Policy Model of Sustainable Infrastructure Development (Case Study : Bandarlampung City, Indonesia)

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Abstract. Infrastructure development does not only affect the economic aspect, but also social and environmental, those are the main dimensions of sustainable development. Many aspects and actors involved in urban infrastructure development requires a comprehensive and integrated policy towards sustainability. Therefore, it is necessary to formulate an infrastructure development policy that considers various dimensions of sustainable development. The main objective of this research is to formulate policy of sustainable infrastructure development. In this research, urban infrastructure covers transportation, water systems (drinking water, storm water, wastewater), green open spaces and solid waste. This research was conducted in Bandarlampung City. This study use a comprehensive modeling, namely the Multi Dimensional Scaling (MDS) with Rapid Appraisal of Infrastructure (Rapinfra), it uses of Analytic Network Process (ANP) and it uses system dynamics model. The findings of the MDS analysis showed that the status of Bandarlampung City infrastructure sustainability is less sustainable. The ANP analysis produces 8 main indicators of the most influential in the development of sustainable infrastructure. The system dynamics model offered 4 scenarios of sustainable urban infrastructure policy model. The best scenario was implemented into 3 policies consist of: the integrated infrastructure management, the population control, and the local economy development.
Keywords: ANP, city, dynamic model, policy, Rapinfra, sustainability infrastructure

1. Introduction

High population growth in city areas has implications for the improvement of the community infrastructure needs. The relationship between cities and infrastructure is now emerging as a key city policy issue [14]. Many relevant aspects and actors involved in city infrastructure development and planning and it required a comprehensive and integrated policy to be sustainable [7, 14, 17, 27]. A variety of strategies, policies, plans and programs of action for the development of an integrated and sustainable infrastructure in urban have been prepared, but the development of urban infrastructure still faces unresolved issues [16, 28]. Infrastructure development does not only affect the economic aspects, but also social and environmental aspects, those are the main dimensions of sustainable development. Therefore, it is important to determine the measuring instrument to identify the ability to build sustainable infrastructure.

Previous studies on sustainable infrastructure reflected the need to design and manage engineering systems by the environment, social and economics consideration. The study include: municipal water system sustainability criteria [6, 23], sustainable transportation [5, 9, 10, 12, 23, 30], drinking water system [6, 23, 25], waste water systems [6 23 26], storm water systems [2, 4, 19, 29], green

infrastructure [1, 15, 22] and solid waste [3, 24]. Based on these studies it is known that there has been no research on criteria and indicators for integrated and sustainable infrastructure. The main objective of this research is to formulate policy of sustainable infrastructure development, with specific objectives are: firstly, to measure the level of sustainability of the city's infrastructure; secondly, to formulate the indicators that influence the sustainability of city infrastructure development and thirdly, to design a policy model of sustainable urban infrastructure with dynamic system. The influential indicators was obtained from the results of stakeholders assessment, public opinion and the assessment of infratsructure planning report against all indicators of sustainable infrastructure development. This research was conducted in Bandarlampung which is one of the fast-growing large cities in Indonesia and in year 2015 it is expected becoming a metropolitan city [21]

2. The Research Method

The scope of the city infrastructure research restricted to a basic network infrastructure that influence city development, namely: transportation, water systems (drinking water, storm water, waste water), green open spaces and solid waste. The research was carried out by Multi Dimensional Scaling (MDS) method, which consisted of the application of Rapinfra (Rapid Appraisal of Infrastructure), Analytic Network Process (ANP) and dynamic system model. The primary data were the data obtained directly from respondents through Focus Group Discussion (FGD) and the data collected from questionaire survey of the community in Bandarlampung City. FGDs conducted in Bandarlampung 3 times (July 2013, August 2013, and January 2014). The sampling technique in this research was the method expert survey [13] by conducting in-depth interviews to the 15 respondents who had been determined. For the survey to the public, the sampling technique the purposive sampling was used to 126 respondents. Analyzing the sustainability status using Multi Dimensional Scaling (MDS) with software Rap-fish [8] were modified to Rapinfra. Sustainability status in this study were analyzed with the five dimensions of sustainability namely environmental, social, economic, technology and good governance. Sustainability analysis conducted through three stages: 1) Attributes determination for sustainable infrastructure development, which includes dimensions of environmental, economic, social, technology and good governance. 2) The valuation of each attribute in an ordinal scale based on sustainability criteria for each dimension. The scoring is based on the result of questionaires in accordance with the stipulated requirement. The scores ranged from 0 – 3, which is interpreted from strongly disagree (poor) to strongly agree (good). 3) Results of the scoring was analyzed using Rapinfra program to determine the position of the sustainability status in each of these dimensions (Table 1).

Leverage analysis was used to determine the sensitive attributes which was very influential in improving the status of sustainable infrastructure development. The determination of sensitive attributes was based on the priority of analysis leverage result that taking into account of the changes the root mean square (RMS) ordination on the X axis. The greater the change in RMS value, the greater the role of these attributes in increasing the sustainability status of city infrastructre.

Table 1. Sustainability Index and Status

Index	Category
0,00 – 25,00	Poor (not sustainable)
25,01 – 50,00	Less (less sustainable)
50,01 – 75,00	Fair (fairly sustainable)
75,01 – 100,00	Good (Sustainable)

Analytic Network Process (ANP) was used to determine the influential indicators of sustainable infrastructure development. The steps of selecting influential indicators as follows: 1). Determination of criteria and indicators based on expert consultation from the results of the previous analysis was based on a literature study, stakeholders and public opinion 2). Determination of the relationship between indicators was obtained through questionnaires 3). Construction of an alternative network model was based on the results of step 1 and 2. 4). Scaling interest for alternative indicators of sustainable

infrastructure development. 5). Testing consistency of pairwise comparison matrices that already meet the inconsistency ratio ≤ 10%. The next step is to calculate the weights of criteria and synthesis of indicators alternative of sustainable infrastructure development with a super decisions software use.
Dynamic system is a comprehensive and integrated way of thinking, it is able to simplify the complex issues without losing the important things of concern [18]. A system dynamics model can not only arrange and describe the complicated connections among each element in different levels, but also deal with dynamic processes with feedback in a system. It also can predict the complex system change under different scenarios, which is very useful in examining and recommending policy decisions in city management.

3. Results and Discussion

3.1. The level of sustainability infrastructure

The findings on sustainable criteria and indicator for infrastructure development from various studies were summarized in Table Appendix 1. Analyzing for indicators of sustainable infrastructure development on previous research, there were obtained 5 criteria with 50 indicators for sustainable infrastructure development (Table 2). The criteria and indicators which resulted from literature review in Table 1 were used for further consulted with experts through focus group discussions (FGD). From the FGD, it fixed the number of criteria to be 5 criteria, while the number of indicators was reduced to 47 indicators.

Table 2 Criteria and indicators of sustainable infrastructure

Environmental Criteria	Social Criteria	Economic Criteria	Technology Criteria	Good Governance Criteria
1. Land carrying capacity	1. Population growth	1. Economic growth	1. Drainage systems	1. Regulation
2. Conservation area damage growth	2. Number of poor	2. City Revenue growth	2. Sewage system	2. Planning (sectoral)
3. Built up area growth	3. Human Development Index (HDI)	3. Investment growth	3. Drinking water system	3. Inter- sector institution
4. Slum area growth	4. The community sewage system	4. The city budget growth	4. Solid waste management	4. The visionary leadership
5. Air quality	5. Catchment areas by public	5. Level of per capita income	5. Green Open Space systems	5. Spatial planning
6. Water quality	6. Processing trash by community	6. Minimum city wage	6. Road systems	6. Law enforcement
7. Land quality	7. Artesian/shallow wells by community	7. Levels of local economic growth	7. Bicycle lanes / non- motorcycle vehicle	7. Socio-political conditions
8. Availability of water resources	8. Levels of security &safety	8. Infrastructure services fee	8. Facilities for pedestrians	8. Call center
9. Traffic congestion level	9. Unemployment rate	9. Land value	9. Public transportation	9. Budgeting
10. City landscape	10. Levels of traffic accident			10. Human resource capacity in goverment
	11. Community behaviour (culture)			11. Community participation

The results of MDS using Rapinfra showed that the sustainability index value of environmental criteria was 42.88% as shown in Figure 1. It was classified as less sustainable, due to 2 attributes laid in bad score which were the rate of conservation, damage and level of traffic congestion. Seven (7) attributes laid in moderate score which were land carrying capacity, the growth rate of built up area, slum area growth, air quality, water quality, land quality and water resources. The less sustainable status was influenced by 4 key indicators that leverage analysis results and it can be seen in figures root mean square (RMS). Key indicators were indicators of the middle to the highest RMS value. The RMS of key indicators were air quality level; the rate of conservation area damage; the level of water quality; the soil quality level (Figure 2).

Other chart which is the output of MDS with Rapinfra sustainability analysis for the economic criteria, social criteria, technological criteria and governance criteria similar such as output over the environmental dimension. The sustainability index value for social criteria was 15.80 % and classified as not sustainable.

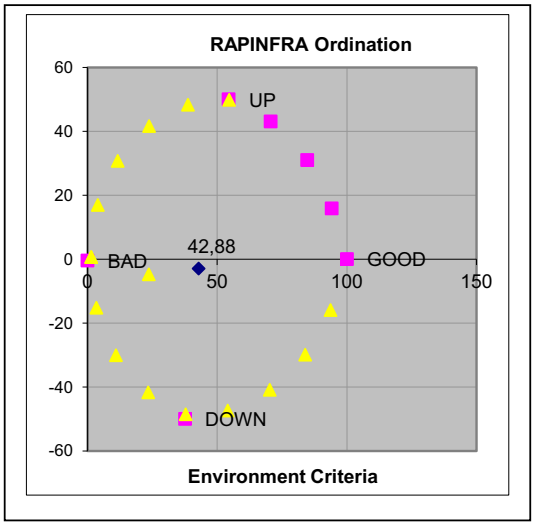

Figure 1. Value Criteria Environmental Sustainability Index

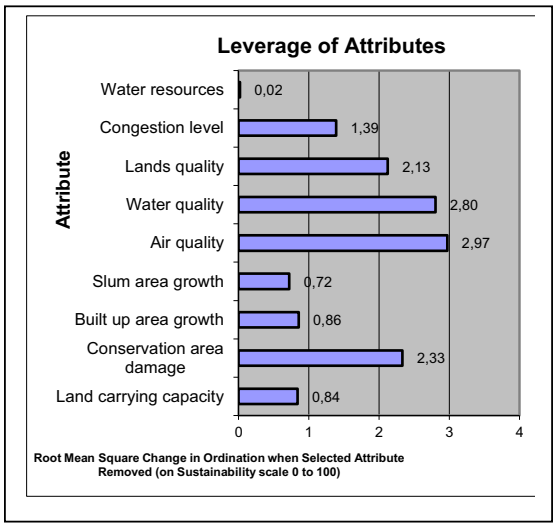

Figure 2. RMS Value of Environmental Criteria

The category was not sustainable due to 7 attributes laid in bad score which were the population growth, the number of poor, artesian/shallow weel by public, catchment area by public, trash processing by public, community behaviour, and safety, security, comfort level. It was also due to 3 attributes laid in moderate score which were HDI, sewage system by public and unemployment rate. The unsustainable status was affected by the 6 key indicators. The RMS of key indicators were: the rate of human development index; the sewage system by public; unemployment rate; trash processing by public; catchment area by public and the making artesian or wells drilled by the public.

The sustainability index value for the economic criteria was 43.88 % which was relatively less sustainable. The category was less sustainable due to all economic attributes laid in moderate score. The less sustainable status was influenced by three key indicators, that the RMS of key indicators were: the rate of investment; level of income per capita, and the local economy growth.

Sustainability index value for technology criteria was 28.32 %. It was classified as less sustainable due to 5 attributes laid in bad score which were sewage system, drinking water system, bicycle lanes/non-motorcycle vehicle, facilities for pedestrians, public transportation. Four (4) attributes laid in moderat score which were drainage systems, solid waste management, green open space systems and road systems. The less sustainable status was influenced by eight key indicators, the RMS of key indicators were: the level of water services; availability of green open space; availability of roads; availability of pedestrian facilities; waste management; availability of municipal sewage system; the availability of bike lanes/non- motorcycle vehicles and the availability of public transport systems.

The sustainability index value of good governance criteria was 44.58 %. It was classified as less sustainable due to 4 attributes laid in bad score which were regulation, inter-sector institution, law enforcement, social political conditions. Five (5) attributes laid in moderate score which were the visionary leadership, spatial planning, budgeting, human resource capacity in goverment, and community participation. Only one attribute laid in good score, it was call center. The less sustainable status was influenced by 5 key indicators, the RMS of key indicators were: law enforcement; call centers; inter-sector institution; leadership, and the local socio-political conditions.

The results of MDS using Rapinfra shows that multicriteria sustainability infrastructure Bandarlampung index value was 38.05 % or less sustainable , as shown in Table 3 and Figure 3.

Sustainable Status			
No.	Criteria	Index value	Sustainable status
1	Environment	42.88	less sustainable
2	Economic	43.88	less sustainable
3	Social	15.80	not sustainable
4	Technology	28.32	less sustainable
5	Governance	44.58	sustainable

Table 3. Sustainable status of infrastructure

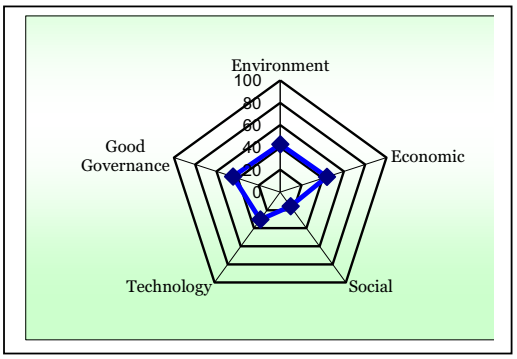

Figure 3 Kite diagram

To determine whether the indicators examined in MDS analysis was quite accurate and can be justified scientifically, this can be seen from the stress and the coefficient of determination (R2). This value was obtained in the MDS analysis using Rapinfra software. The results of the analysis were considered sufficiently accurate and reliable because it has a smaller stress value of 0.25 or 25% and the coefficient of determination (R2) values approaching 1.0 or 100 percent [11]. The analysis showed that all indicators were assessed fairly accurate and accountable. It was shown that the stress value by 14% - 15% and the coefficient of determination (R2) of 0.95%. Stress value indicates the proportion of variance that was not explained by the model. It showed that, the lower the value the better the model MDS stress.

3.2. Priority Indicators Analysis on Sustainable Infrastructure Development

The processes to obtain indicators of sustainable infrastructure development priorities starting from the results of a literature review of 50 indicators, then taken to the FGD, in order to obtain 47 indicators. These indicators is used for the assessment of the various sources which include: stakeholders opinion, communities and planning documents performance. The combined results from the three sources were obtained 27 influential indicators, then this influential indicator was brought to the FGD, in order to obtain 20 indicators were selected to be analyzed in the ANP. ANP analysis results obtained with 8 priority indicator , this stage can be seen in Figure 4.

The community survey showed that 24 indicators of the level of importance according to 5 criteria. Influential indicators for environmental criteria were 5 namely: the level of congestion, water quality, availability of raw water sources, air quality and growth of built up area. There were 5 influential indicators for social criteria, namely: HDI level, level of security and safety, unemployment growth rate, waste management system by community and community behavior. There were 4 influential indicators economic criteria, which include: city minimum wage level, local economy development, the growth of infrastructure budget and economic growth (GDP). Influential indicators for technology criteria were 6 consist of: the availability of drinking water system, waste management system, drainage system, green open space system, wastewater system, and public transport system. There were four influential indicators for governance criteria, namely: visionary leadership, law enforcement, infrastructure planning and infrastructure budget.

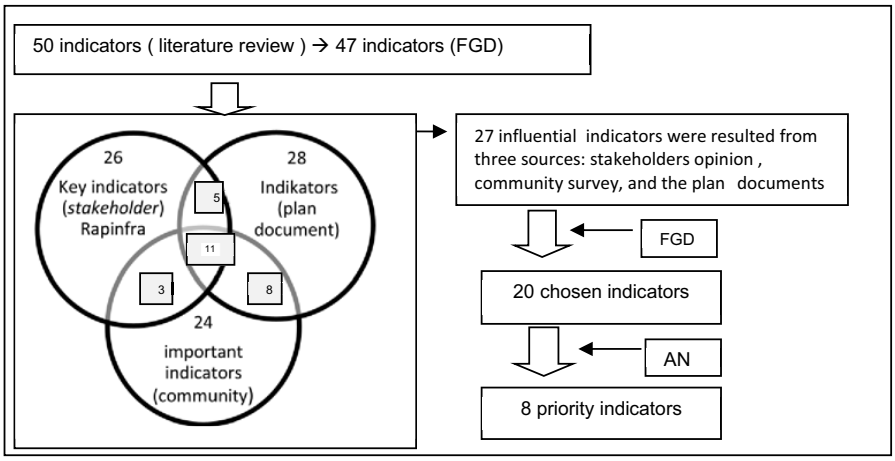

Figure 4. Phases analysis of priority indicator in sustainable infrastucture development

Planning document, which it was the reference of infrastructure development was the Spatial Plan, Sectoral Master Plan and Mid-Term Development Plan (RPJMD). There was also the Mid-Term Infrastructure Plan (RPIJM) space -based and sector and it was currently in the process of preparing the plan. The results showed that the existing infrastructure development plans in the form of a program of activities still does not meet the indicators of sustainable infrastructure development even most plans do not formulate some sort of performance indicators as a measure of development, except RPJMD. Indicators of sustainable infrastructure development on RPJMD were 28 indicators consist of: 6 indicators of environmental criteria, namely: reduced rate of destruction of mountains and hills (conservation area), city slum area, growth of built up area, reduced air pollution, preservation water sources and reduced traffic congestion point. The attributes of social criteria were include 5 indicators, namely: increasing HDI level, reduced the number of poor, security and safety; waste management and unemployment rate. Economic criteria which consist of 5 indicators were: economic growth, city revenue growth, GDP growth rate, the rate of minimum city wage. Criteria technology has 7 indicators namely: growth of number of roads, arranged green open space areas, reduced sedimentation of waterways and drainage, increasing water service, available sewerage installation, available facilities and mass transit traffic. Good governance criteria has 5 indicators, namely: increasing the amount of the approved legislation, capacity building through discipline and education of civil servants, availability of media complaints, budgeting, availability of information planning in accordance with the implementation plan.

The key indicators of MDS previous results (26 indicators) then combined with the results of the community survey (24 indicators) and outcome indicators in the assessment of infrastructure planning documents (28 indicators) to obtain the most influential indicators in the sustainable infrastructure development. Composite indicator made up of indicators that appear at least twice in all three stages of the analysis, in order to obtain 27 indicators (Figure 4).

Figure 4 shown that there were 27 the powerfull indicators in sustainable infrastructure development. The environmental criteria has 6 indicators namely: availability of raw water, air quality, water quality, damage of conservation, growth of built up area development and traffic congestion. The social criteria has 4 indicators consist of: HDI, security and safety, unemployment rate, public participation and citizen behavior. The economic criteria has 4 indicators namely: the rate of investment, income per capita, the rate of the local economy and minimum city wage. The technological criteria has 7 indicators namely: the availability of clean water systems, waste management, green open spaces, road network, drainage system, waste water system, and public transport. The governance criteria has 6 indicators including: visionary leadership, call center, law enforcement and sanctions, infrastructure

planning and infrastructure budgets. The 27 powerfull indicators on Figure 4 discussed by experts in the FGD and obtained 20 indicators, and then these indicators will be processed at the stage of ANP (Figure 5).

The calculation result with the super decisions obtained the weight of each indicator, the greater the weight of indicator, the greater the influence of these indicator on sustainable infrastructure development. There were 8 main indicators that the most influential or the priority indicators on sustainable infrastructure development. The priority indicator on economic criteria was local economic growth with weights 0.725. For governance criteria, there were two priority indicators, namely: infrastructure planning with weights 0.475 and infrastructure budget with weights 0.446. On the technological criteria, the priority indicator was the availability of clean water system with weights 0.425. For social criteria there were two priority indicators, namely: community participation with weights 0.418 and people's behavior with weights 0.404. On environmental criteria, there were two priority indicators namely: air quality with a weight of 0.369, and the growth of built up area with weight 0.345.

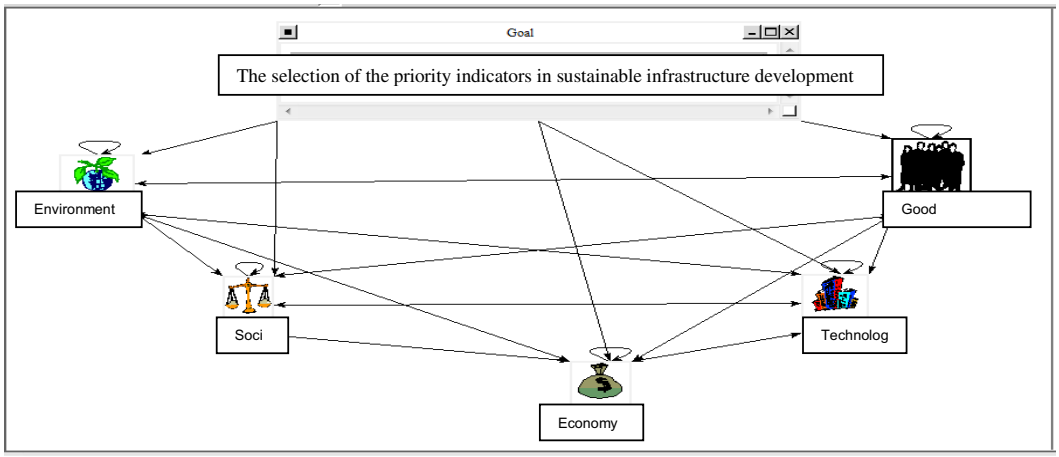

Figure 5. Network link between sustainable infrastructure development criteria in ANP

The results of the analysis of ANP recommend policy directions in the development of sustainable infrastructure ought to consider 8 priority indicators. Policy recommendations in sustainable infrastructure development were the first: the local economic growth that address the needs of micro economic infrastructure such as: provision of space for small enterprise and street vendors in the city. Second: an integrated infrastructure planning between spatial and sectoral development plans. The Indonesian government is currently preparing a program planning development of spatial-based infrastructure to support integrated development through The Medium Term of Infrastructure Investment Program Plan (RPI2JM). This program may be the first step in planning an integrated infrastructure development and sector-based spatial development. This plan can work well if the planning process also involves decision-makers from related sectors. Third: an increase in the infrastructure budget, efficiency and effectiveness of the budget. Fourth: the availability of clean water system which was distributed to all parts of the city, increasing the amount of raw water sources and water management with 5 R (restore, reduce, reuse, recycle, rechargeable). Fifth: increased community participation in the management of city infrastructure, building consensus between the government and the residents of the city as well as the transparency of information. Sixth: city infrastructure management that considers the behavior of (cultural) communities, for example the pattern of movement of people in the use of transport (public transport, bicycle or on foot) and open space utilization patterns. Seventh:

air quality with the increased use of public transport, periodic emissions testing, vehicle age restrictions, environmentally friendly fuel, green industry and waste management without burning. Eighth: the city land use in accordance with the city spatial plan, that requires the provision of 30% open space, minimizing damage to protected areas (mountains, slopes and hills) and the efficient use of space with vertical building development.

3.3. Policy Model of Sustainable Infrastructure Development

Sustainable infrastructure development model of Bandarlampung represents the existence of various factors affecting the availability of the city's infrastructure. This dynamic system model is constructed from three sub- models: the sub-model of social, sub-model of the physical environment , and the sub-model of economic. Sub physical model of the environment consists of sub-models of road system, water resources system, waste sytem and green open space system (Appendix 1 and Appendix 2).

Dynamic simulation models are used to create a scenario of sustainable infrastructure development in Bandarlampung. Simulations carried out for a period of 20 years (2007- 2026). Scenarios developed by simulation intervention on model parameters, namely social (population), economic (medium, small, micro enterprises/MSMEs), physical and environment (clean water, green space, sewage and roads), see table 4. Alternative policy scenario includes four types of scenarios which consisted of 1 scenario without intervention (bussiness as usual), and 3 types of scenarios with interventions namely: pessimistic, moderate and optimistic. The third scenario simulated by changing the parameters of current conditions into better conditions in the future. Optimistic scenario is the scenario that led to the intervention expectations of appropriate conditions of minimum service standards (SPM) which is adapted from the Minister of Settlement and Regional Infrastructure Regulation No. 534/KPTS/M/2001 on Guidelines for Minimum Service Standards, and the Minister of Public Works Regulation No. 01/PRT/2014 on Minimum Service Standards for all public works and Spatial Planning, and the target of achieving the Millennium Development Goals (MDGs) as outlined in Long-term National Development Plan (RPJPN) 2015 -2019.

Table 4. Intervention of Scenario Parameter

Parameter	Existing condition	Pesimistic scenario	Moderate scenario	Optimistic scenario
Social (in-migration growth)	0.013	0.010	0.008	0.005
Local economy				
- Middle enterprise growth (%)	0.10	0.11	0.12	0.13
- Small enterprisesgrowth(%)	0.08	0.09	0.10	0.11
- Micro enterprise growth(%)	0.10	0.11	0.12	0.13
Physical and Environmental				
a. Vehicles				
- Private car age (year)	20	17	14	10
- Motor cycle age (year)	15	12	9	5
b. Area of Public Green Open Space (%)	12.6	15.1	17.5	20
c. Garbage transporting (%)	68	80	90	100
d. Drinking Water Leakage (%)	60	46.7	33.4	20
e. Raw water supply (%)	75	85	95	100
f. Communal WWTP supply (%)	20	40	60	80

Note: WWTP: waste water treatment plan

3.4. Sustainable index of infrastructure development

The result of the simulation scenario on city infrastructure sustainability index value are: the lowest index value of 78.79 and the highest index value 142.08. If the lowest value is assumed to be equivalent to the result of the MDS in the previous section, then the existing condition of the city's infrastructure is also less sustainable. Values reflecting the status of sustainability of infrastructure of the city, the higher the index value, the higher the status of the sustainability of urban infrastructure or the better the quality of the environment as a result of infrastructure development of the city (Table 5 and Table 6).

Table 5. Sustainable index of infrastructure development

	Sustainable index of infrastructure development						
Scenario	Popu-lation	Local economy	Water supply	Waste treatment	Flood index	Traffic jam index	Public green open space
Without intervention	0.761	0.704	0.452	4.092	1.004	3.416	0.405
Pesimistic	0.739	0.813	0.593	2.151	0.972	1.898	0.731
Moderate	0.724	0.927	0.977	2.463	0.952	0.517	0.827
Optimistic	0.703	1.072	1.295	1.118	0.934	0.331	0.870
Weight (AHP)	0.349	0.133	0.136	0.058	0.087	0.152	0.085
Trend (CPI)	negative	positive	positive	negative	negative	negative	positive

Table 6. Infrastructure sustainability index value with CPI

	Sustainable index of infrastructure development								
Scenario	Popu-lation	Local economy	Water supply	Waste treatment	Flood index	Traffic jam	Public green open space	Total index value	Sustainable Status/level
Without intervention	92	100	100	27	93	10	100	78.79	less
Pesimistic	95	115	131	52	96	17	180	95.77	fairly
Moderate	97	132	216	45	98	64	204	119.05	good
Optimistic	100	152	287	100	100	100	215	142.08	very good
Weight	0.349	0.133	0.136	0.058	0.087	0.152	0.085		

Note : The weight is the result of assessment using AHP (Analytic Hierarcy Process) ; CPI: *Composite Performance Index*

Model of sustainable urban infrastructure development policies with moderate scenario is chosen the most appropriate scenario to be implemented in the time frame until 2026 with consideration of the availability of the resources available today, include: human resources in the government, budgetary resources, and resources of land. The priority policy for the sustainable development of the city's infrastructure moderate scenario are:

a. Physical and environmental policy field is through an integrated infrastructure management program that includes: (1) the management of water resources, in particular the increase in the volume of raw water, clean water service improvement, reduction of loss/leakage of water, integrated solid waste management, communal waste water treatment plan/WWTP; (2) the provision of mass transit is easily accessible, secure, inexpensive and convenient; and the imposition of restrictions on the age of a motor vehicle; (3) an increase the quantity and quality of public green open space.
b. Social policies that include population control through restrictions on the number of people coming into the city. To support the program it is necessary to measure the change in the form of equitable development of infrastructure to the suburbs and judicial operations.
c. Policy economics is managing the local economy through an increase in the number of medium, small and micro enterprises (MSMEs) by providing access to MSMEs on the provision of urban infrastructure needed such as: cheap transport, accessible water supply and integrated waste management.

4. Conclusion

The sustainable infrastructure development benchmarks were generated in this study which included 5 criterias such as environmental, social, economic, technological and governance, and 47 indicators. The status of Bandarlampung infrastructure sustainability was considered as less sustainable with a score of 38.05 % which means that the availability of the infrastructure was still in good condition. However, it needs to be improved to achieve sustainable infrastructure development.

The ANP analysis recommended that the policy directions in the development of sustainable infrastructure ought to consider 8 key indicators as follows: the local economic growth, infrastructure

planning, infrastructure budgets, availability of clean water systems, community participation, people's behavioral, air quality and growth of built up area. The were eight (8) recommendation policies in sustainable infrastructure development. Firstly: the local economic growth that address the needs of micro economic infrastructure such as: provision of space for small enterprise and street vendors in the city. Secondly: an integrated infrastructure planning between spatial and sectoral development plans should consider the indicators of sustainable infrastructure development through The Medium Term of Infrastructure Investment Program Plan (RPI2JM). Thirdly: an increase in the infrastructure budget for more efficiency and effectiveness. Fourthly: the availability of clean water system which was widely distributed throughout the city by increasing the amount of raw water sources and water management with 5 R (restore, reduce, reuse, recycle, rechargable). Fifthly: increased community participation in the management of city infrastructure, building consensus between the government and the residents of the city as well as the transparency of information. Sixthly: city infrastructure management that considers the community behavior, for example the pattern of movement of people in the use of transport (public transport, bicycle or on foot) and open space utilization patterns. Seventhly: air quality with the increased use of public transport, periodical emission testing, vehicle age restrictions, environmental friendly fuel, green industry and waste management without burning. Eighthly: the city land use in accordance with the city's spatial plan, that requires the provision of 30% open space, minimizing damage to protected areas (mountains, slopes and hills) and the efficient use of space with vertical building development.

The system dynamics model of sustainable infrastructure development in the study area is comprised of three sub-models: the sub social model, sub-model of the physical environment, and sub-model of the economy has resulted in the formulation of the sustainability index value of city infrastructure. The index value can be increased in line with the simulation scenarios. The results without the intervention and pessimistic scenario showed a trend is not sustainable with the sustainability level is still relatively low. Results of moderate and optimistic scenarios already showed a better level of sustainability or already ongoing and highly sustainable. Selected scenario is the most moderate scenario might be implemented because of the limitations of existing resources include budgetary resources, human resources in bureaucracy and land resources. Under the moderate scenario, estimated in 2026 at Bandarlampung infrastructure development is still ongoing, but should be anticipated external influences also the city which can lower the level of sustainability.

In order to increase the value of the city's infrastructure and the status of sustainability in order to materialize the scenario chosen, it must be supported by appropriate policies. The findings of priority policy can be used as a basis for intervention in the upgrading of the sustainability of urban infrastructure in the future. So that the policy can be implemented, it is equipped with programs and action change as follows:

a. Policy priorities for sustainable infrastructure development is the policy of physical and environmental fields through an integrated infrastructure management program that includes: (1) the management of water resources in an integrated manner, in particular the increase in the volume of raw water, clean water service improvement, reduction of water leakage and waste management (liquid and solid); (2) the provision of mass transit is easily accessible, secure, inexpensive and comfortable which is supported by the provision of facilities for pedestrians such as sidewalks, pedestrian bridges and public transportation stops, restrictions on the age of a motor vehicle; (3) an increase in the breadth and quality of public availability of green open space through revitalization of existing open space, developing innovative garden (the wall garden, vertical garden and roof garden) and increase the number of parks in the suburbs.
b. Supporting policies to policy priorities are:
   - Social policy that includes population control through restrictions on the number of people coming into the city. To support the program it is necessary to measure the change in the form of equitable development of infrastructure to the suburbs and judicial operations.

Policy management economics is the local economy through an increase in the number of MSMEs by providing access to MSMEs through supporting the provision of basic urban infrastructure in the form of adequate infrastructure.

Recommendation

In order to improve further sustainability infrastructure development of Bandarlampung City, the priority indicators in determining the policy of the city's infrastructure development should be taken into consideration by the local authorities. Model of sustainable infrastructure development policy is a policy concept design that can be adopted in the planning of city infrastructure. The preparation of policy planning and sustainable infrastructure development in urban areas are advised to apply the criteria and indicators generated in this study .

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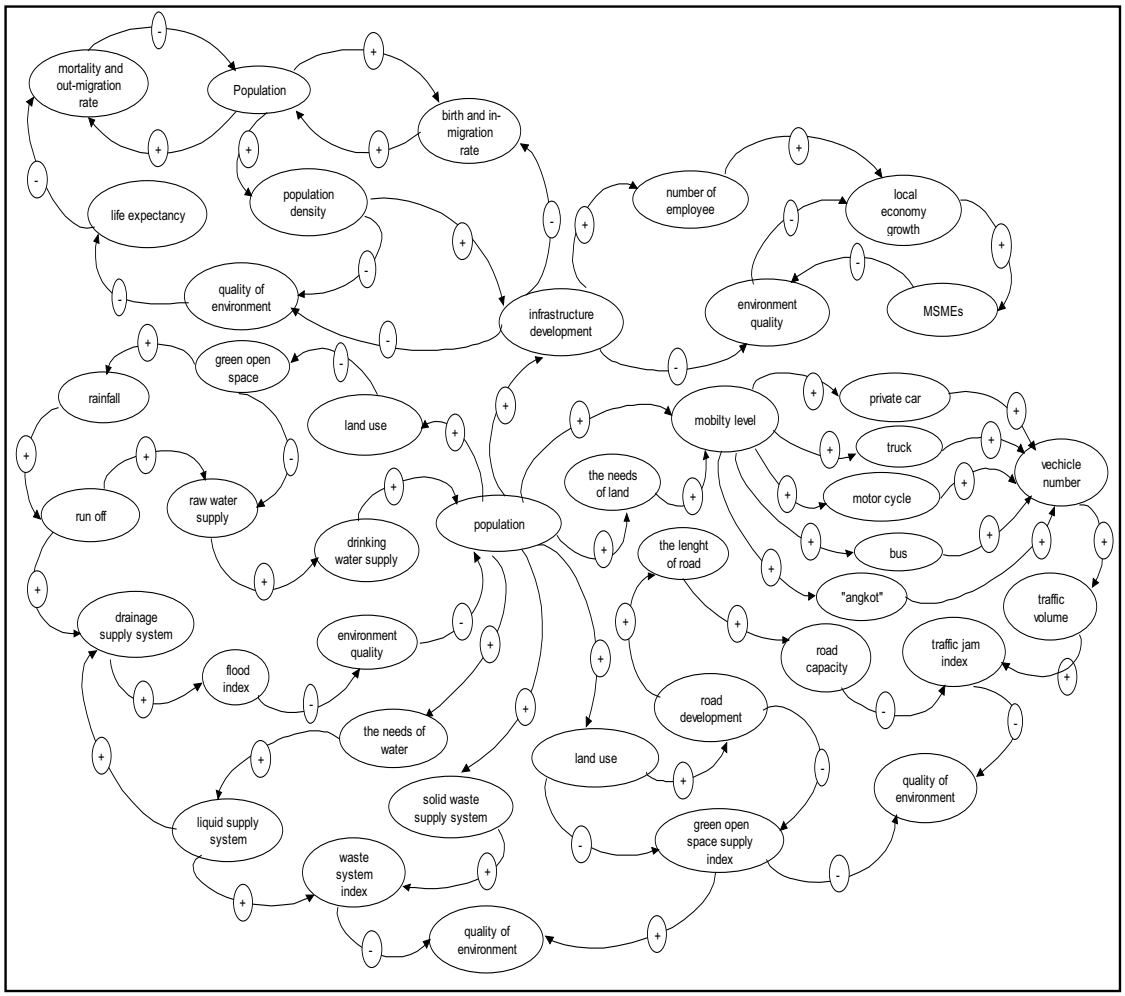
APPENDIX-1 : Table Sustainability citeria and incators for different infrastructure system from various studies (2000-2013)

Criteria and indicators	Transportation					Drinking Water			Storm water (Drainage)				Waste water			Solid waste			Green open space		
Environmental criteria:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Air pollution (ambient air quality)	X	X	X	X	X	-	-	-	-	-	-	-	-	-	-	X	X	X	X	-	-
2. Emission levels (motor vehicle), GHG	X	-	X	-	X	X	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-
3. Noise pollution (noise level Traffic)	-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-
4. Area of green space and network	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-
5. Conversion rate of land (land use)	X	X	-	X	X	X	-	-	X	X	-	-	X	-	-	-	-	X	-	X	-
6. Controlling land use	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Landscape condition	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
8. Use of energy (fuel consumption)	X	X	X	X	X	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
9. Use of renewable energy	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10. Land degradation	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. The efficiency of movement / mobility	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
12. Environmental management (3 R) /quality	-	-	-	X	-	-	X	-	-	-	-	-	-	X	X	X	-	X	-	-	-
13. The environmental impact of facilities	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Protection of wildlife / habitat / biodiversity	-	X	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	X
15. Water polution/water quality	-	X	X	-	-	X	X	X	X	X	X	X	X	X	X	-	-	-	X	-	-
16. The efficiency of natural resources	-	X	-	-	-	-	X	-	-	-	X	-	-	X	X	-	-	X	-	-	-
17. Material and construction waste	-	-	X	-	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
18. Pollution of ground water (ground)/quality	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-
19. Permanent puddle and flood	-	-	-	-	-	X	-	-	X	-	X	-	X	-	-	-	-	-	-	-	-
20. Environment Aesthetic	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
21. Ecological network (hubs-nodes-corridors)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
22. Water resources (air baku)	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Economic criteria:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. The regional Economic Growth	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2. Gross Regional Domestic Product	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. Budget implementation infrastructure (OM)	X	X	-	X	X	X	X	X	X	-	X	X	X	X	X	X	X	X	-	-	-
4. The Local Government Revenue	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-
5. Trip fee/service fee	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Growth centers	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. The growth of land value	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
8. Dimensions of city area	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Infrastructure rate/user fee	X	X	X	X	-	X	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-
10. Revenue per capita	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11. Supporting industrial/ investment develop.	X	X	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
12. Creation of jobs	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-
13. Absorption of labor	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-
14. Revenue population	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-
15. Local Economic Development (LED)	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	X	-	X
16. Saving of roads maintenance	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-
Social criteria:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Population growth	-	-	-	-	X	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-
2. Levels traffic(infrastructure) accidents	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3. The Safety level	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-
4. The Security level	-	X	X	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-	X	X	-
5. Behaviour of community as an infras. user	-	X	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
6. The healthy level	X	X	X	-	X	X	X	-	X	-	-	X	X	X	-	X	-	-	X	-	X
7. Growth of private vehicles	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Education and skills rate	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	X	-	X
9. Welfare society level	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-
10. Population density	-	X	-	-	X	-	X	-	-	-	-	-	-	X	-	-	-	-	-	-	-
11. Facilities for the disabled	-	X	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
12. Access to public services	X	-	X	X	X	X	-	-	X	-	-	X	X	-	-	-	-	-	-	-	X
13. Satisfaction of road (infrastructure) users	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
14. Levels Traffic violations	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15. Equity / fairness	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
16. Survival rate	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-
17. Making infiltration wells by community	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18. Protection of culture resources/traditional	-	X	X	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
19. The social interaction and social access	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	X
20. Willing to pay	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
Technology Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Capacity of infrastructure (supply)	X	-	-	-	X	X	-	-	X	-	-	-	X	-	-	-	-	-	-	X	-
2. Levels of service (performance)	X	X	X	-	X	X	-	X	X	-	-	-	X	-	-	-	-	-	X	-	-
3. Integration of infrastructure	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-
4. Development of road network	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5. Diversification of transportation mode	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
6. Bike and pedestrian path	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7. Facilities for pedestrian (crossing bridge)	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
8. Facilities non-motorcycle vehicle	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9. Infrastructure technology (design of infra.)	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	X	-	X	-	-	-
10. The public transport quality	-	-	X	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-
11. Easily obtained/operated of technology	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-
12. Diversification of green open space	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X
13. Leakage	-	-	-	-	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
Governance criteria:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. Law enforcement and sanctions/control	X	-	-	-	X	X	-	-	X	-	-	-	X	-	X	-	-	-	-	-	-
2. Quality of human resources	-	-	X	-	X	-	-	X	-	-	-	X	-	-	-	-	X	-	-	-	-
3. Community participation	X	X	X	X	-	X	-	X	X	X	X	-	X	-	-	-	X	-	-	X	-
4. Planning	-	X	X	-	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	X
5. Budget development and R & D	X	X	X	-	X	X	-	-	X	X	-	-	X	-	-	-	-	-	-	X	-
6. Regulation / Law	X	-	-	-	-	X	-	X	X	-	X	-	X	-	-	X	X	-	-	X	-
7. Institutional	-	-	-	-	-	-	-	X	-	X	X	-	-	-	-	-	X	-	-	X	-
8. Call Center	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-
9. Cooperation (between regions, private-goverm)	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-
10. Integrated infrastructure institution	-	-	-	-	X	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	X
11. Conformity with the Spatial planning	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-

Appendix-2: Causal diagram of sustainable infrastructure development model



Appendix-3: Stock flow diagram of sustainable infrastructure developm