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Dynamic Of Green Open Space And Temperature Humidity Index In Malang City

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Abstract

Purposes of this study were (1) to contruct structuring model of Green Open Space and Temperature Humidity Index in Malang City, and (2) to design a simulation scenarios of Green Open Space planning policies in Malang City. This study emphasizes the quantitative approach, using software tools modeling with "Powersim Constructor". The study does not ignore the naturalistic paradigm with a qualitative approach through grounded research. Procedure of this study includes (1) the collection, presentation and analysis of data, (2) engineering dynamic models using software Powersim Contructor : system analysis; engineering dynamic models; analysis of several scenarios, (3) development of policy alternatives / engineering model. Based on the structure of the developed model, it is showed that declining trend of Green Open Space in Malang, where at the beginning of the simulation (2010), Green Open Space amounted to 52,598,270 m², whereas at the end of the simulation (2060) only 18,898,531 m². The increase of temperature and decrease of relative humidity have increased Temperature Humidity Index value, in which the results of simulations carried out at the beginning of the year simulation Temperature Humidity Index value 23.82 and increased to 27.53 at the final periode of simulation. Analysis of Green Open Space policies in Malang City formulated three scenarios, namely independent scenario, moderate scenario and sustainable scenario. Simulation results of independent scenario, showed that areas of Green Open Space at the end of simulation only 7,356,628 m² and Temperature Humidity Index value amounted to 33.86 (uncomfortable). In the moderate scenario, the end of simulation Green Open Space amounted to 24,379,079 m² and Temperature Humidity Index value amounted to 26.52 (uncomfortable). While the sustainable scenario showed areas of Green Open Space amounted to 34,521,096 m² and Temperature Humidity Index value amounted to 25.61 at the end of simulation periode (enough comfortable). Sustainable scenario can be used as an effective policy alternatives in planning the Green Open Space *at the Malang City*.

Keywords: *green, space, index, temperature, humidity, scenario*

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I. Introduction

Presence of the *Green Open Space* (GOS) is very important in an urban areas, in addition to functioning as a social facility, also has ecological benefits, health and economic benefits [1, 2, 3]. Development of urban forest landscape for urban green spaces in Indonesia is ideal for comfort activity in urban form, especially with the percentage of 70-80% tree canopy cover [4]. Presence of GOS required by 30% of the total areas based on "Law of The Republic of Indonesia Number 26 /2007 concerning Spatial Management" [5], the proportion can overcome the negative effects that will emerge in the region. Its effects on global warming [6], flooding [7], sinking islands and loss of germplasm that are susceptible to temperature [8]. Quantity GOS is less than ideal proportions, be a problem in the urban areas, because of the development undertaken is not offset by the allocation of GOS. Urban green spaces as an important contributor can be a significant part of sustainable development. Developments of urban green spaces need consider interdisciplinary an integrative approaches such as economic, social, management and planning aspects to improve existing urban green space policies. Sustainable development of cities and development of urban green spaces are very important, since almost half of the world population now live in urban areas where the pace for rural-urban migration and pressure from international migration in developed countries is still high, as most of the immigrants in developed countries live in central or big cities of the country [9].

The complex dynamics of an urban areas suggest any challenges for sustainable development. The urban physical area is continually crowded with many buildings, blocked surfaces, either on the roofs of buildings or the yards. High urbanization and the high pace of social and economic development in Asia resulting from the increase of population in cities, lack of infrastructure, congested traffic, environmental degradation and housing shortage are major issues faced by cities in Asia in their sustainable development [10]. The urban surroundings tend to be economically developed, but the corresponding ecological environments have not been developed. One effect is an increase in ambient temperature leads to the emergence of the urban heat island [11]. Heat island effects, occurs when air above the city is described as the island air with hot surfaces are concentrated in urban areas, the temperature of the air above it goes down to the sub-urban and rural [12, 13, 14]. The concentration of population in certain parts of the city coupled with the industry and trade as well as a dense urban transport causes thermal pollution then form heat island.

GOS help circulate air during the daylight, with the GOS naturally the hot air will be pushed to the top and otherwise on a cold night will fall under the canopy of trees. Tree canopy cover can reduce about 80% of solar radiation and regulate the movement of the wind so as to give the effect of a drop in temperature and the effect of the cool under a tree [15]. GOS as a guarantor of the natural balance, ecologically can accommodate the needs of human life itself, including the natural habitat of flora, fauna, and microbes are required in the human life cycle. The dynamics of temperature and humidity can influence the comfortable. The comfortable is a term used to express the influence of environmental conditions expressed quantitatively through relationships humidity and air temperature is called the Temperature Humidity Index [16, 17, 18, 19, 20]. Purposes of this study were (1) to contruct structuring model of Green Open Space (GOS) and Temperature Humidity Index (THI) in Malang City, and (2) to design a simulation scenarios of green open space planning policies in Malang City.

II. Research Methods

This study emphasizes the quantitative approach, using software tools modeling with "Powersim Constructor" [21, 22, 23, 24, 25, 26, 27, 28]. The study does not ignore the naturalistic paradigm with a qualitative approach through grounded research [24, 29]. Construction analysis approach using constant comparison technique (comparative and critical analysis of data using the array of categories and concepts) [24]. The experiment was conducted in Malang City, East Java, Indonesia. Areas of Malang City is amounted to 110.06 km². The city is located in the highlands which is enough cool, is located at an altitude of between 440-667 m above sea level,and 112.06° - 112.07° east longitude and from 7.06° to 8.02° south latitude, surrounded by : Arjuno mountain, Tengger mountain, Kawi mountain, and Kelud mountain. Implementation of the research for five (5) months (April - August 2012), from literature study, field surveys, data collection, data compilation, and data analysis.

The design of this model to analyze the proportion of green open space in Malang City, to anticipate the rapid changes in land use as a result of population pressure and socio-economic activities of the city. With this model are expected to be obtained equilibrium aspects of ecological, economic, and social sustainability of urban development. Procedure of this study include (1) the collection, presentation and analysis of data,(2) engineering dynamic models using Powersim Contructor software, systems analysis (stakeholder analysis, formulation and manufacturing issues causal loop diagram); engineering dynamic models; analysis of several scenarios : description of the model output to describe the behavior of the model and find the best alternative policy, and (3) the development of alternative policy / engineering model. Engineering of protocols dynamic model includes the concept selection process and the variables that are consistent and relevant to engineered models. Cognitive mapping system with a method of thinking done to develop an abstract model of the real situation. Furthermore, thorough and in-depth review of the assumptions and the consistency of the variables and parameters based on justification experts. Construction phase model that includes an abstract model that was developed is to be represented in a dynamic model, verification and validation of models, structural and functional improvement through simulation. Stages of sensitivity analysis to determine which variables were significant. Variables that are less / no effect in the model are eliminated. Stages of policy analysis: structural or functional intervention model to understand the various alternative scenarios and simulations based on the best policy [26,27,28].

Quantitative analys is comfort index can be seen from the simulation data of air temperature and relative humidity, using the equation introduced by Nievwolt in 1975 [20] : $THI = 0.8T + (T \times RH)/500$, where THI = Temperature Humidity Index, T=Air Temperature (° C), RH=Relative Humidity (%) [13, 16,17,18, 30]. THI =19-23 is declared "comfortable", THI=23-26 is declared "enough comfortable", THI> 26 is declared "discomfort" [31].

III. Results And Discussion

Basically, the city is formed by several elements / components. Urban constituent components are divided into two major components: physical and non-physical. Urban constituent components are basically having a mutual relationship. Therefore, in the process of structuring and management of urban spaces need to pay attention to all components and assume that each of these components are interrelated and are within one system [21, 27, 32]. Green Open Space (GOS) is one of the constituent components of the town whose existence is strongly influenced by the other constituent components. Therefore, to optimize the arrangement of GOS also need to pay attention to all the components. The population continues to grow, cause increased demand for settlement / housing and public facilities / social, so the impact on the reduction of green open space of the city [11, 27, 33, 34]. The increased of economic activity caused demand for development of trade/services and industry land so increased, then availability of GOS becomes of diminishing [10, 27, 35]. With increasing population, the need of vehicles are also increasing. Increased of vehicles, causing increased air temperature and relative humidity decrease, resulting in decreased environmental comfort [21, 27, 36, 37]. Relationship between GOS and THI in Malang City can be seen in Figure 1.

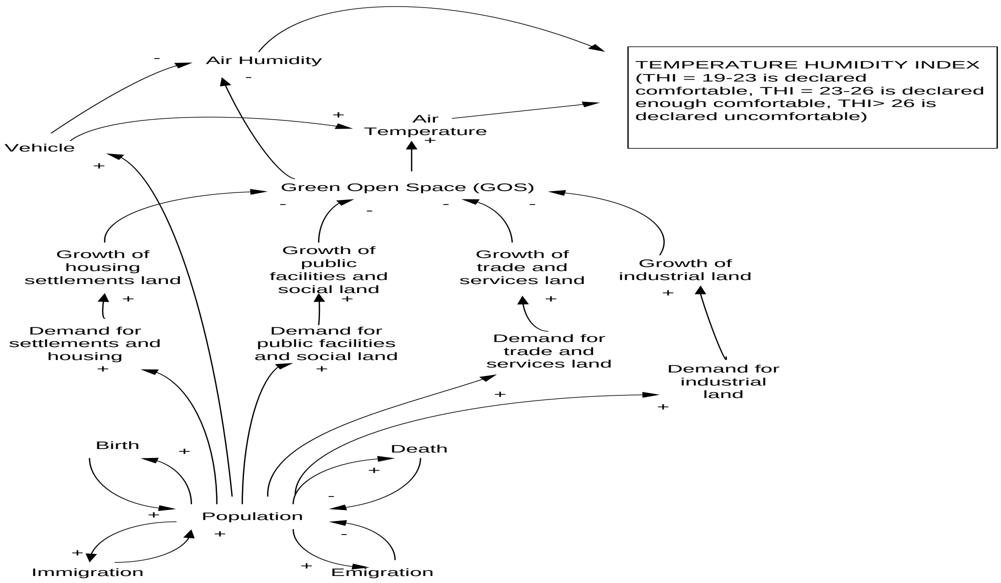

Figure 1.Causal Loop Diagram "The Dynamics of GOS and THI in Malang City"

Input - Output Diagram of *Green Open Space* Planning in Malang City can be seen in Figure 2.

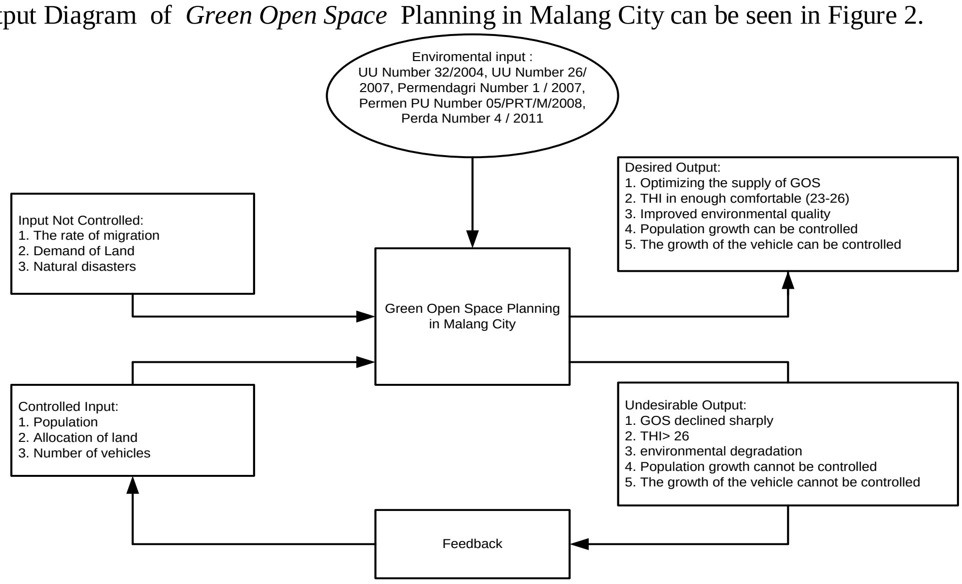

Figure 2. Input-Output Diagram of GOS Planning in Malang City

Structuring Model of GOS and THI in Malang City can be seen in Figure 3.

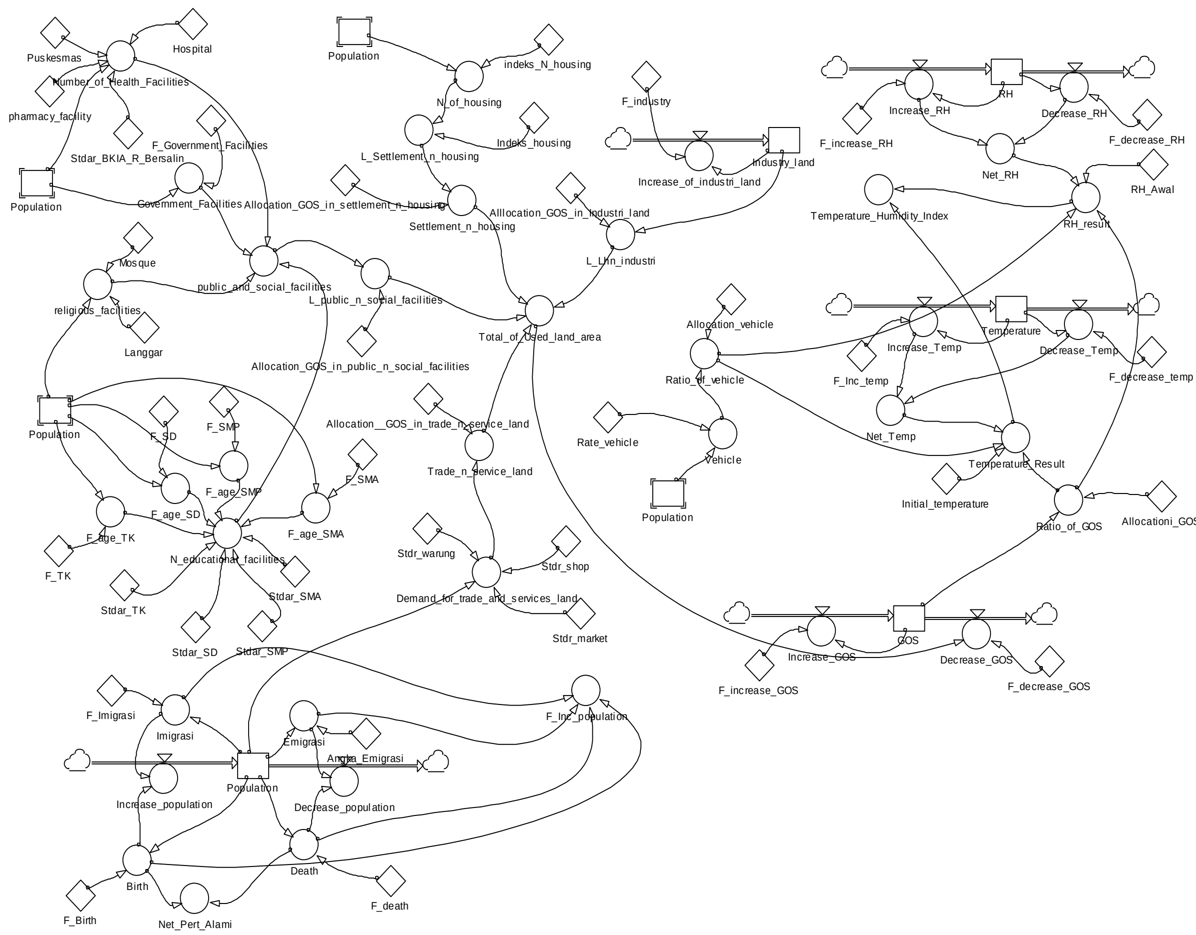

Figure 3. Structuring Model of GOS and THI in Malang City

The simulation results (Table 1) showed GOS in Malang City, where at the beginning of the simulation (2010), GOS in Malang City amount to 52,598,270 m², whereas at the end of simulation (2060) amount to 18,898,531 m². The air temperature at the beginning of simulation amount to 24.70°C and increased to 28.81°C in the final simulation. Relative humidity (RH) at the beginning of the simulation amount to 82.23% and decreased to77.88% in the end of simulation. The increase of air temperature and decrease of relative humidity cause increased THI values, where the results of simulations carried out at the beginning of the year simulation THI value 23.82 and increased to 27.53 in the final periode of simulation.

Table 1. Dynamics Simulation Results of Population, Vehicles, GOS and THI in Malang City

Year	Population (people)	Vehicles (unit)	GOS (m²)	T (°C)	RH (%)	THI
2010	820,243	410,121	52,598,270	24.70	82.23	23.82
2020	940,174	470,087	47,635,266	24.95	80.77	23.99
2030	1,077,641	538,820	41,915,993	25.32	79.69	24.29
2040	1,235,207	617,603	35,319,348	25.89	78.90	24.80
2050	1,415,812	707,906	27,702,901	26.85	78.32	25.69
2060	1,622,825	811,412	18,898,531	28.81	77.88	27.53

Basically GOS has many functions especially with regard to the environmental aspects. One function of GOS is the ability to reduce the air temperature. The low percentage of GOS in the city, so the air temperature is higher. Otherwise, the high percentage of GOS, so the air temperature will getting lower [19, 38]. High air temperatures and low relative humidity will decrease the environmental comfort in Malang City [16, 17, 39]. Analysis of GOS planning policies in Malang City are formulated into three scenarios, namely (1) independent scenario, (2) moderate scenario, and (3) sustainable scenario.

Table 2. Scenarios of GOS Planning Policy in Malang City

Variable	Independent	Moderate	Sustainable
Population	Population growth rate increased by 1.1%	Population growth rate decreased by 0.5%	Population growth rate decreased by 0.8 %
Allocation of green open space in settlement areas/housing	-	5%	20%
Allocation of green open space in industry areas	-	5%	20%
Allocation of green open space in trade/ services areas	-	5%	20%
Allocation of green open space in public areas and social facilities	-	5%	20%

(1) Independent Scenario

In this independent scenario, determined an increase in the number of people going out of control and the rapid decline of the GOS. GOS is reduced caused by demand of the settlement land, trade / services, industrial, public and social facilities, which are not controlled.

Table 3. Dynamics Simulation Results of Population, Vehicles, GOS and THI in Independent Scenario

Year	Population (people)	Vehicles (unit)	GOS (m²)	T (°C)	RH (%)	THI
2010	820,243	410,121	52,598,270	24.70	82.23	23.82
2020	1,047,320	523,660	47,387,427	24.99	80.49	24.01
2030	1,337,261	668,630	40,723,626	25.44	79.30	24.39
2040	1,707,470	853,735	32,201,054	26.23	78.48	25.10
2050	2,180,168	1,090,084	21,300,328	27.89	77.90	26.66
2060	2,783,729	1,391,864	7,356,628	35.46	77.48	33.86

In this independent scenario, conditions Malang City is declared "uncomfortable" because the value of THI at the end of the simulation periode (year 2060) amount to ***33.86.***

(2) Moderate Scenario

In the moderate scenario, increase of population are relatively controlled. Land convertion rate has increased, but not too much effort to improve any existing GOS.

Table 4. Dynamics Simulation Results of Population, Vehicles, GOS and THI in Moderate Scenario

Year	Population (people)	Vehicles (unit)	GOS (m²)	T (°C)	RH (%)	THI
2010	820,243	410,121	52,598,270	24.70	82.23	23.82
2020	894,818	447,409	47,985,962	24.93	80.91	23.98
2030	976,174	488,087	42,917,100	25.26	79.91	24.25
2040	1,064,926	532,463	37,337,379	25.74	79.15	24.67
2050	1,161,748	580,874	31,183,154	26.48	78.57	25.35
2060	1,267,373	633,686	24,379,079	27.73	78.13	26.52

In the moderate scenario, conditions Malang City is declared ***"uncomfortable"*** because the value of THI at the end of the simulation period (year 2060) amount to ***26.52 .***

(3) Sustainable Scenario

In sustainable scenario, increasing the number of people considered to be relatively restrained. The utilization rate of land for the development of socio-economic activities have increased, but attempted to allocate GOS in residential land, industrial land, public and social facilities, trades and services land. With the provision of GOS, it is expected that optimal environmental quality of Malang City in accordance with the standards of comfort.

Table 5. Dynamics Simulation Results of Population, Vehicles, GOS and THI in Sustainable Scenario

Year	Population (people)	Vehicles (unit)	GOS (m²)	T (°C)	RH (%)	THI
2010	820,243	410,121	52,598,270	24.70	82.23	23.82
2020	868,559	434,279	49,688,587	24.90	81.03	23.96
2030	919,722	459,861	46,462,914	25.17	80.10	24.17
2040	973,899	486,949	42,887,780	25.54	79.38	24.49
2050	1,031,267	515,633	38,923,266	26.04	78.82	24.94
2060	1,092,015	546,007	34,521,096	26.76	78.38	25.61

The simulation results with the sustainable scenario, showing the value of THI resulting increased from 23.82 (2010) to ***25.61*** at the end of the simulation (2060). The ideal level of comfort that in this case represented by the THI in tropic climate is the value of THI = 19-23 is declared “comfortable”, THI = 23-26 is declared "enough comfortable", THI> 26 is declared "uncomfortable" [31]. In this *sustainable scenario* in Malang City conditions is declared ***" enough comfortable ".***

Comparison of "D*ynamics Simulation Results of Independent, Moderate and Sustainable Scenario*" can be seen in Figure 4.

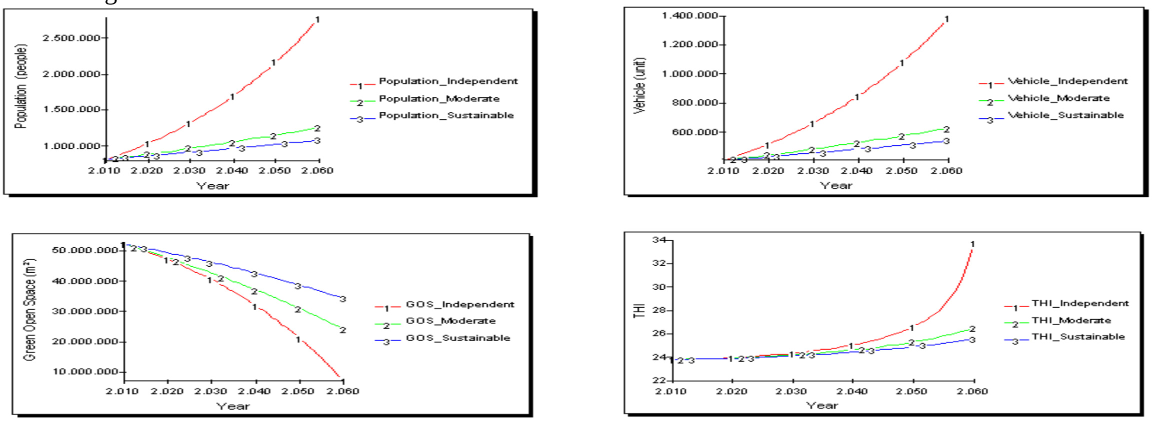

Figure 4. Comparison of "Dynamics Simulation Results of Population, Vehicle, GOS and THI "
(Independent, Moderate and Sustainable Scenario)

From results of the three scenarios, the sustainable scenario is considered able to accommodate the requirement GOS Malang City in real term until 2060, and even in that year target of 30% GOS are still fulfilled, because GOS amounted to ***34,521,096 m²*** (***31.3 %*** of the areas of Malang City) . "Law of The Republic of Indonesia Number 26 /2007 concerning Spatial Management" [5], mandates the proportion of Green Open Space in a urban region must be at least thirty percent (30%) of the urban, which is filled with good plants that grow naturally or are deliberately planted. Sustainable development is not just to maximize the development of the city with the development of the means and physical infrastructure of a modern city but also must be able to maintain the quality and sustainability of urban environment through the provision of optimal GOS. To meet socio-economic, environmental, psychological needs of urban dwellers, there should develop some criterion based on the attitudes of perceived user to shape adequate uses of land and provide facilities within urban green spaces in cities [40]. Planning authorities were advised to adopt a strategic approach and plan positively for providing green spaces. This was to provide strong protection for existing ones, resist new development opportunities which might diminish recreational provision, ensure accessibility, and to provide good quality green spaces and recreational facilities [41]. The principle of sustainable development requires a harmony between the pace of development activities with the carrying capacity (carrying capacity) of the natural environment [21, 27]. The quality depends on how the city of urban green space is planned, managed and protected [9, 42].

IV. Conclusion

Areas of GOS in Malang City tend to decrease, at the beginning of the year simulation (2010), areas of GOS Malang City amounted to 52,598,270 m², whereas at the end of simulation (2060) decreased to 18,898,531 m². Air temperature has increased, which in the early years of air temperature simulations in Malang City is 24.70 ºC and increased to 28.82 ºC at the end of simulation. Relative Humidity (RH) at the beginning of the simulation is 82.23% and decreased to 77.88% at the end of simulation. The increase of temperature and decrease of relative humidity have increased THI (Temperature Humidity Index) value, in which the results of simulations carried out at the beginning of the year simulation THI value ***23.82*** and increased to ***27.53*** in the final periode of simulation. Analysis of GOS policies in Malang City included three scenarios, namely independent scenario, moderate scenario and sustainable scenario. Simulation results of independent scenario, showed that areas of GOS at the end of simulation only 7,356,628 m² and THI value amounted to 33.86 (uncomfortable). In the moderate scenario, the end of simulation GOS amounted to 24,379,079 m² and THI value amounted to 26.52 (uncomfortable). While the *sustainable scenario* showed areas of GOS amounted to ***34,521,096 m²*** and THI value amounted to ***25.61*** at the end of simulation periode ***(enough comfortable).*** *Sustainable scenario* can be used as an effective policy alternatives in planning the green open space at the Malang City.

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