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Green Open Space Scenarios in Reducing CO_2 Emissions in Malang City, Indonesia: A Dynamic System Approach

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Abstract: Purposes of this study were (1) to contruct model of Green Open Space as sequester CO_2 emissions in Malang City, and (2) to design scenarios of Green Open Space policies in order to optimize the absorption of CO_2 emissions in Malang City. This study envolved the quantitative and qualitative approaches, using modeling software tools of "Powersim Constructor". Procedures in this study included (1) the collection, presentation and analysis of data, (2) developing dynamic models by using software of Powersim Contructor : system analysis; developing dynamic models; evaluating several scenarios, (3) development of policy alternatives model. Based on the developed model, it is suggested that declining trend of Green Open Space (GOS) in Malang city; at beginning of simulation periode (2010), areas of GOS about to 5,259.83 ha, whereas at the end of simulation periode (2060) only 1,940.56 ha. Absorption of CO_2 emissions about 158,620.98 tons/year at 2010, and decreased to 78,976.37 tons / year at 2060. This was due to the significant decreasing of GOS areas in Malang City. CO_2 emissions continue to increase, which at the beginning of simulation periode (2010) amounted to 124,630.06 tons/year and increased to 677,651.20 tons / year at the final periode simulation (2060). CO_2 emissions increase annually in line with the increasing number of vehicles in Malang City. The increasing number of vehicles and fuel oil consumption result in the CO_2 emissions. The Addition of trees population in Malang City as many as 28,491 trees (2016), and at the end of the simulation (2060) must be about 3,508,743 trees. Policy analysis model of GOS in Malang City formulated three scenarios, namely independent, moderate and sustainable scenario. Simulation results of the independent scenario, showed that areas of green open space at the end of simulation periode (2060) only 587.83 ha (with total CO_2 emissions amounted to 1,020,768.97 tons / year, the absorption of C02 emissions by 32,997.29 tons / year, and the addition of trees population about 5,785,882 tree). The moderate scenario suggested that at the end of simulation periode (2060) the Green Open Space areas about 2,028.30 ha (with total CO_2 emissions amounted to 391,930.80 tons / year, the absorption of CO_2 emissions by 132,694.84 tons / year, and the addition of trees population about 1,518,477 tree). While the sustainable scenario showed the areas of Green Open Space about 3,324.14 ha (the total CO_2 emissions of only 283,035.18 tons / year, the absorption of CO_2 emissions amounted to 183,574.93 tons / year, and the addition of trees population about 582,589 tree). With the increase of land coverage of urban trees, a more amount of CO_2 are absorbed, and the residual of CO_2 emissions getting lower. The recommended ways in reducing CO_2 emissions in Malang City are : saving fuel oil (diesel fuel and gasoline fuel), restriction ownership of private vehicles, especially motorcycles and private cars, efforts to use LPG, improving qualities of existing public transportation systems. The sustainable scenario can be implemented as an effective policies in development of urban GOS in Malang City.

Keywords: *green open space, CO_2 emissions, dynamic model*

I. INTRODUCTION

City as a gathering place for residents experiencing rapid growth due to their special attractions for the surrounding rural population. Urban development is usually followed by the provision of many properties and facilities [1]. Over time, the city will arise various problems due to the imbalance between needs of residents and urban environmental capacity [2]. Urban population growth is always followed by accretion land built up in the city [3,4]. According to Suryantoro [5] rapid changes in urban landuse can lead to many difficulties in controlling urban spatial structure, so as to result in urban spatial mismatch. This resulted in the use of urban land in any physical development and a lot of land surfaces are covered by the pavement displacing the green open spaces. In almost all cities in Indonesia, residential and business interests are the top priorities, especially demand of land for buildings significantly increase. These conditions suggested that any piece of urban lands must be used in meaningful ways and managed as efficiently as possible. This resulted in the emergence of the phenomena that in any time an urban green open space (GOS) can be converted into others more economically uses [6]. Tendency of rapid physical development results in a scarcity of urban green open spaces [1, 2, 7, 8].

In Indonesia, approximately 70% of urban air pollution have been caused by vehicles emissions. Vehicles produce any harmful substances with any negative impacts, for human and environmental health [9, 10]. The increase in CO_2 concentration is caused by the increasing consumption of fuel oil, coal, and other organic fuels in many human activities. In some cities, the quality and quantity of green space continues to decline, so that CO_2 emissions increase [10,11]. Excessive release of CO_2 emissions into the atmosphere causing greenhouse gas levels in the atmosphere rise, resulting in an increase of greenhouse effects and warming effects [12, 13, 14]. It is impacted on global warming [14], flooding [15], extreme climate [16], the losses of small island ecosystems and losses of germplasm which are susceptible to the temperature changes [17]. Therefore, the CO_2 in the air should be sought not growing up; one of the ways is to reduce CO_2 emissions in urban areas by developing any urban forests [18, 19].

Use of energy derived from petroleum are generally the most widely used as a fuel in urban areas in the form of gasoline and diesel fuels [19, 20]. Rate of fuel consumption or fuel oil depending on the number and types of vehicles. Economic growth will affect the level of social welfare and public consumptive patterns. In terms of transportation, the public is increasingly looked to private vehicle transportation thereby increasing the population and activities of motor vehicles, especially motorcycles. This behavior brings any negative effects such as traffic's congestion and urban air pollution [21]. Traffic congestion due to the high number of vehicles causing an air pollution because vehicles can not operate at optimum fuel usage (vehicle speed that produces minimum emissions), resulting in less efficient combustion and produces more exhausted gases [9,13].

Each member of the household suggest any activities that may affect its daily mobilities. Urban communities tend to prefer a personal vehicle rather than using public transport , it due to the facts that any public transport systems have not been able to provide any good transporting services. These conditions resulted in the couple decided to use private vehicles (cars and motorcycles) in supporting any personal mobilities [22]. In addition, for the convenience factor has become the basis of public private vehicle to buy a car or motorcycle. The ease of such advances and cheap mortgage provided by the vehicle distributors [23,24]. The transport sector has been the largest consumer of petroleum followed by the industrial sectors due to surge in the number of motor vehicles. The increasing number of vehicle emissions resulted in a significant contributor in urban air pollution [25].

Purposes of this study were (1) to contruct model of Green Open Space as sequester CO_2 emissions in Malang City, and (2) to design scenarios of Green Open Space policies in order to optimize the absorption of CO_2 emissions in Malang City.

II. RESEARCH METHODS

This study involved both of qualitative and quantitative approaches, using modeling software of "The Powersim Constructor" [1, 2, 26, 27, 28, 29, 30]. The naturalistic paradigms were implemented through any qualitative approaches [31, 32]. Construction analysis involved the constant comparison technique (comparative and critical analysis of data using the array of categories and concepts). The research activities were conducted in Malang City, East Java, Indonesia. Areas of Malang City is about 110.06 km², it is located in the highlands which is the air is cool, its altitude 440 - 667 m above sea level, its latitude 112.06° - 112.07° east and 7.06° - 8.02° south; it is surrounded by the Arjuno mountain, Tengger mountain, Kawi mountain, and Kelud mountain. Research activities were taken place for seven months (Mei 2012 - November 2012).

Model was designed to analyze proportion of green open space in Malang City, to anticipate rapid changes of landuse as a result of a high pressure of urban population and socio-economic activities of the city. With this model are expected to be obtained equilibrium among the ecological, economic, and social aspects in the sustainable urban development. Data analysis included (1) collection, presentation and analysis of data, (2) developing a dynamic model using Powersim Contructor software, systems analysis (stakeholder analysis, formulation and manufacturing strategic issues); (3) scenarios simulation: description of the model output and behavior of model and find the best alternatives; and (4) developing the alternative management policies.

Model construction included the abstract model that was developed and represented in the dynamic model, verification and validation of models, structural and functional improvement through simulations. Sensitivity analysis was conducted to determine the "significancy" of variables. Variables that are "not significant" are eliminated from the model. Policy analysis involved any structural or functional intervention model to evaluate various alternative scenarios in obtaining the best alternative policy [1, 2, 26, 30].

To find out how much carbon dioxide emissions resulting from the city activities, it is estimated the CO2 emissions [11, 33, 34, 35]. Emission factor is used to get the value of carbon dioxide by weight magnitudes are assessed, such as gasoline and diesel. Factor for the calculation of carbon dioxide emissions in this study were obtained through the study of literature.

CO2 emission factors for gasoline fuel, diesel fuel, LPG (liquefied petroleum gas) are presented in Table 1.

Table 1. Fuel Emission Factor in Calculating CO_2 Emission

No	Fuel Type	CO_2 Emission	Unit
1	Gasoline fuel	2,31	Kg/liter
2	Diesel fuel	2,68	Kg/liter
3	LPG fuel	1,51	Kg/Kg

Analysis of CO_2 absorption was conducting to obtain informations about bthe capacity of urban GOS in absorbing CO_2. Approach which is used in estimating the CO_2 uptake is the vegetation coverage of landsurface. The ability of urban vegetation and urban tree in absorbing CO_2 are diverse. The GOS suggests a variety types of vegetation who have a diverse capacity in absorbing CO_2. The dominant types of urban vegetation are urban trees, shrubs and grassland, and urban agriculture. The CO_2 absorption capacity of the urban vegetation are diverse [36, 37, 38, 39], it is presented in Table 2.

Table 2. CO_2 Absorption of the Vegetation Type

Vegetation type	CO_2 Absorption	
	(kg/ha/hour)	(tons/ha/year)
Tree	129,92	569,07
Shrublands	12,56	55
Grassland	2,74	12
Agriculture	2,74	12

GOS areas required (with tree cover) = Residual CO_2 Emissions / CO_2 Absorption with tree cover.
Its assumption : Coverage areas of tree canopy = 0.0003 ha; The number of trees that must be lived in the city = GOS area required / (0.0003).

III. RESULTS AND DISCUSSION

System identification is a chain of relationships between the statement of needs with a specific statement of problems that must be solved to meet those needs [26, 40]. This identification processes can be presented in the form of the causal loop diagram. This diagram suggests any expressions of interaction between the system elements which results in the system performance. All of the components of urban system are basically linked interrelations. Therefore, in the process of structuring and managing the urban GOS, all of components should be considered and it is assumed that each of these components are interrelated in one system [1, 2, 29, 41]. The urban GOS is one of elements of the urban system whose existence is strongly influenced by the others element of urban development. To optimize arrangements of green spaces, all of the elements should be involved . Model of Green Open Space in Absorbing CO_2 Emissions in Malang City is presented in Figure 1.

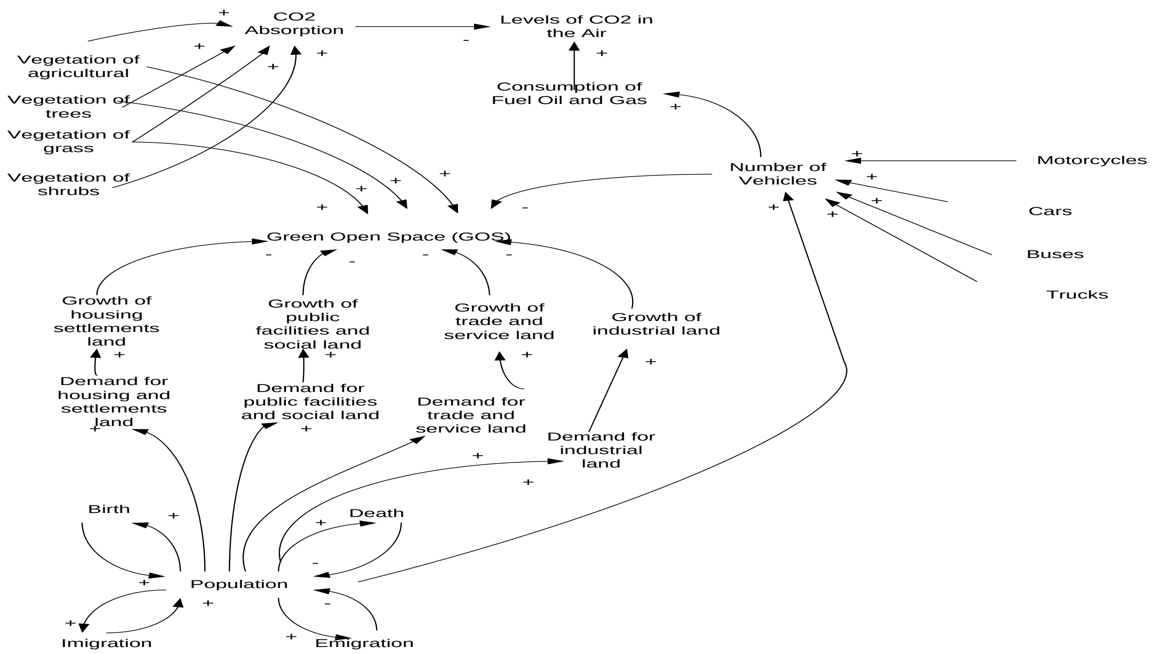


Figure 1. Causal Loop Diagram " Model of Green Open Space in Absorbing CO_2 Emissions in Malang City"

Population is a very important aspect in the planning and management of the city system, many environmental problems are related to the population problems. Population of Malang City continues to increase from year to year. The increasing number of people, results in the increasing need of the residential lands, housing and public facilities land, it is impacted on the reduction of GOS areas in Malang City [1, 2, 7, 42, 43]. Urban economic activities resulted in the need of land for trade services and industrial activities, and it induced any conversion of the existing GOS [1, 2, 44]. Vehicles are the important tools in supporting people mobilities. Therefore, increasing urban population have created demand of vehicles, especially motorcycles and private cars. It is also triggered by the behavior of urban family who have more than one or two motor vehicles. The increase number of vehicles, resulting in the increasing demand of fossil fuels. High demand for these fuels, causing the increase of gasoline and diesel consumption. Gasoline and diesel fuels consumption is the largest contributor to the increase of CO_2 emissions in Malang City. The relationship between input and output in "Model of Green Open Space in absorbing CO2 Emissions in Malang City" is presented in Figure 2.

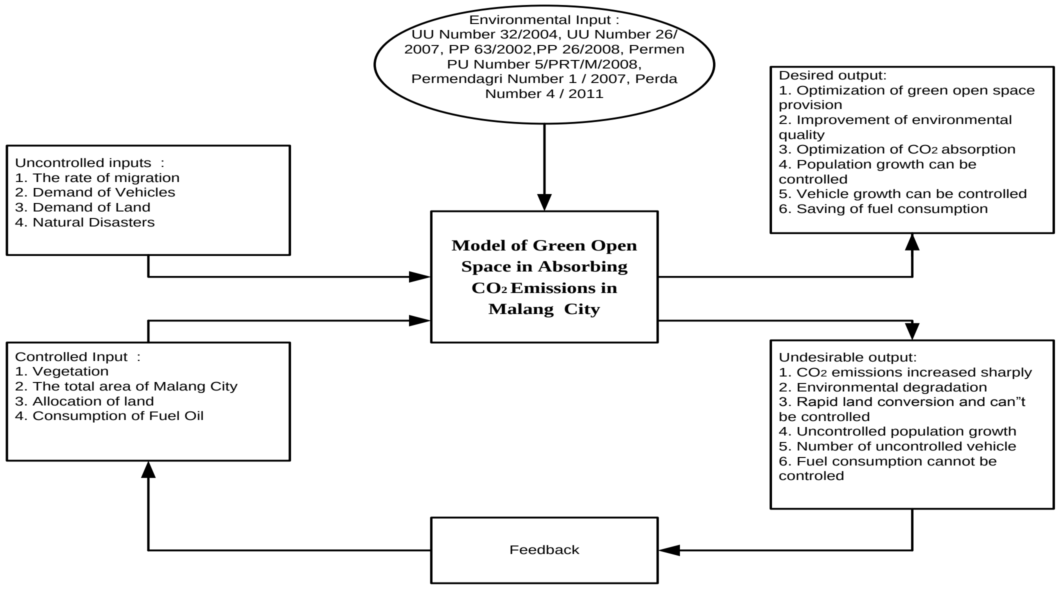
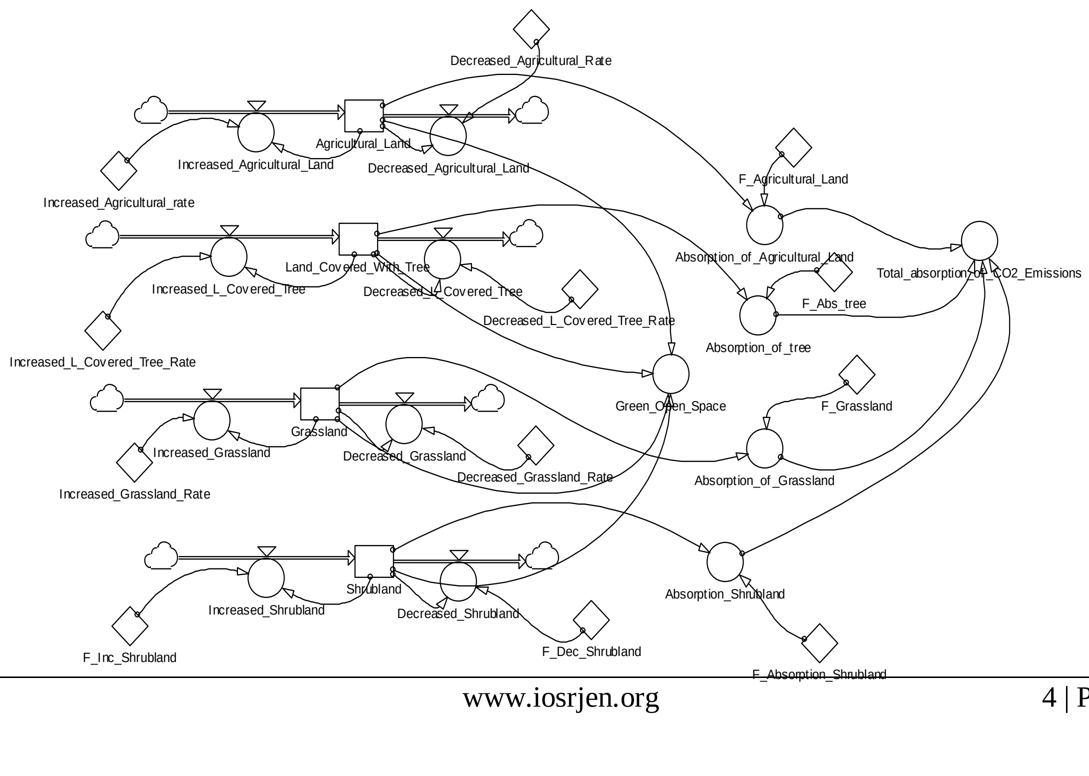
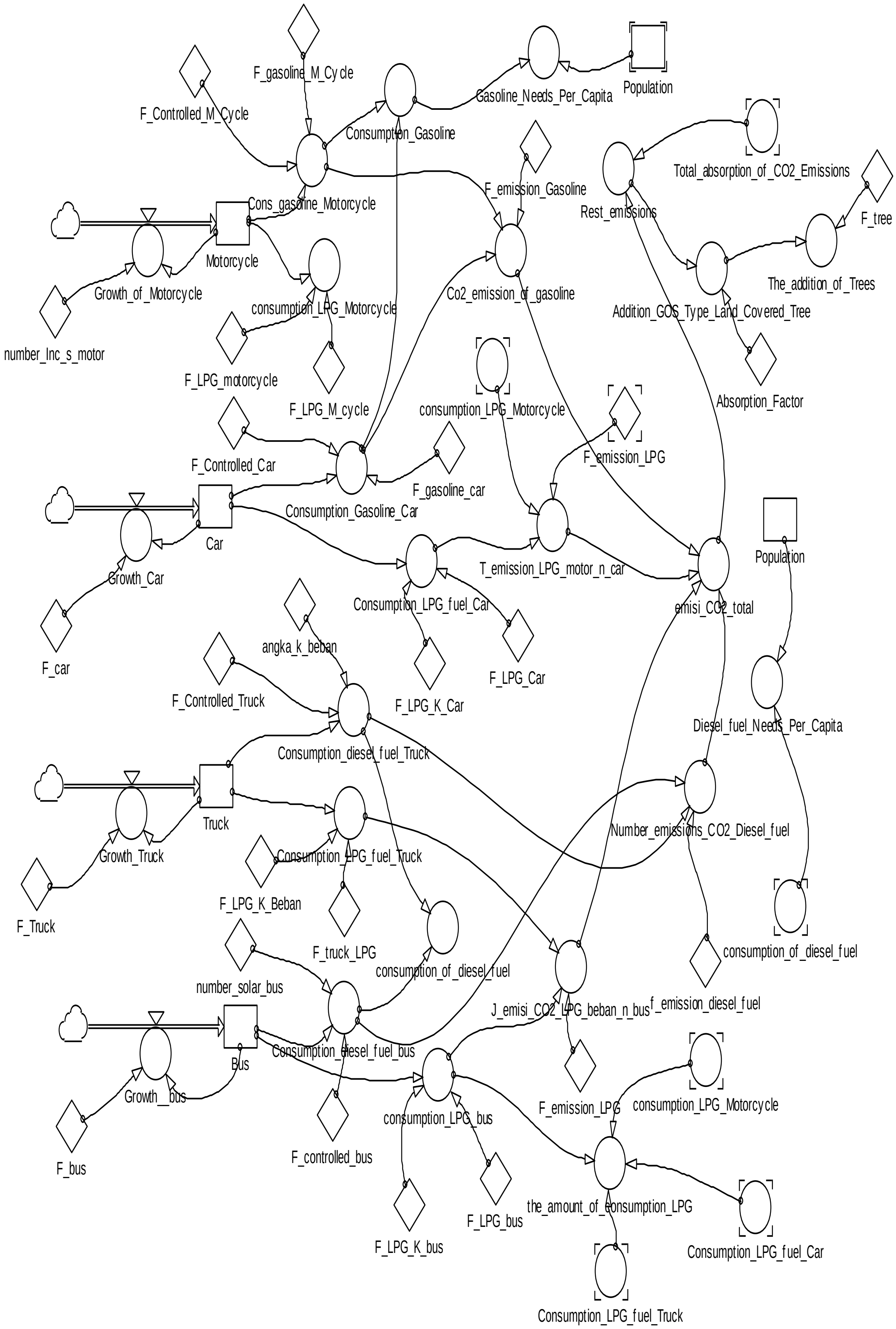


Figure 2. Input-Output Diagram "Model of Green Open Space in Absorbing CO_2 Emissions in Malang City"

Flowchart of "Model of Green Open Space in Absorbing CO_2 Emissions in Malang City" *using Powersim Constructor* is presented in Figure 3.

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F_Controlled_M_Cycle
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Gasoline_Needs_Per_Capita
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F_emission_Gasoline
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Absorption_Factor
F_Controlled_Car
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F_emission_LPG
Consumption_Gasoline_Car
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F_car
angka_k_beban
F_LPG_K_Car
F_LPG_Car
F_Controlled_Truck
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Diesel_fuel_Needs_Per_Capita
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Growth_Truck
Consumption_LPG_fuel_Truck
Number_emissions_CO2_Diesel_fuel
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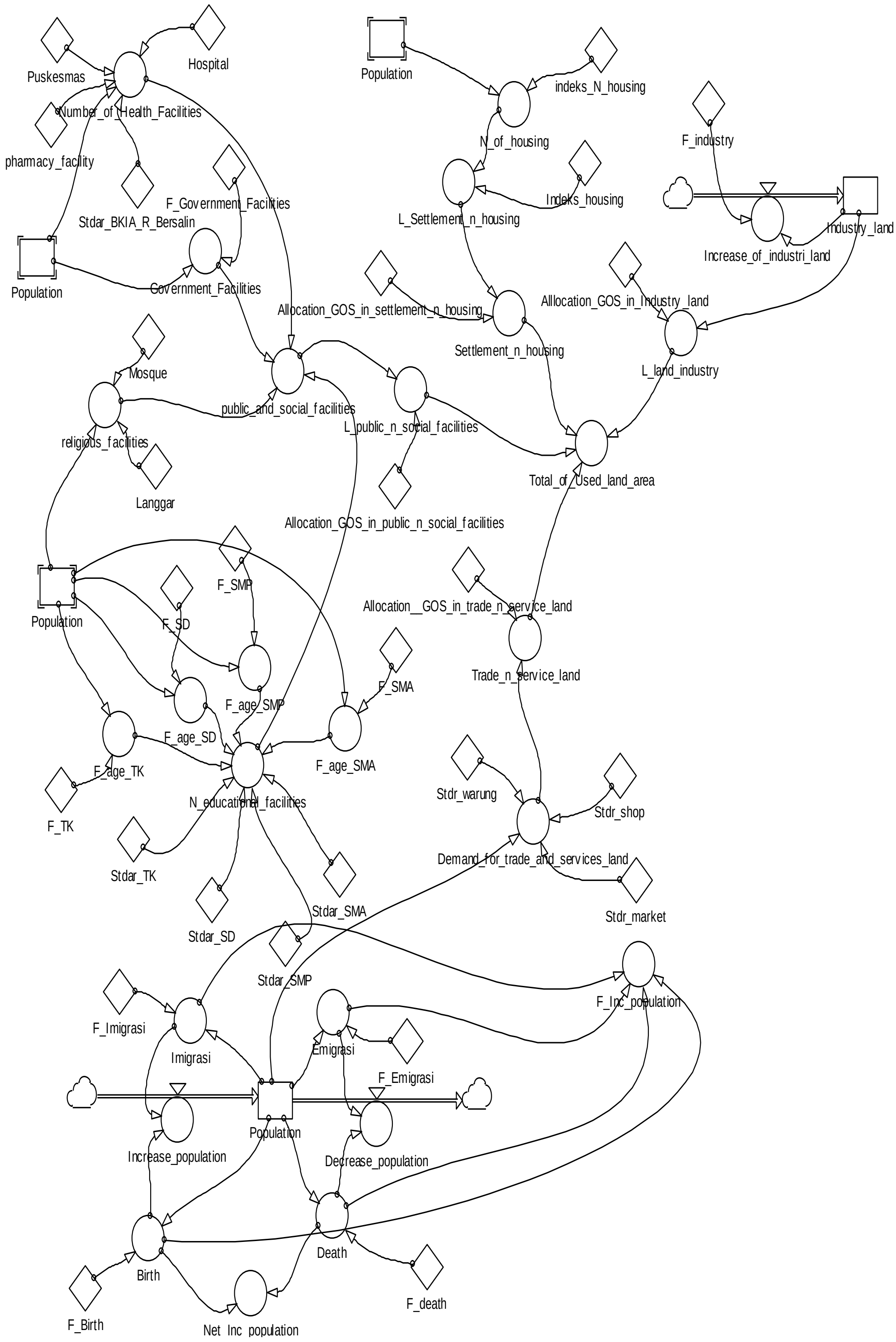


Figure 3. Flow Chart of " Model of Green Open Space in Absorbing CO_2 Emissions in Malang City" *using Powersim Constructor*

Analysis of model is to understand system behavior as a result from assumptions in the model. Understanding of this model behavior is performed by using "Powersim Constructor" software, which describe the behavior of all variables in model with respect to time.

Table 3. Dynamic Simulation Results of Land Cover (Agriculture Land , Tree Coverage of Land, Grasslands, Shrublands)

Year	Agriculture Land (ha)	Tree Coverage of Land (ha)	Grasslands (ha)	Shrublands (ha)	Total Urban GOS (ha)
2010	2,617.09	143.71	2,139.80	359,23	5,259.83
2020	2,116.63	129.97	1,748,37	308,84	4,303.81
2030	1,711.87	117.54	1,428.55	265.52	3,523.48
2040	1,384.52	106.30	1,167.23	228,28	2,886.33
2050	1,119.76	96.14	953.71	196.26	2,365.87
2060	905.63	86.94	779.25	168.73	1,940.56

Based on the results of simulation model (Table 3), agriculture land are reduced significantly, at the beginning of the simulation (2010) about 2,617.09 ha and then declining to 905.63 at the end of the simulation (2060). For "tree coverage of land", at the beginning of simulation (2010) amount to 143.71 ha and declining to 86.94 ha in the end of simulation periode (2060). Shrublands and grasslands also decreased significantly. Development of settlements activities, trade and service activities, public and social facilities, and industrial activities are continuously growing, it results in any losses of GOS in Malang City. The high activities of civil construction sector in Malang City resulting in declining the urban GOS.

Table 4. Growth of Motor Vehicles (Motorcycles, Car, Truck, Bus) in Malang City

Year	Population (people)	Motorcycles (unit)	Cars (unit)	Trucks (unit)	Bus (unit)
2010	820,243	337,826	57,766	13,879	650
2020	840,174	500,065	62,557	18,652	691
2030	1,077,641	740,218	67,745	25,067	735
2040	1,235,207	1,095,704	73,364	33,687	782
2050	1,415,812	1,621,909	79,449	45,273	832
2060	1,622,825	2,400,822	86,039	60,844	885

The simulation results (Table 4) showed that an increasing number of vehicles from the beginning to the end of the simulation periode in line with the urban population growth. In the motorcycle increases sharply at the start of the simulation (2010) of 337,826 units and increase become to 2,400,822 units by the end of the simulation (2060). The population of cars also increased, which at the beginning of simulation (2010) amounted to 57,766 units and increased to 86,039 at the end of simulation (2060). Number of trucks at the beginning of the simulation (2010) amounted to 13,879 units and increased to 60,844 unit at the end of the simulation periode (2060). Number of buses at the beginning of the simulation (2010) amounted to 650 unit, become to 885 unit at the end of the simulation periode (2060). Economic growth affects level of social welfare and public consumptive patterns. In terms of transportation, the population of private vehicles increase significantly, especially motorcycles. It results in any negative effects of urban congestions and air pollution [21, 25].

Traffic congestion due to the high number of vehicles causing an increase of air pollution, because any vehicles can not operate at optimum fuel usage (vehicle speed that produces minimum emissions), and inefficient combustion of fules produces a more emissions [9, 13]. The people tend to prefer a personal vehicles rather than public transport, it due to the bad services of the existing "public transport systems". Moreover, the ease of having a private vehicles, a motorcycle or car; it is easy to get credit for vehicles [23, 24].

Table 5. CO_2 Emissions Generated by The Gasoline and Diesel Fuels.

Year	Gasoline fuel comsumption (liter)	Diesel fuel comsumption (liter)	The amount of CO_2 Emissions Gasoline fuel (tons/year)	The amount of CO_2 Emissions diesel fuel (tons/year)	Total of CO_2 Emissions (tons/year)
2010	45,335,800.00	7,427,000.00	104,725.70	19,904.36	124,630.06
2020	62,517,949.66	9,844,690.09	144,416.46	26,383.77	170,800.23
2030	87,571,014.24	13,085,155.43	202,289.04	35,068.22	237,357.26
2040	124,243,378.33	17,430,806.71	287,002.20	46,714.56	333,716.77
2050	178,080,947.71	23,261,144.86	411,366.99	62,339.87	473,706.86
2060	257,290,181.37	31,086,149.74	594,340.32	83,310.88	677,651.20

Simulation result (Table 5) showed the total of CO_2 emissions are increased, where at the beginning of simulation (2010) amounted to 124,630.06 tons/year increased to 677,651.20 tons/year at the end of simulation (2060). The transport sector has been the largest consumer of oil fuel, followed by the industrial sector. emissions of vehicles exhaust from burning fuel into a significant contributor to air pollution. At Malang

City has been no use of fuel gas for vehicles. Fuel consumption in transportation activities contribute CO_2 pollutants in the environment [10, 11, 19, 45, 46].

Table 6. Dynamics of CO_2 Absorption (agricultural land, tree coverage of land, grassland, shrubs)

Year	CO_2 Absorption of Agricultural Land (tons/year)	CO_2 Absorption Tree Coverage of Land (tons/year)	CO_2 Absorption of Grasslands (tons/year)	CO_2 Absorption of shrublands (tons/year)	Total of CO_2 Absorption (tons/year)
2010	31,405.04	81,780.48	25,677.58	19,757.88	158,620.98
2020	25,399.57	73,960.80	20,980.45	16,986.45	137,327.27
2030	20,542.50	66,888.82	17,142.56	14,603.77	119,177.64
2040	16,614.23	60,493.05	14,006.72	12,555.30	103,669.30
2050	13,437.15	54,708.83	11,444.51	10,794.18	90,384.66
2060	10,867.61	49,477.69	9,351.00	9,280.08	78,976.37

From Table 6 showed the absorption of CO_2 are decreased, where at the beginning of the simulation (2010) amounted to 158,620.98 tons / year, and decreased to 78,976.37 tons / year at the end of simulation (2060). Total of CO2 Emissions are increased, beginning at year 2016, there was a crisis the absorption of CO_2 emissions, and remaining emissions amount to 7,257.59 tons / year. This happened due to the lack of green open space in the ability to absorb CO_2 emissions, while CO_2 emissions increased each year in line with the increased of vehicles in Malang City. To neutralize CO_2 emissions produced of vehicles require the addition of green open space by "tree coverage of land". Result of the simulation, the addition of trees population began in 2016 as many as 28,491 trees, and increased at the end of the simulation (2060) as many as 3,506,743 trees [10, 11, 19, 21].

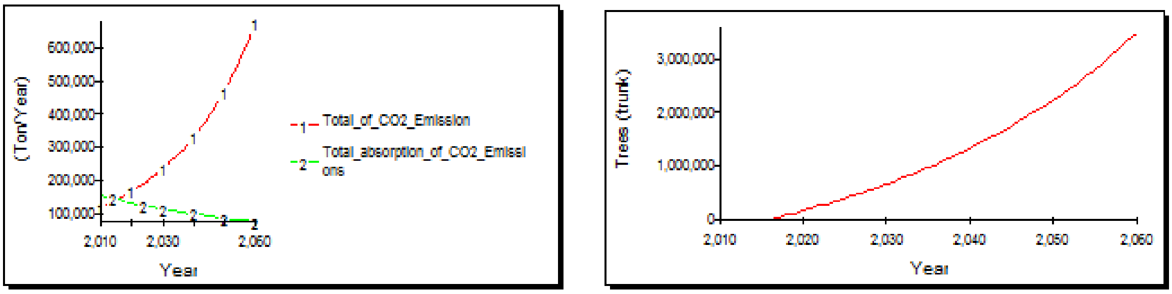


Figure 4. CO_2 Emissions, CO_2 absorption, and population of urban tree.

Policy analysis is performed by the change of parameters and then observed their output. It is intended to understand model behavior when any parameters are changed. Policy analysis is also intended to understand patterns of change in policy or external factors that is included into the system. In the analysis of this policy are suggested effects of parameters changes. Implementation of policy analysis are formulated into three scenarios : (1) independent scenario, (2) moderate scenario, and (3) sustainable scenario.

Table 7. Policy Scenarios for " The Model of Green Open Space in Absorbing CO_2 Emissions in Malang City"

Variable	The Independent Scenario	The Moderate Scenario	The Sustainable Scenario
Vehicles			
- Motorcycle	Growth rate increased by 1 %	Growth rate decreased by 1 %	Growth rate decreased by 2 %
- Car	Growth rate increased by 1 %	Growth rate decreased by 0,2 %	Growth rate decreased by 0,1 %
- Truck	Growth rate increased by 1 %	Growth rate decreased by 0,2 %	Growth rate increased by 0,5 %
- Bus	Growth rate increased by 1 %	Growth rate decreased by 0,2 %	Growth rate increased by 2 %
GOS			
- Agricultural land	Growth rate decreased by 3 %	Growth rate decreased by 1.5 %	Growth rate decreased by 2 %
- Tree	Growth rate decreased by 1.5 %	Growth rate increased by 1.5 %	Growth rate increased by 2 %
- Grassland	Growth rate decreased by 2 %	Growth rate increased by 1 %	Growth rate increased by 2.3 %
- Shrubs	Growth rate decreased by 1.5 %	Growth rate decreased by 0.5 %	Growth rate increased by 1 %
Saving Fuel Oil	10%	20%	30%
Using of LPG	10%	20%	30%

(1) The Independent Scenario

In this independent scenarios, the number of vehicles are not controlled and the conversion of urban GOS (agriculture lands, urban tree population, grasslands and shrublands) are relatively numerous. The losses of

GOS is due to the high demand of residential lands, trade and services center, industrial location, public facilities; these demand are uncontrolled. The increasing of vehicles number and its fuels consumption is not controlled, so the CO_2 emissions are very high. In this scenario, efforts suggested are any savings of fuels usage about 10% and the use of LPG about 10%.

Table 8. Simulation Results of the Independent Scenario (Dynamics of GOS, Consumption of Gasoline Fuel, Consumption of Diesel Fuel, Consumption of LPG, Total of CO_2 Emission, CO_2 Absorption, and The Addition of Trees Population)

Year	GOS areas (ha)	Consumption of Gasoline Fuel (liter)	Consumption of Diesel Fuel (liter)	Consumption of LPG (kg)	Total of CO_2 Emission (tons/year)	CO_2 Absorption (tons/year)	The Addition of Trees Population (trunk)
2010	5,259.83	40,802,220.00	6,684,300.00	2,638,140.00	116,150.64	158,620.98	0
2020	3,349.61	61,954,076.65	9,760,179.06	3,984,125.32	175,287.23	113,736.20	360,535
2030	2,146.39	95,527,713.22	14,289,832.63	6,100,974.77	268,178.24	82,405.47	1,088,165
2040	1,384.35	149,163,154.87	20,967,348.38	9,451,694.63	415,031.44	60,263.50	2,078,056
2050	898.93	235,271,614.24	30,819,434.47	14,782,835.93	648,395.59	44,443.94	3,537,711
2060	587.83	374,029,495.09	45,365,034.67	23,299,696.10	1,020,768.97	32,997.29	5,785,882

Simulation results of the Independent Scenario showed that declining of GOS is very sharply, where at the beginning of the simulation (2010) amounted to 5,259.83 ha, and decreased to 587.83 ha at the end of simulation (2060). The absorption of CO_2 emissions are decreased, at the beginning of the simulation (2010) amounted to 158,620.98 tons / year, decreased to 32,997.29 tons / year at the end of the simulation (2060). Meanwhile, gasoline consumption increased from 40,802,220 liter / year at the beginning of the simulation (2010) up to 374,029,495.09 liters / year at the end of the simulation (2060). Consumption of the diesel fuel is increased from 6,684,300 liters / year at the beginning of the simulation (2010) to 45,365,034.67 liters / year at the end of the simulation (2060). LPG consumption increased from 2,638,140 kg / year at the beginning of the simulation (2010) up to 23,299,696 kg / year at the end of simulation (2060). With the increasing number of vehicles, it will be followed by increasing of gasoline fuel, diesel fuel, and LPG consumption . The CO_2 emissions increased from 116,150.64 tons / year (2010) to 1,020,768.97 tons / year (2060). In order to minimize effects of environmental pollution caused by CO_2 emissions, it would be required a high coverage of urban tree in Malang City. The addition of trees population at the beginning of simulation (2010) is to near zero, it is rising up to 5,785,882 trees at the end simulation periode (2060).

(2) The Moderate Scenario

In the Moderate Scenario, increase of the vehicles is controlled. Land conversion rate has increased, however not enough efforts in improving the existing GOS. In this scenario, efforts to save fuels usage about 20% and the using of LPG about 20%.

Table 9. Simulation Results of the Moderate Scenario (Dynamics of GOS, Consumption of Gasoline Fuel, Consumption of Diesel Fuel, Consumption of LPG, Total of CO_2 Emission, CO_2 Absorption, and The Addition of Trees Population)

Year	GOS (ha)	Consumption of Gasoline Fuel (liter)	Consumption of Diesel Fuel (liter)	Consumption of LPG (kg)	Total of CO_2 Emission (tons/year)	CO_2 Absorption (tons/year)	The Addition of Trees Population (trunk)
2010	5,259.83	36,268,640.00	5,941,600.00	2,662,515.00	107,671.23	158,690.98	0
2020	4,193.57	46,133,120.23	7,723,967.01	4,006,337.54	137,433.26	147,094.27	0
2030	3,405.84	59,229,328.08	10,068,617.16	6,120,372.71	176,883.63	139,636.10	218,177
2040	2,816.89	76,658,793.14	13,154,186.68	9,467,501.46	229,287.23	135,205.86	551,086
2050	2,370.82	99,901,267.87	17,216,118.23	14,794,127.13	299,017.03	133,066.52	972,058
2060	2,028.30	130,944,766.98	22,564,727.72	23,305,373.21	391,930.80	132,694.84	1,518,477

Simulation results of the Moderate Scenario showed that declining of GOS is a fairly restrained, where at the beginning of the simulation (2010) amounted to 5,259.83 ha, and decreased to 2,028.30 ha at the end of the simulation. The absorption of CO_2 emissions are decreased, at the beginning of the simulation (2010) amounted to 158,690.98 tons/year decreased to 132,694.84 tons/ year at the end of simulation (2060). Meanwhile, gasoline consumption increased from 36,268,640 liters/year at the beginning of the simulation (2010) up to 130,944,766.98 liters/year at the end of simulation (2060). Consumption of the diesel fuel is increased from 5,941,600.00 liters/ year at the beginning of the simulation (2010) up to 22,564,727.72 liters/year at the end of the simulation (2060). LPG consumption increased from 2,662,515 kg / year at the beginning of the simulation (2010) up to 23,305,373.21 kg /year at the end of the simulation (2060). With the increasing number of vehicles, it will be followed by increasing of gasoline, diesel, and LPG consumption. The CO_2 emissions increased from 107,671.23 tons / year (2010) to 391,930.80 tons / year (2060). In order to minimize effects of environmental pollution caused by CO_2 emissions, it would be required a high coverage of urban tree in Malang City. The addition of trees population at the beginning of simulation (2010) is to near zero, it is rising up to 1,518,477 trees at the end simulation periode (2060).

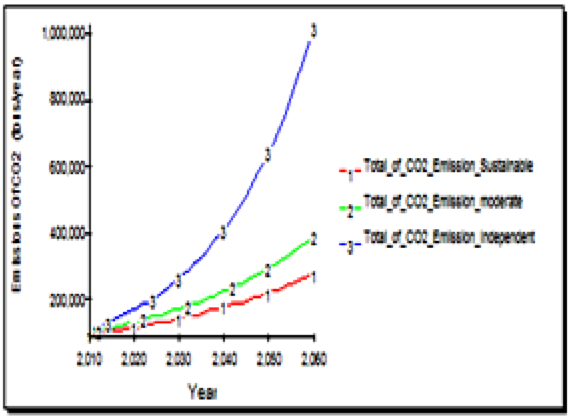
(3) The Sustainable Scenario

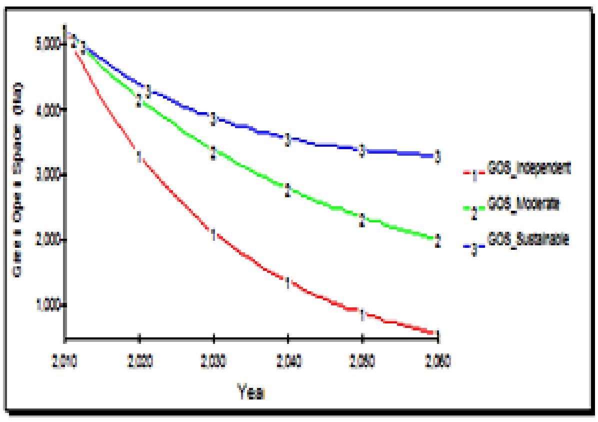
In this sustainable scenario , increase of the vehicles number is loosely restrained. Land utilization rate also increased and it is relatively loose restrained, not too much conversion of existing GOS in Malang City. In this scenario, the important efforts are to save fuels usage by 30% and to use LPG about 30%.

Table 10 Simulation Results of the Sustainable Scenario (Dynamics of GOS, Consumption of Gasoline Fuel, Consumption of Diesel Fuel, Consumption of LPG, Total of CO_2 Emission, CO_2 Absorption, and The Addition of Trees Population)

Year	GOS (ha)	Consumption of Gasoline Fuel (liter)	Consumption of Diesel Fuel (liter)	Consumption of LPG (kg)	Total of CO_2 Emission (tons/year)	CO_2 Absorption (tons/year)	The Addition of Trees Population (trunk)
2010	5,259.83	31,735,060.00	5,198,900.00	2,686,890.00	99,191.81	158,620.98	0
2020	4,427.17	37,498,076.77	7,294,165.04	4,050,208.76	120,662.41	156,249.46	0
2030	3,905.13	44,437,420.85	10,238,115.32	6,190,021.01	147,780.03	158,518.62	0
2040	3.589.15	52,804,506.83	14,375,787.96	9,571,084.04	182,243.15	164,263.59	105,315
2050	3,410.53	62,905,360.17	20,192,878.91	14,942,232.31	226,316.51	172,759.42	313,711
2060	3,324.14	75,112,544.34	28,373,198.36	23,511,738,94	283,035.18	183,574.93	582,589

Simulation results of the Sustainable Scenario showed the losses of GOS is loosely controlled, where at the beginning of the simulation (2010) amounted to 5,259.83 ha, and decreased to 3,324.14 ha at the end of the simulation (2060). The absorption of CO_2 emissions are increased, at the beginning of simulation (2010) amounted to 158,620.98 tons/year increased to 183,574.93 tons/ year at the end of the simulation (2060). The increasing of CO_2 absorption because there was any attempts to plant any urban tree in a piece of land. Meanwhile, gasoline consumption increased from 31,735,060 liters / year at the beginning time of simulation (2010) to 75,112,544.34 liters/year at the end of simulation (2060). Consumption of the diesel fuel is increased from 5,198,900 liters/year at the beginning of the simulation (2010) up to 28,373,198.36 liters/year at the end of the simulation (2060). LPG consumption increased from 2,686,890 kg / year at the beginning of the simulation (2010) up to 23,511,738,94 kg / year at the end of simulation (2060). With the increasing number of vehicles, it will be followed by increasing of gasoline fuel, diesel fuel, and LPG consumption. The CO_2 emissions increased from 99,191.81 tons/year (2010) to 283,035.18 tons/year (2060). In order to minimize effects of environmental pollution caused by CO_2 emissions, it would be required a high coverage of urban tree in Malang City (19, 38, 39, 47]. The addition of trees population at the beginning of simulation (2010) is to near zero, it is rising up to 582,589 trees at the end simulation periode (2060). Results of the independent, moderate and sustainable scenarios are presented in Figure 5.





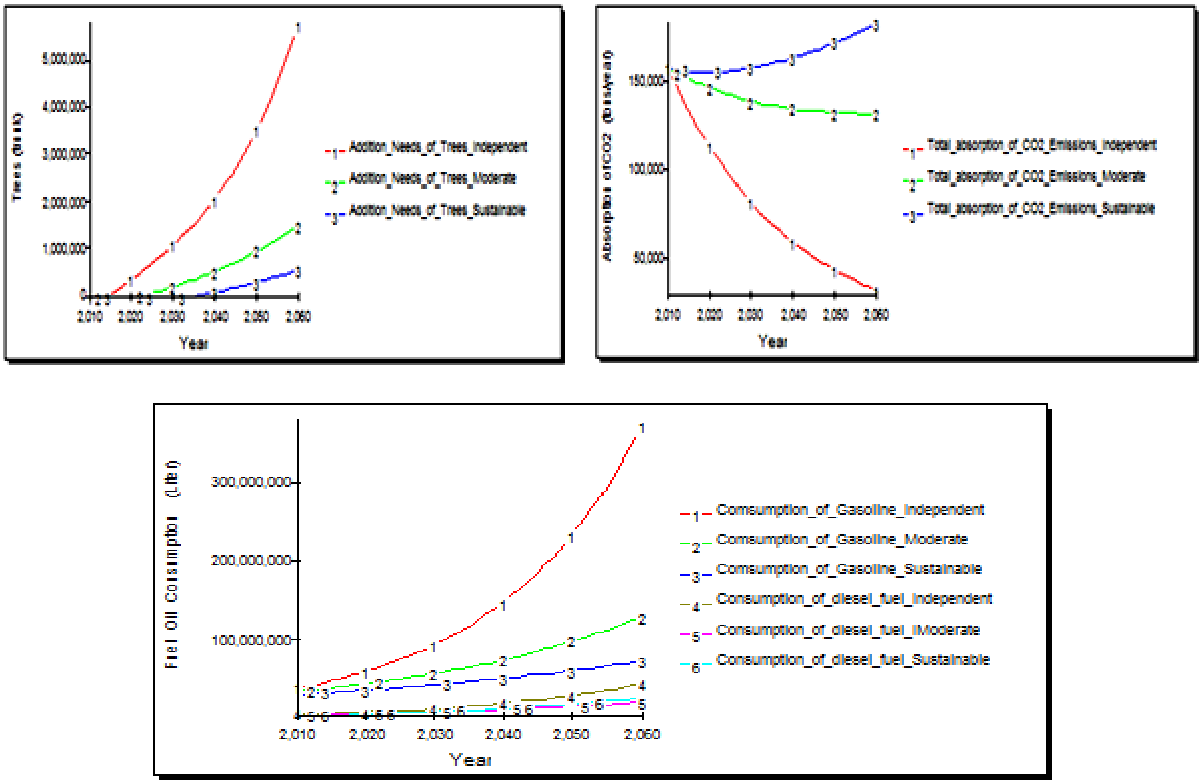


Figure 5. Simulation Results of the Independent, Moderate and Sustainable Scenarios

Results of simulation scenarios (Figure 5) showed that the sustainable scenario is the best scenario, this scenario able to accommodate any requirements of GOS planning in Malang City until 2060, and even in that year target of 30% GOS are still fulfilled, GOS coverage about 3,324.14 ha (**30.2 %** of the areas of Malang City). The Government regulation Republic of Indonesia No. 26 /2007 concerning the Spatial Management [48], mandates the proportion of the GOS in the urban region must be at least thirty percent (30%) of the areas. Under the sustainable scenario , efforts recommended in reducing CO_2 emissions are saving fuel oil (diesel fuel and gasoline fuel), the restrictions of private vehicles ownerhip, especially motorcycles and cars; the use of LPG, the improvement public transportation system by increasing the number of buses [21, 35, 49]. Increasing number of vehicles caused increasing any fuels consumption, it results in a higher CO_2 emissions [11, 19, 45, 46]. The sustainable scenario suggested the smallest CO_2 emissions compared with other scenarios, and a highest CO_2 emissions absorption than other scenarios. With increasing the urban tree population, the absorption of CO_2 also become larger, and the residual of CO_2 emissions become lower [10, 21, 38, 39]. In sustainable scenario, the addition of the tree population in Malang City also smaller, only 582.589 trees at the end of simulation periode (2060). The sustainable scenario is done to achieve a balancing equilibrium among the aspects of economic, social, cultural and environmental qualities. The principles of sustainable urban development suggest a harmonious relationships between the development activities and the carrying capacity of the natural environment [2, 29].

IV. CONCLUSIONS

Based on the developed model, it is suggested that declining trend of Green Open Space (GOS) in Malang city; at beginning of simulation periode (2010), areas of GOS about to 5,259.83 ha, whereas at the end of simulation periode (2060) only 1,940.56 ha. Absorption of CO_2 emissions about 158,620.98 tons/year at 2010, and decreased to 78,976.37 tons / year at 2060. This was due to the significant decreasing of GOS areas in Malang City. CO_2 emissions continue to increase, which at the beginning of simulation periode (2010) amounted to 124,630.06 tons/year and increased to 677,651.20 tons / year at the final periode simulation (2060). CO_2 emissions increase annually in line with the increasing number of vehicles in Malang City. The increasing number of vehicles and fuel oil consumption result in the CO_2 emissions. The Addition of trees population in Malang City as many as 28,491 trees (2016), and at the end of the simulation (2060) must be about 3,508,743 trees. Policy analysis model of GOS in Malang City formulated three scenarios, namely independent, moderate and sustainable scenario. Simulation results of the independent scenario, showed that areas of green open space at the end of simulation periode (2060) only 587.83 ha (with total CO_2 emissions amounted to 1,020,768.97 tons / year, the absorption of C02 emissions by 32,997.29 tons / year, and the addition of trees population about 5,785,882 tree). The moderate scenario suggested that at the end of simulation periode (2060) the Green Open Space areas about 2,028.30 ha (with total CO_2 emissions amounted to 391,930.80 tons / year, the absorption of C02 emissions by 132,694.84 tons / year, and the addition of trees population about 1,518,477 tree). While the sustainable scenario showed the areas of Green Open Space about 3,324.14 ha (the total CO_2 emissions of only 283,035.18 tons / year, the absorption of C02 emissions amounted to 183,574.93 tons / year, and the addition of trees population about 582,589 tree). With the increase of land coverage of urban trees, a more amount of CO_2 are absorbed, and the residual of CO_2 emissions getting lower. The recommended ways in reducing CO_2 emissions in Malang City are : saving fuel oil (diesel fuel and gasoline fuel), restriction ownership of private vehicles, especially motorcycles and private cars, efforts to use LPG, improving qualities of existing public transportation systems. The sustainable scenario can be implemented as an effective policies in development of urban GOS in Malang City.

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