The Role of System Dynamic in Future City Landscape Development Planning (Case: Bogor Municipality)

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Abstract

In complete sense, city development is dynamic and multi-sector phenomena, as consequences of population and economic growth development. In the spatial sense, such city developments were carried on expense of greenery open space. Meanwhile, in such interaction, open space availability occures as a stock-and-flow phenomena in which system dynamic analysis could contribute to solve the problem. A case study in Bogor Municipality was carried out to study how such dynamic phenomena directed toward better open space availability. There were three sub causal loops (sub model) developed in analysis i.e. population growth, economic growth (with regional domestic product) and open space availability (with criteria of open space availability and temperature humidity index). Using the three sub models, system dynamic (sysdyn) analysis was run in three scenario i.e. progressive, sustainable and conservative scenarios. The analysis showed that sustainable scenario with population growth rate of 0.2% and regional domestic product growth of 0.5% give open space area growth of 0.2% per year. Due to pressures of population and economic growth, two other scenarios could not give additional open space area. Combining with geographic information system (GIS), such additional open space areas were plotted spatially.

Keywords: green open space (GOS), city landscape development, stock-and-flow phenomena, system dynamic, landscape management, landscape planning policy.

Introduction

Green open space (GOS) as important landscape element is usually sacrifice for city development. It is converted from time to time for other urban activities, which is indicating that the green open space in urban areas is a dynamic and multi-sector problem. Meanwhile, GOS (Simonds, 1983; Hakim, 2002; Dahlan, 2008) supports:

a. Better ecosystem (particularly orographic and hydrologic) function for Bogor and its downstream (Jakarta)
b. Better climatologic balance: comfort (thermal humidity index, as Wardhani [2006] cited)

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c. Better edaphic function
d. Better ecological function
e. Better aesthetical function
f. Better protective function
g. Better community health function
h. Better educative function

Current policy of GOS management is (1) still partial in which components involved in the urban system is not clearly backwardly and forwardly linked, structured and considered so that the effect caused by a change of one component, as conversion of GOS to other component, as for housing and business district, is not clearly recognized or usually ignored, (2) oversimplified that a city development is reduced as economic-based oriented spatial planning, (3) oversimplified that GOS change is only considered as affected by single (linear) spatial phenomena, (4) static that urban planning is only based on a certain and discrete time consideration. Meanwhile, system dynamic (sysdyn) provide a more dynamic, in which GOS change is perceived as a spatial and non-spatial phenomena of “stock and flow” (Tasrif, 2007). Spatial and non-spatial phenomena in green open space system involve (have relevancy with) phenomena of (1) feed back that important for learning process in policy making, (2) stock (level) and flow (current) that described changes in level of spatial and non spatial phenomena and the rate of flow of them, (3) delay and non-linearity that considered the actual phenomena of the complex system. By such advantage, sysdyn is relevant to support policy making and simulation.

Landscape planning policy in sysdyn sense is defined as direction used for lessening negative gap of expected output, outcome and impact with actual output, outcome and impact in the field within a certain time frame. As other cases in environmental management (Mihalic, 2003), negative impact of city development may outburst by derivation of system, growth and behavior theories, meanwhile policy instruments counteract constructed by the same theories.

Using sysdyn benefits of green OS could be transformed into criteria of objectives, treated as stock and flow phenomena and mapped. This paper offer sysdyn as tools for Bogor Municipality (West Jawa Province) long term GOS planning based on criteria of comfort and space availability for better ecosystem.

In Bogor, a significant decrease of GOS has occurred. It decreased 1.06% during five year period of 2000-2005, decrease from 5,917 ha (in 2000) to 5,791 ha (in 2005, Bappeda, 2007). It might be due to pressures of population increase and economic activities. Statistic (BPS Bogor, 2007) showed that during 1995-2006 population increase significantly (35.7%) from 647.9 thousands (in 1995) to 879.1 thousand (in 2006). This increase demands linearly developed land needs that pressured existing GOS. Therefore a non-linear based policy will be needed. Non-spatial phenomena based policy could be created to slower even in the long run to increase availability of GOS. Example of policies that may be needed by Bogor Government derived from above instruments are compensation of space in a CBD by freeing other GOS in the vicinity area, compensation of development of higher storey building for housing which freeing

GOS, controlling population growth etc, in which such policies intervene natural phenomena of GOS.

The research aimed (1) to elaborate the structure of the green open space model management of Bogor city based on biophysical aspects, social and economy, (2) to develop policy scenarios of green open space management of Bogor city, and (3) to analyze the spatial distribution optimization of green open space of Bogor city. This elaborations are expected (1) to produce a green open space management system design in order to realize Bogor city as a sustainable city, and (2) as a mean for local government to determine the appropriate decisions in formulating policy for green open space management in Bogor city.

Methodology

An analysis of system dynamic (Tasrif, 2007) for GOS planning was applied for Bogor Municipality (distric level), West Jawa Province covering area of 11,850 ha during Feb-Nov 2008. Analysis consist of three procedures i.e. constructing model, describing policy and optimizing spatial distribution of GOS.

Constructing Model

Constructing system dynamic model consists of six steps (Hadi, Omo Rusdiana, Suwarto, 2004) i.e. (1) need analysis in which all actors engage (local government and community) in spatial planning defined, (2) problem identification that started by defining problem needed for testing of policies, (3) system conceptualization in which causal loop diagram interpreted into input-output system, (4) model formulation, (5) model behavior, and (6) model testing. There were three sub causal loops (sub model) developed in this analysis i.e. population growth, economic growth (with regional domestic product) and open space availability (with open space availability and temperature humidity index). Using the three sub models, a system dynamic (sysdyn) analysis application PowerSim was run in three scenarios i.e. progressive, sustainable and conservative scenarios.

Policy Analysis of Open Space Planning

In this stage, models are tested to policy alternative. As stated earlier, negative impact of city development may outburst by derivation of system, growth and behavior theories (Mihalic, 2003), meanwhile policy instruments counteract constructed by the same theories. Common instrument of the policies to redirect or to control natural phenomena particularly stock-and-flow into planned phenomena may be derived from the three theories. Environmental tax, subsidy, negotiation, concession, public investation, fee and contribution, licensing etc are derived from system theory; certification, carrying capacity determination, environmental impact analysis obligation are samples of growth theory; while labeling and landscape information provision are derived from behavior theory.

Proposed GOS Distribution

This analysis was aimed to determined land distribution for GOS development in Bogor Municipality. In general, spatial distribution of such land in this study was determined by selected scenario. Such distributions were redirected to urban open space needed for community and conservation. A criteria elaborated based on topography (slope), soil sensitivity and land cover (Table 1) was established.

Table 1. Land suitability criteria for proposed additional GOS of Bogor

Variable	Weight	Sub variable	Score
Slope		0-8% (flat)	1
	15	8-15% (light steep)	2
		15-45% (steep)	3
		> 45% (too steep)	4
Sensitivity		None	1
	10	Less sensitive	2
		Sensitive	3
		Very sensitive	4
Land cover		Full cover vegetation	1
	15	Medium cover vegetation	2
		Agricultural land	3
		Land for housing and other hardscape	4

Source : Ministry of Agriculture [Deptan] (1980) *in* Yuzni (2009) modified

Result and Discussion

System Dynamic Model of GOS Planning

The first step of contsructing model have identified *stakeholder* enganged in GOS utilization namely district government of Bogor Municipality and the community. The government need GOS (1) sustainably used by its inhabitant, (2) to improve city environmental quality, (3) to control environmental degradation, (4) to increase domestic income. Community need GOS (1) to provide social interaction, and (2) to increase income. All party need GOS existency. Contrary to the need, it is a fact that Bogor GOS decrease 1.06% during 2000-2005, from 5,917 ha (49.93%) in 2000 to 5.791 (48,87%) (Bappeda Bogor, 2007). Such decrease occurs due to increase in population that demand land for housing and business activities. According to statistic of BPS, population increase from 647.9 thousand (1995) to 679.1 thousands (2006). Such decrease in GOS was presumed to degrade urban environment, as increase in temperature due to hard landscape element addition. BMG (climate station in Bogor) reported the increase in temperature. Average temperature increase from 26.73oC (in 2001) to 27.04oC (in 2005). Urban environment will be dominated by hard landscape elements. An master input-output digram (Figure 1) was set up to construct model.

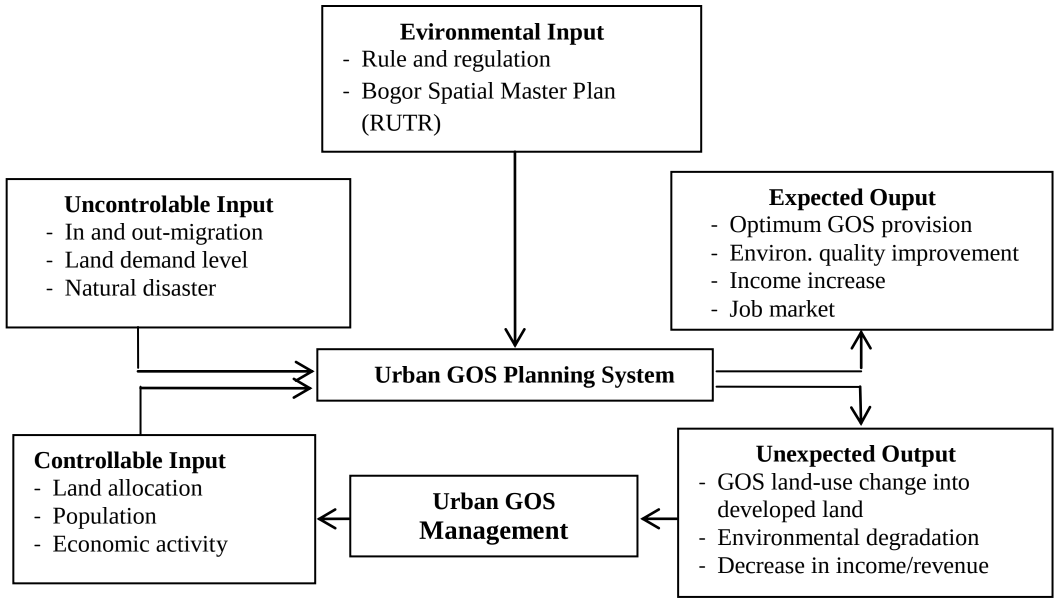


Figure 1. Input-output Diagram of Bogor GOS Planning

In the step of conseptualization a causal loop diagram was contsructed. In this loop , 3 sub zoom (loop) of the loop were identified: population, domestic product (economic activity) and GOS (biophysic). The three sub loop represent vitality aspect (Lynch, 1981) an essential function of a good city. Inshort, in iterative way, increase in population will increase demand on land for housing, services and trading, industry, and social and common facilities. Such demand linearly decrease GOS of the city. Economic activity will attrack people, people will need land that parallel to economic activity need land for development of economic activities. At last such activities will also increase demand for land. The decrease in GOS will increase temperature within certain humidity (RH) that means lower comfortability of the environment. Decrease in GOS will also decrease economic activity due to land availability. Such causal loop then was developed to be model.

For each loop or sub model model (sub zoom) some variables were inputted. In the model of population number of population was inputted. For economic sub-model, domestic products (PDRB) contributed by three sectors (services and trading, industry and agriculture) were inputted. In GOS sub model, two variable were observed and inputted to the sub model. The two variables were GOS and THI (temperature humidity index). For GOS sub model, factors affecting changes in GOS were land utilized for development of physical urban facilities and infrastructures for industries, housing, services, and social and public or common facilities.

In general, formula developed in the three models are as follow:

1. Sub-model of population$_t$

Y_1 (t = T) = Y_1 (t = 0) + $_0\int$ X_1 in-migrate.dt – X_1 out-migrate.dt..(1)

Y_1 (t = T) = present (t = T) population
Y_1 (t = 0) = population starts (t = 0)
X_1 in-migrate.dt = population increase
X_1 out-migrate.dt = population decrease

2. Sub-model of economic

$Y_2 = X_{2A} + X_{2B}$..(2)

Y_2 = Total domestic product (PDRB)
X_{2A} = PDRB of non-GOS activity sectors
X_{2B} = PDRB GOS activity sectors

3. Sub-model of GOS

Y_3 (t = T) = Y_3 (t = 0) + $_0\int^t$ X_3 in-migrate.dt – X_3 out-migrate.dt..(3)

Y_3 (t = T) = present (t = T) GOS area
Y_3 (t = 0) = initial (t = 0) GOS area
X_3 in-migrate.dt = GOS increase
X_3 out-migrate.dt = GOS decrease

THI = (0,8.T) + (RH.T)/500..(4)

THI = Temperature Humidity Index
T = temperature
RH = relative humidity

Above models then were run in application and tested to the actual condition. The testing result showed that the system generated similar result to the actual one (Table 2). By such condition it can be concluded that the structure of the model was valid enough.

Table 2. Simulation Result of Foundation Models

Year	**Population**	**Dom Prod (PDRB) (million rupiah)**	**GOS (ha)**	**THI (°C)**
2000	714.730	1.878.754	5.918	27,09
2005	852.636	2.470.670	5.801	27,08
2010	1.017.151	3.260.695	5.415	2709
2015	1.213.408	4.321.219	4.924	27,12
2020	1.447.533	5.748.424	4.336	27,16
2025	1.726.823	7.673.206	3.634	27,25
2029	1.988.800	9.689.482	2.977	27,38

Policy Analysis

Policy analysis was started by establishing scenarios. Three scenarios were applied for Bogor GOS development simulation. Intervention variables applied are presented in Table 3.

Table 3. Intervention Varibles of Three Scenarios

Sub-model \ Scenario	**Progressive**	**Sustainable**	**Conservative**
Population	Population growth rate increase by 1%	Population growth rate increase by 0,2%	Population growth rate decrease by 1%
Dom product (PDRB)	PDRB increase by 1%	PDRB increase by 0,5%	PDRB decrease by 2%
GOS	No additional GOS	GOS increase 0,2%	No additional GOS

Scenario simulation showed that for all scenarios it is very difficult to maintain GOS existence (Table 4). The most realistic scenario is sustainable scenario. A strong policy should be created to maintain GOS existence. Theoretically, the policy may be derived from three theories namely system, growth and behavior (Mihalic, 2003) for elements presented in Figure 1 i.e. uncontrolable input (in and out-migration; land demand level; and natural disaster) through planning system and unexpected output (GOS land-use change into developed land; environmental degradation; decrease in income/revenue) through GOS management. In the root of system theory, policy instrument as environmental tax for non-GOS development, subsidy and public investation for all GOS development may be applied to redirect or intervent existing phenomena. In the root of growth theory, carrying capacity mapping for all Bogor sectors in Bogor Master Plan (RUTR, Figure 1), environmental impact analysis obligation for all non-GOS development may be applied. GIS and other spatial information system and certified developer authorizing non-GOS development represent policy instruments derived from behavior theory.

Table 4. Result of Three Scenario Simulation on Population, Economic Activity, GOS Availability and Human Comfort (THI)

Variable	year	Scenario		
		Progressive	Sustainable	Conservative
Population	2000	714,730	714,730	714,730
	2029	2, 627,504	1,680,305	1,302,705
PDRB (mi rupiahs)	2000	1,878,754	1,878,754	1,878,754
	2029	12,704,663	10,379,916	7,499,459
GOS availability (ha)	2000	5,918	5,918	5,918
	2029	2,548	3,504	3,504
THI (t in ^{o}C)	2000	27.09	27.09	27.09
	2029	27.44	27.05	27.37

Proposed Additional GOS Distribution

Based on sustainable scenario a GIS map of Bogor is presented (Figure 2). Additional GOS are still needed to improve comfortability (in term of THI), to maintain environmental function and conservation. In general, urban GOS is an important spatial component functions as *biofiltering*, *biocontrolling* and *bioengineering* urban environment (Nurisyah, 2007). As cited by Lynch (1983) regarding history of GOS in world metropolitan, GOS was valued as a sustenance (an aspect of urban vitality) of a city. For Bogor case it had been identified additional GOS needed particularly in administrative village (*Kelurahan*) Kayumanis, Kedung Halang, Mulyaharja, Pamoyanan, Kertamaya, Genteng, Balumbang Jaya, Situ Gede, dan Semplak mostly in northern and southern part of Bogor.

Conclusion and Recommendation

Conclusion

1. Three dynamic perspectives of government and community activities i.e. biophysic, social and economy were valued important and scientifically can be incorporated into model.
2. Sustainable scenario was judged as the most possible scenario giving better GOS and comfortability.
3. GIS analisys showed that at present Bogor need additional GOS distributed particularly in southern and northern part i.e. village (*Kelurahan*) Kayumanis, Kedung Halang, Mulyaharja, Pamoyanan, Kertamaya, Genteng, Balumbang Jaya, Situ Gede, dan Semplak

Recommendation

1. System thinking in complementary with system dynamic is recommended tools to manage and plan a complex phenomena of green openspace development in a model of medium scale city as Bogor.
2. Strong policy should be developed to maintain existing and planned GOS
3. Policy instrument to manage GOS could be derived from theory of system, growth or behavior.

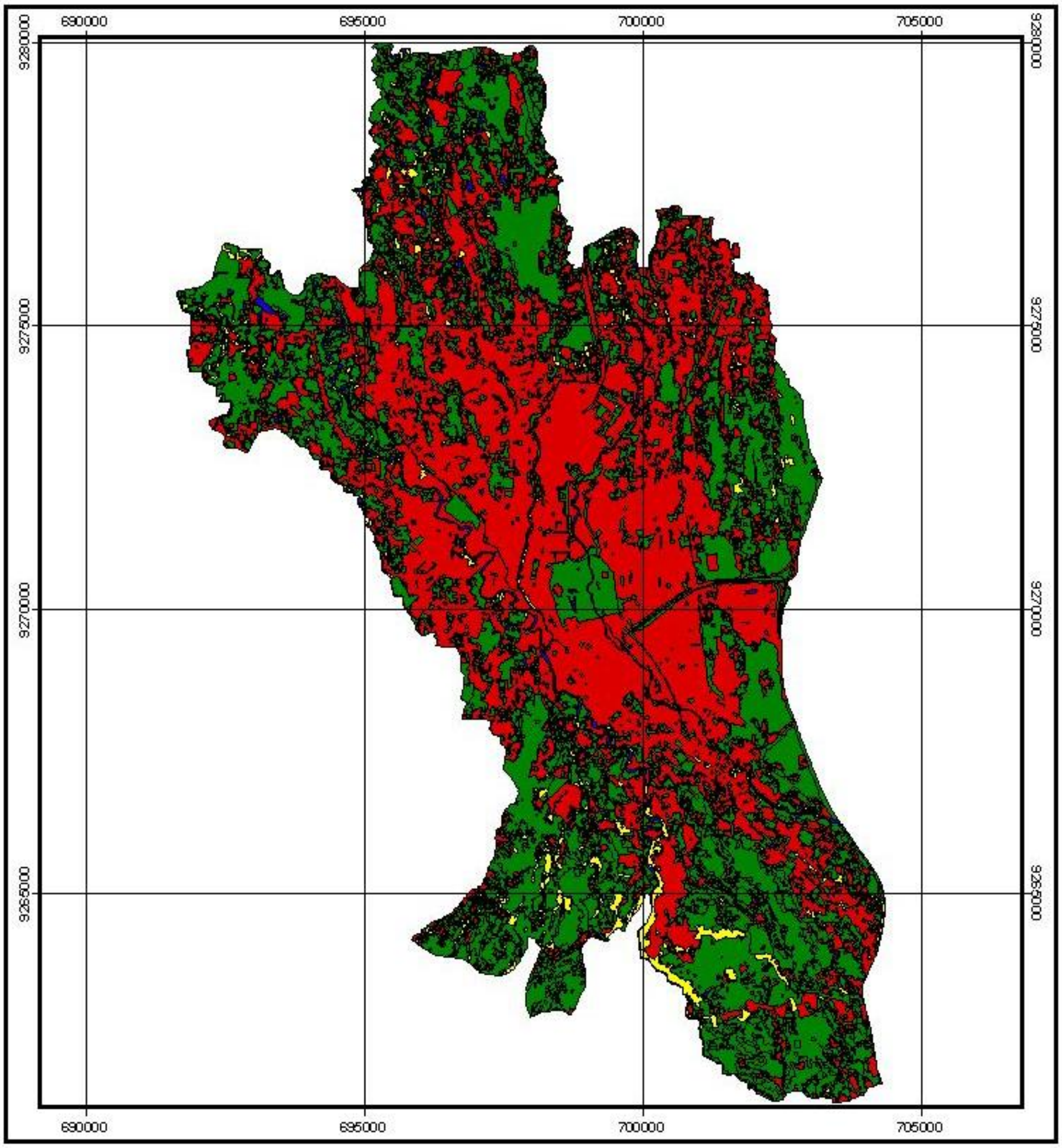
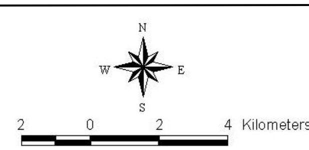


Figure 2 Proposed Green Open Space Distribution of Bogor

LEGENDA

- Water front
- Green open space (GOS)
- Hardscape
- Proposed additional GOS

Orientation map



Source map:
Analysis processed by AC Achsan

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