hijau Perkotaan

## ABSTRACT

*Kota Depok, located in the western part of West Java Province, has experienced rapid growth over the past few decades. This growth occurred alongside intense urbanization, industrial development, and population increase. Apart from the positive impact of economic growth and infrastructure development, this rapid development causes environmental damage and loss of green open land. This can impact air, water, and soil quality and threaten environmental sustainability. This paper systematically tries to inventory the factors involved in urban green spaces' sustainability with a structural approach using Cross-Impact Matric Multiplication Applied to Classification (MICMAC) software. Of the 12 factors analyzed, five have a strong level of influence and low dependence, and 3 have a strong influence but have high reliance. These factors are 1) LU policy, 2) law enforcement, 3) environmental education, 4) stakeholder integrity, and 5) community involvement and participation, while 1) biodiversity conservation, 2) land value, and 3) environmental maintenance and protection is a factor that has a strong influence but is also highly dependent. Stakeholders can use the results of identifying these key factors as considerations for making decisions.*

**Keywords:** Sustainability, MICMAC, Urban Green Space

## Introduction

Green Open Space (RTH) is an important component in the urban structure whose availability must be considered both in quantity and quality in city planning (Dwihatmojo 2013). Green open space has a role in reducing the Urban Heat Island effect (Estoque *et al.* 2017), and greenhouse gas emissions, especially CO<sub>2</sub>, and controlling air quality (Rawung 2015), research results show that green open space with good conditions can cause the air temperature to decrease by 5.86% and increase humidity by 4% (Prakoso dan Herdiansyah 2019). The availability and adequacy of green open space is one of the requirements for creating a healthy and comfortable city environment. However, often its existence is only considered as a complement to add to the aesthetics of the environment, and what is even sadder is that it is only considered as a reserve that can be replaced with other more economically profitable land uses in the future (Sugandhy dan Hakim 2007).

Kota Depok is one of the areas that is developing rapidly due to the spillover effect. Kota Depok has a fairly rapid level of population and economic development. This condition causes an increasing demand for land to meet the needs for developing urban supporting facilities and infrastructure. The increasing demand for land and limited land availability will cause changes in land use (Dewi 2018).

The research results show that from 2006 to 2019 there was a significant increase in built-up land of 3,579 ha. In 2016, Kota Depok, with an area of 20,029 ha, only had green open space of 3,270 ha from the supposed 6,009 ha, still a deficit of 2,739 ha (Aji *et al.* 2020). This is a serious problem because along with the increase in population and supporting activities, the availability of green open space in the future is expected to be increasingly pressured by the growth of built space.

Many factors become obstacles to the continued existence of urban green space. The sustainability of urban green space is influenced by a multitude of crucial factors that play a significant role in ensuring the effectiveness and longevity of green space within urban environments.

Factors such as urbanization, land use policies, and spatial configuration have been identified as key determinants affecting the sustainability of urban green spaces (Chen *et al.* 2021), (Song *et al.* 2021); (Zhang *et al.* 2022)). Community engagement and participation also play a crucial role in influencing the sustainability of urban green space. The involvement of local communities in the planning, development, and maintenance of green space can have a significant impact on their long-term viability and success. (Nugraha *et al.* 2022) discussed the opportunities and challenges of urban green space for climate change mitigation and adaptation, emphasizing the potential of multi-stakeholder cooperation and community engagement in urban forest development for climate change resilience. (Jahrl *et al.* 2022) examined the role of community gardens as a response to the contradictions of sustainable urban policy, emphasizing the impact of civil society engagement and community involvement in shaping urban land management.

Other factors that can influence the sustainability of urban green space are the land's economic value and stakeholder's integrity. The economic value of land plays a crucial role in the conversion of urban green space. Research by (Liu *et al.* 2016) shows that pressure from developers and investors to maximize profits often leads to the conversion of green land into more financially beneficial uses, such as commercial property development or luxury housing. While stakeholder integrity is fundamental to the sustainability of urban green space. Ethical behavior, transparent operations, and committed engagement from all stakeholders are essential to ensure that these space can fulfill their potential as sustainable, inclusive, and restorative urban ecosystems. Future policies and research should focus on strengthening these attributes to ensure the long-term preservation and enhancement of urban green space.

The development of urban green space policies and strategies is essential for promoting sustainable urban development and maintaining a balance between economic, social, and environmental aspects in cities (Cellindita *et al.* 2021). Understanding the drivers that affect urban green space is key to enhancing their potential for providing ecosystem services and contributing to urban sustainability goals (Badiu *et al.* 2016).

## METHOD

The research was conducted in Kota Depok, which consists of 11 districts: Beji District, Sukmajaya District, Cilodong District, Pancoran Mas District, Cipayung District, Limo District, Cinere District, Cimanggis District, Tapos District, Bojongsari District, and Sawangan District. Geographically, the Kota Depok is located at coordinates 6° 19' 00" – 6° 28' 00" South Latitude and 106° 43' 00" - 106° 55' 30" East Longitude (Figure 1).

## Data Analysis

The Matrice d' Impacts Croisés-Multiplication Appliquée à un Classement (MICMAC) is a valuable tool for analyzing factors influencing the development of green space (Ariyani *et al.* 2022). Research in Tabriz City has utilized MICMAC to identify key factors crucial for optimal urban green space development (Teymouri & Hodjati, 2017). This systematic approach aids in pinpointing critical factors that inform sustainable urban planning and development decisions. MICMAC has been applied in various fields, including supply chain management and healthcare waste management, to analyze relationships between different factors (Ariyani *et al.* 2022); (Thakur 2021). Through MICMAC analysis, researchers can distinguish independent and dependent drivers, offering a comprehensive understanding of system interactions (Bagheri *et al.* 2023). Combining MICMAC with methodologies like Interpretive Structural Modeling (ISM) has been effective in revealing interdependencies and hierarchies among critical success factors for sustainability (Swarnakar *et al.* 2021); (Paul *et al.* 2022)). Moreover, MICMAC has been extended to areas such as lean sustainability in start-ups during the COVID-19 era,

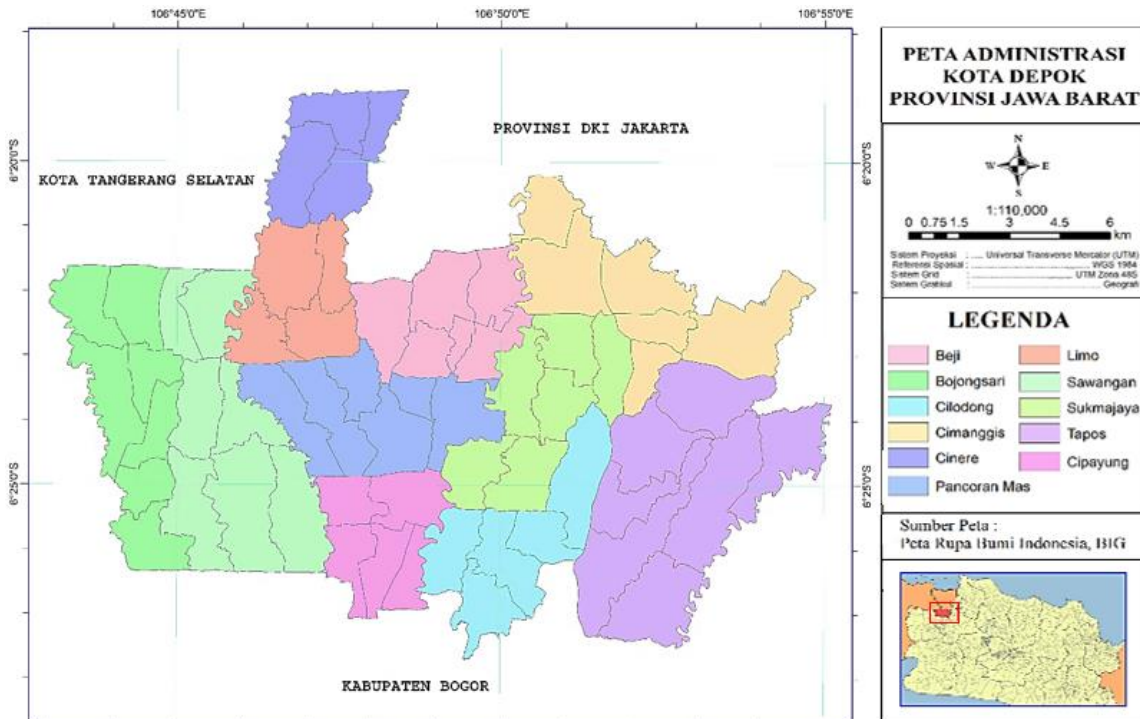


Figure 1. Map of Kota Depok

where it has been used to assess organizations' readiness for sustainable practices (Sreenivasan & Suresh, 2022). By employing MICMAC analysis, researchers can evaluate the preparedness of organizations to adopt lean-sustainability practices, especially amidst challenges posed by the pandemic. In conclusion, MICMAC serves as a valuable tool for analyzing relationships and dependencies among factors, proving instrumental in various research domains, particularly in understanding sustainability complexities and facilitating informed decision-making processes. MICMAC is a structural analysis tool that identifies dependencies between variables using a two-dimensional matrix called the "Structural Analysis Matrix". Structural analysis stages to identify key variables and relationships between variables in urban green space sustainability using the MICMAC approach are carried out in 3 phases:

- i. Arrange a list of variables  
 In this phase, an inventory of the variables that characterize the system in the internal and external environment is carried out. In the initial stage, variables were identified that were considered important for the sustainability of green open space in Kota Depok by conducting literature studies, questionnaires, and in-depth interviews.
- ii. Describing relationships between variables  
 This stage is to build a matrix of pairwise comparison criteria from the results of questionnaire analysis. Initial identification to determine key variables that can change the system by testing the influence and dependence relationship between each variable.

- iii. Identifying key variables  
 In this phase, key variables that are important for system evolution are identified and re-ranked. The result is a mapping of key variables based on two criteria, influence and dependence variables (Figure 2).

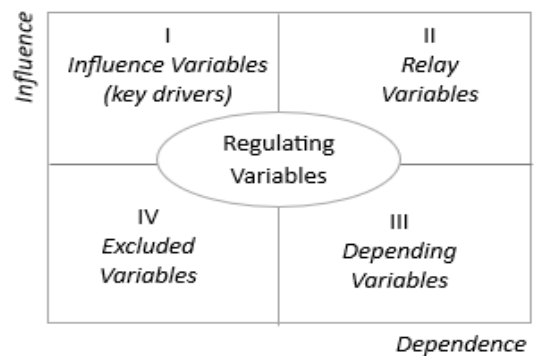


Figure 2. Map of Influence/Dependence Variable

**RESULT AND DISCUSSION**

The identification of variables was conducted through a literature review and in-depth interviews with multiple stakeholders. The sources used in this research were academics, government agencies from the Depok Municipal (such as the Environmental and Sanitation Agency, the Public Works and Spatial Planning Agency, and the Housing and Settlement Agency), as well as non-governmental organizations (NGOs) operating in the environmental sector. The findings on the identification of variables associated with the sustainability of urban green space are displayed in Table 1.

**Table 1.** Contributing Variables

DIMENSION	VARIABLES	SHORT LABEL
Economy	Value of Land	ValLand
	Economic Growth	EcoGrowth
	Resource Allocation and Financial Sustainability	FinAll
Social	Population Density	PopDens
	Community Engagement and Participation	CommPar
	Environmental education and awareness	EnvEdu
Policy	Equitable Access and Social Equity	EquiAccess
	Land Use Policy	LUPolicy
	Law Enforcement	LawEnforce
	Integrity of Stakeholders	Integrity
Ecology	Maintenance and Protection of the Environment	MainProtec
	Biodiversity Conservation	BioConserv

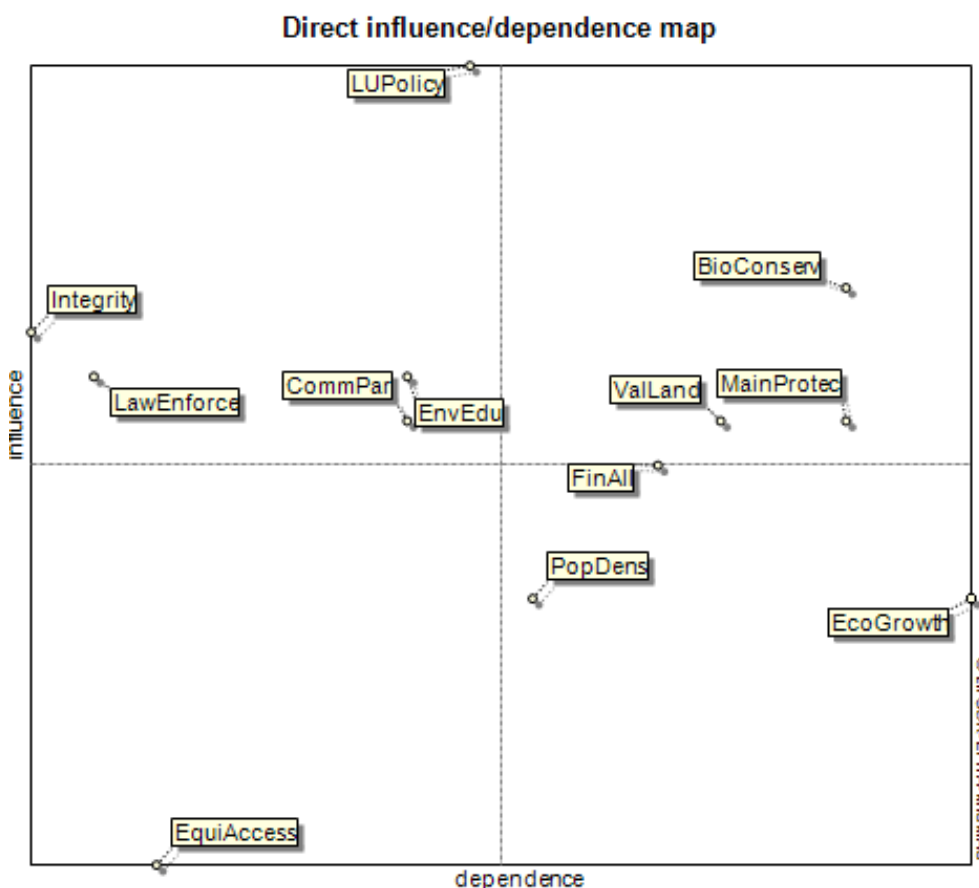
**Table 2.** Matrix Of Direct Influences (MDI)

	1: ValLand	2: EcoGrowth	3: FinAll	4: PopDens	5: CommPar	6: EnvEdu	7: EquiAccess	8: LUPolicy	9: LawEnforce	10: Integrity	11: MainProtec	12: BioConserv
1: ValLand	0	3	2	2	0	0	0	3	0	0	0	0
2: EcoGrowth	3	0	0	3	0	0	0	0	0	0	0	0
3: FinAll	0	0	0	0	0	3	0	0	0	0	3	3
4: PopDens	2	2	0	0	0	0	2	0	0	0	0	0
5: CommPar	2	2	0	0	0	2	2	0	0	0	2	0
6: EnvEdu	0	0	2	0	3	0	2	0	0	0	2	2
7: EquiAccess	0	0	0	0	0	0	0	0	0	0	0	0
8: LUPolicy	3	3	3	3	0	0	0	0	0	0	3	3
9: LawEnforce	0	3	0	0	2	2	0	0	0	2	0	2
10: Integrity	0	2	0	0	2	0	0	2	2	0	2	2
11: MainProtec	1	0	3	0	1	1	0	0	1	0	0	3
12: BioConserv	2	2	2	2	0	0	0	2	0	0	3	0

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Subsequently, the five experts evaluated the link between the selected variables to determine the magnitude of their influence. This assessment is presented in the MDI matrix depicted in Table 2. As a result of mapping the variable desire for urban green space using Micmac software, it is known that there are grouping variables based on the level

of influence and dependence between variables. Several variables are known to have a strong level of influence, so they become key variables or strategy variables related to the desire for urban green space in the research area. The results of the level of direct influence and dependence between variables are presented in Figure 3.



**Figure 3.** Direct Dependence/Influence Map

Figure 3 shows that after taking into account the influence between variables, five variables have a strong level of influence and low dependence (influential variables) and three variables are sectors with strong influence but have high dependence (relay variables). These variables are:

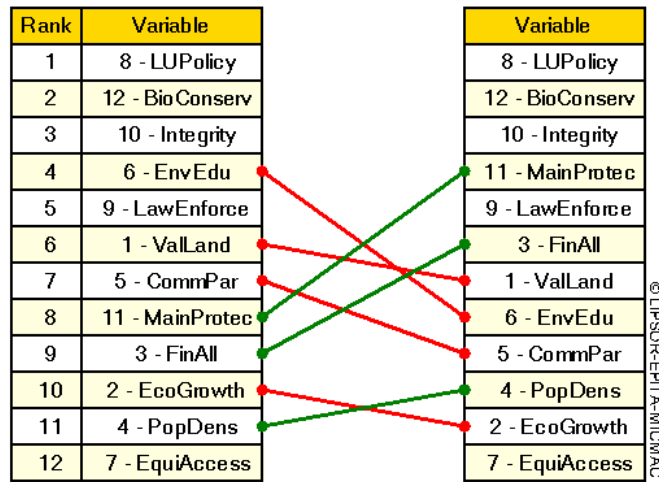
- 1) Land Use Policy, 2) Law Enforcement, 3) Environmental Education 4) Stakeholders Integrity, and 5) Community Engagement and Participation,
- while 1) Biodiversity Conservation, 2) Land Value, and 3) Maintenance and Protection of the

Environment is a variable with a strong influence but high dependence.

The level of influence of a variable can directly change along with the interaction of that variable with other variables. Figure 4. shows that there has been a shift in the position of several variables with indirect influence. This happens because there is a

possibility that the variables influence each other, either directly or indirectly. In ranking the variables, it can be seen that regulations or policies related to land use planning have a very strong influence on maintaining the sustainability of the existence of urban green space.

**Classify variables according to their influences**

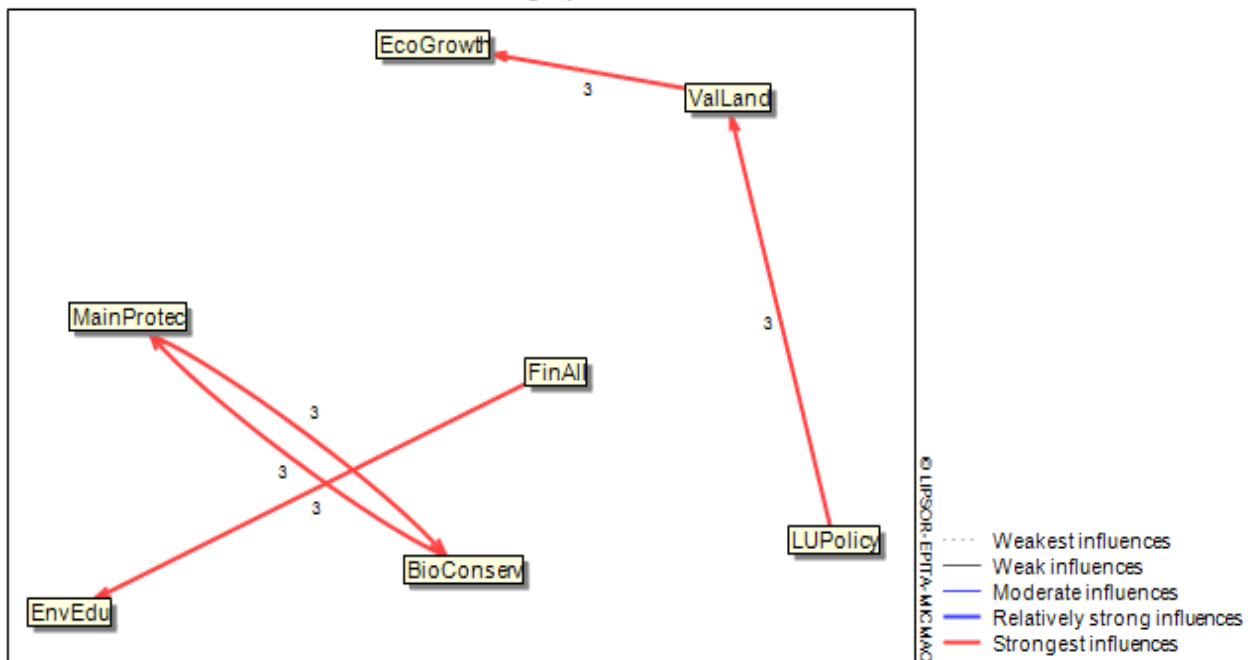


**Figure 4.** Variables Ranking Based On Their Influence

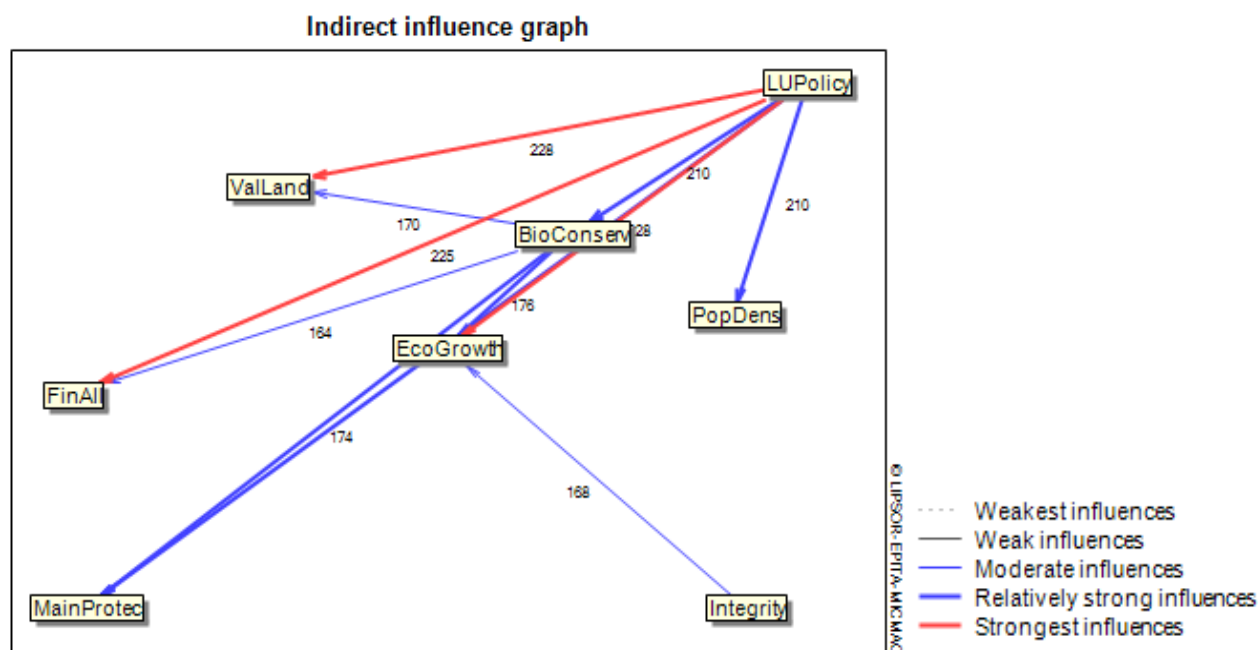
This can be understood because this policy is a guideline used by regional governments in Indonesia to regulate land use and regional development in an integrated and sustainable manner. Then in second place is biodiversity conservation, this is understandable because by integrating conservation principles into the planning and management of urban green space, we can ensure that this rich and valuable biodiversity will be maintained for future generations.

In addition to examining significant characteristics that greatly impact the sustainable management of urban green space, Micmac is capable of illustrating the connections between these variables, as depicted in Figure 5 and 6.

**Direct influence graph**



**Figure 5.** Direct Influence Graph



**Figure 6.** Indirect Influence Graph

Based on this figure, in direct influence graph has been identified that land use policy has a very strong influence on land values, while in indirect influence graph also influence economic growth, and budget allocations for related activities.

## CONCLUSION

Kota Depok transformed into a Municipality in 1999, and due to its proximity to the capital, the city experienced extraordinary physical growth. The transformation of green land into urban areas continues to be carried out to facilitate economic progress and growth. If this continues, the city will experience very serious damage and lose valuable green space for economic purposes.

To maintain the sustainability of the existence of urban green space, it is necessary to take a systematic and structured approach. The application of MICMAC (Matrice d'Impacts Croisés Multiplication Appliquée à un Classement) in the context of urban green space sustainability provides a systematic approach to understanding the factors that influence the success of urban green space conservation and management efforts. All factors involved in this research are considered as a system with interrelated elements and a structure. The Micmac method is then used to test the strength of the relationship between the driving variables (influence/driving power) and the dependency variables (dependence power) in a system.

In this research has been identified that 8 factors out of 12 have a strong level of influence, namely "land use policy, law enforcement, environmental education, stakeholder integrity, community engagement and participation, biodiversity conservation, land value, and maintenance and

protection of the environment". 5 factors out of 8 influence variables become the key variables and the rest are relay variables. Through this research, also been identified from the direct influence graph that land use policy has a very strong influence on land values. Land use policy becomes strategic policy to determine whether developing urban green space is sustainable or not.

The application of MICMAC as a structural approach in studying the sustainability of urban green space makes it possible to formulate more effective and adaptive strategies for maintaining the sustainability of the urban environment. With this approach, we can ensure that urban green space continues to provide ecological, social, and economic benefits for urban communities sustainably.

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