A set of sustainable urban landscape indicators and parameters to evaluate urban green open space in Bandung City

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Abstract. To improve the environmental quality and to increase citizens’ index of happiness, Bandung City government has built or either rebuilt and revitalized some urban green open spaces, or in popular are known as public park. Until now the government has built hundreds of parks scattered throughout the city of Bandung, ranging from neighbourhood park to city parks. With the availability of many public parks in Bandung, this attract the citizens’ attention, both Bandung’s citizen and surrounding citizen, to having activities at public park as an alternative destination. Based on the current conditions, the development of green open space in Bandung more likely to focus on meet user’s satisfaction and put aside the fulfilment of other function (ecological, health, socio cultural, economy, and aesthetic) as part of the efforts to increase Bandung city urban green open space sustainability. Since the development of green open spaces only expected to accommodate more visitors, this will result in expanding pavement area which potentially reducing the park’s ability to absorb water and reducing existing vegetation. In order to prove that, it is necessary to evaluate the performance of urban green open spaces in Bandung. The evaluation’s aims to value the balance between its aesthetical and social function, with its ecological function. This paper will propose a set of indicators which can be used as a tool to evaluate performance of urban green open space as an effort to increase Bandung city urban green open space sustainability. These indicators were obtained through in-depth research and review of some related literatures, sub indicators which obtained at that stage will combined and modified to appropriate with the Bandung City urban green open space characteristics. There are four main evaluation indicator categories, which are ecology, socio-cultural, health, and economy indicator. These categories of indicator would be developed into sustainable urban landscape sub-indicators and parameters based on sustainable landscape design principles. In the end, these indicators were expected not only to be applied in Bandung City area but also in other cities as well with appropriate adjustment to the city’s character and condition. In the end, these indicators are expected not only can be applied in Bandung City area, but also in other cities, with appropriate adjustments base on the character and condition of the city.

Keywords: sustainable landscape, urban green open space

1. Introduction

In the last three years, Bandung City has gained a significant benefit by the introduction of urban green open space as one of the city’s image, it can increase the visitors both from Bandung citizen and tourists.
Bandung City Government has made redesign, renovation and rebuilding of the urban green open space. This became one of success’ parameters in building the city.

The enthusiasm of city residents in utilizing urban parks (especially those that have undergone the process of revitalization/rearrangement) as a place to indulge in public space, has become an indicator of increasing happiness index of Bandung citizens. City Government in this case managed to increase awareness of the citizens to have activities in urban parks that have been rarely done by the public. The City Government also managed to make the activity in the park as a regular need of Bandung city residents and tourists, either as a daily or periodic activity, especially on weekend [5].

The success of Bandung City Government in attracting Bandung citizen and tourist to utilize and have activities in the city park should be appreciated, which different from the activities of other cities’ residents, who spend their time by visiting shopping areas and other commercial areas. but the success should be reviewed critically and thoroughly related to the impact of the existence and sustainability of Bandung's city park as part of Bandung's green open space system. In that perspective, it is necessary to review the success of urban park utilization with the necessity of maintaining balance with other aspects that should exist in a green open space of the city. Micro aspects related to the existence of the main elements that support economic factors, socio-cultural and including its role in macro in maintaining and increasing the ecological value of a city. The existing urban green open space rearrangement aims to accommodate new activities and facilities, which often pay less attention to ecological values, including the increasing pavement area that reduces and even minimizes the catchment area within the city's green open spaces. Therefore, it is necessary to find the indicators needed in the process of evaluating green open space in Bandung. Indicators that can cover all aspects of planning and designing sustainable urban green open spaces.

The revitalization project of the park that tends to be people-oriented are potentially disregard the ecological function of the green infrastructure itself. The new parks were built on former park, so it was not significantly added green public space area in Bandung. These new parks development was not spreading distribution of urban public space. This development of new green open spaces was expected to accommodate more visitors, results in expanding pavement area and potentially reducing the park’s ability to absorb water and reduce existing vegetation.

Based on data from Bandung City Government Parks Service in 2016, the amount of green open space recorded as a park in the city of Bandung there are 430 parks with a total area of 216,195 hectares. The data includes parks of various shapes and types with varying extents from the smallest of roadside gardens and 16 m² road islands to large-scale city parks such as Tegallega Park with an area of 190,011 m². Distribution of urban parks in the city of Bandung by its location almost mostly located in two areas of Cibeunying Region and Bojonagara Region whose position is in the northern part of Bandung. This pattern of distribution occurs because most of the green parks/ open spaces in Bandung are built during the Dutch East Indies colonial period. A total of 33 existing parks in the city of Bandung is then revitalized and reorganized into thematic parks by the city council. While in other parts of the City was the parks and green open space that most of them spread in the area of new housing and green areas in road corridors.

2. Revitalized Bandung Urban Park Condition

Based on the results of field observations, especially on 16 parks from 33 parks and green spaces of Bandung city that has been revitalized/ redesigned, can be presented various recent conditions. The term “Thematic park” were introduced: Thematic park were given as one of the ways the municipality provides specificity of structuring in every revitalized park by trying to give meaning and function to the theme chosen on the park, including new landscape furniture that suitable to the theme [1]. In searching for themes for individual parks, it is a theme that is linked to specific community activities in the city community (football, photography, skate boarding, music, movies, flower lovers) [4], or tailored to a specific age category of user; children, teenagers, elderly) or themes based on it’s unique landscape character.
Planning and design only focused on each park with its special themes thus, there is no interconnection plan between parks, especially in viewing the function of the park as part of the city’s green open space system. With the inclusion of activities and facilities within the parks there is a change of park conditions that reduce the fulfillment of ecological aspects such as the function of maintaining microclimate, biodiversity, hydrology, and functions as a recharge area.

Aspects designed according to the results of the design and the design document: focus on fulfilling the facilities of potential users/communities, selection of vegetation types for visual/aesthetic needs, artificial water utilization (fulfillment of recreation and beauty aspects, pavement and material use) making icons in accordance with the theme park [1]. From the aspect of urban park utilization by the public (resident and visitors/tourists) then the thematic park is mostly used for sports activities, recreation and education, public activities/events (special events, meeting point), economic activity of street vendors and CFD effects around Dago-Gasibu of surrounding parks, socializing (social media influences).

In order to conduct the evaluation, it is necessary to look for the indicators which are the basis for evaluating. So that all aspects and function of the park are represented and not also make an evaluation that is inconsistent with the context when the park has been designed with a specific purpose and facilities according to the developed theme of each thematic park.

3. Research Framework and Method
The research background is an issue regarding sustainability of revitalized Bandung urban park, which need to be evaluated its performance. There are some criteria and parameter that needs to be concerned in evaluating urban park performance. To reach those criteria, evaluations were done by assessing the park components and elements, so it has to be a quantitative assessment. The indicators were combined through selected landscape indicator, sustainable green open space indicator, and successful public open space indicator, which results in a proposed set of urban park indicator, adjusted with Bandung urban park’s characteristics.

Method used in this research are literature review and site observation. A literature review is conducted on topics ranging from landscape indicators, successful public space indicators, to the qualitative and quantitative parameters of each component. At this stage the general indicators of the landscape are collected and defined. After the initial proposed indicators are established, a preliminary site observation to the 30 parks in Bandung city conducted to check whether the indicators are suitable with the park’s condition and its context. After these preliminary site observations were conducted, further refinement of the initial indicators was carried out, and resulting a more comprehensive indicator set, with scoring method and parameter for each component (see Figure 1).

![Figure 1. Research framework and method.](image-url)
4. Sustainable Landscape and Landscape indicator

Urban green open space has three benefits that are ecological and environmental benefits (a habitat to support biodiversity conservation, improve micro-climate, decrease carbon emission levels, filters out other particles and dust, controls water regime and reduces run-off, absorb and reduce the noise generated by human activities, and also act like wind breaker), social benefits (offer citizens various activity choices which promote social cohesion, designed and serve to everyone in the community, serve the community’s leisure needs and socialize, and environmental education), and health benefits (to protect from exposed to pollution and infectious diseases, against an urban passive lifestyles lead to some serious health problems, urban citizens have less contact opportunities with nature which is also linked to health and well being) [7].

A conceptual framework has proposed (Figure 2) which links green infrastructure performance into ecosystem services, ecosystem health and human health and wellbeing. This framework provides a conceptual basis to establish a composite indicator-based model for assessing green infrastructure sustainability performance [6].

![Figure 2. Conceptual framework of green infrastructure [6].](image)

4.1. Environmental indicator

The indicator is a parameter associated with an environmental phenomenon, which can provide information on the characteristics of the event in its global form (OECD 2003). Then, an indicator is an element of the environment or characteristic of it able to represent, individually or in combination with other parameters, environmental characteristics not directly measurable through physical units (Malcevschi, 1991). By using the indicators we can obtain targeted information, in order to concisely represent the problems studied while maintaining the informative content of the analysis intact (Schmidt 1986). Selected indicators must have unique, strategic, computable, and statistically monitorable characteristics (Carollo, 2008). Other useful features to consider when formulating and selecting indicators are that they be representative, accessible, and reliable (Vismara, 1990). We distinguish, therefore, “descriptive” indicators and “performance” indicators: the first kind is used to characterise the environmental situation and monitor the planning process; the second kind enables measuring of the degree to which objectives are achieved [2].

One consolidated instrument for the integrated analysis of the social-economic and environmental aspects in the field of sustainability assessment is the system of environmental indicators known as the DPSIR model (Driving forces, Pressures, State, Impacts and Responses), established by the Organisation for Economic Co-operation and Development in the early 1990s (OECD 1993), and acknowledged by the European Environment Agency (EEA 1995) [2].
Figure 3. DPSIR model [4].

4.2. Landscape indicator
Vallega (2008) first establishes the functions of the indicators as recognition (monitoring and measuring), evaluation (judgement of the value), and orientation (supplying indications) function. Landscape indicators can be identify at least in three categories: “structural”, for which we can make objective measurements that, when changes occur, affect more subjective cognitive aspects; “functional”, or physical–biological indicators, mainly attributable to the aspects of ecosystems that occur at different scales; and “cognitive-functional”, relating to the nature of the first two categories of indicator, seeking to address the possible subjectivity of other indicators.

Landscape indicators are very important as they identify resources, qualities, and criticalities of a particular area and act within the four (ecological, social, cultural, and institutional) contexts of sustainability: they should not be used alone but in a broader context [3].

Table 1. Landscape indicators, its characteristics and function [3].

| Category | Indicator | Characteristics | Function |
|----------|-----------|-----------------|----------|
| Biological quality | 1. loss of species | environmental indicators to use in introductory phase | risk evaluation |
| | 2. richness of species | | |
| | 3. endangered species | | |
| | 4. protected species | | |
| | 5. environmentally sensitive areas | | |
| Environmental quality | 1. transparency of air | quality estimation | risk evaluation |
| | 2. transparency of water bodies | | |
| | 3. protection of the caves | | |
| Urban quality | 1. wellness acoustic | indicators to evaluate risk | evaluation |
| | 2. spaces pedestrian | how urban sprawl has contributed to the transformation of the territory | |
| | 3. revitalization historic spaces | | |
| | 4. enhancement urban green | | |
| Culture tangible | 1. protection of the Archaeological Heritage | include indicators that relate to the material signs that culture imparts on the territory connecting the landscape | *richness* |
| | 2. enhancement of industrial | | *valuing* |
| | 3. creating cultural trails | | *development* |
| | 4. protection UNESCO sites | | |
| Intangible culture | 1. viewpoints | indicators that lead to the symbolic value of places | *membership* |
| | 2. places of Taste | | *enhancement* |
| | 3. places heterotopic | | *development* |
| | 4. places of events | | |
| | 5. places of personality | | |
| Aesthetic quality | 1. value of the skyline landscape | indicators to monitor the extent to which the infrastructure as a pressure factor | risk evaluation |
| | 2. safeguarding the terraced landscape | | |
| | 3. landscapes injured | | |
| | 4. pressure of parking | | |
| Institutional action | 1. efficiency of the measures referred to landscape planning | indicators to monitor the extent to which | *planning* |
| | | | *development* |
According to DSE (2007) sustainability assessment is ‘a generic term for a methodology that aims to assist decision making by identifying, measuring and comparing the social, economic and environmental implications of a project, program, or policy option’ (DSE, 2007, pp1). Green infrastructure performance indicators play an important role in successfully achieving the urban sustainability targets. An Attilia Peano (Turin Polytechnic) study group conducted the following, final example of research surrounding landscape indicators in which categories were grouped as ecology, perception, land uses, cultural heritage, and economy [4].

Figure 4. Landscape indicator category [4].

5. Development of Indicators and Criteria/Parameter to Evaluate Bandung Public Green Open Space Performance

Performance evaluation on urban park, in which its function as the city’s green infrastructure, has many different methods depends on what indicators and parameter used. As physical and nature feature of the park represents the perceived environment, the assessments are often based on visual perception. Measuring the perception of the landscape is not easy and involves many critical assumption, in other words, the quality assessment based on perception may be considered subjective. Landscape is considered a resource used and consumed by people, so the quality of this resource is important. Landscape can be modified and managed to provide services for society and based on the society’s needs. To obtain a better-quality assessment than the subjective one, further steps have to be made for a more objective result. To assess performance and success of green infrastructure, a selection of indicators has to be combined and adjusted with the city’s characteristics in order to generate a reasonable result [8]. These 28 indicators have been selected based on previous literature review of landscape indicator, sustainable green open space indicator. The indicators that considered appropriate to the green open spaces context in Bandung will be selected as an indicator in this study. The proposed variables or the indicators are both qualitative and quantitative. Preliminary survey within 16 new revitalised park in Bandung has been conducted to identify which indicator be in those parks. The preliminary survey of the 16 Bandung urban parks was conducted in Babakan Siliwangi Park,
Cikapayang Park, Ganesha Park, Maluku Park, Tongkeng Park, Pustaka Bunga Park, Saparua Park, Cilaki Park, Pet Park, Inklusi Park, Persib Park, Karang Taruna Park, Lansia Park, Karta Park, Superhero Park, and Seram Park.

Based on these preliminary survey, the following results are obtained: The park that has the most indicators is Maluku park. The following are the maximum and minimum score of each performance indicator. The maximum number of ecological indicators were found on Maluku Park with total score were 0.69 out of 1. The minimum number of ecological indicators were in Karta Park with score 0.31. The maximum number of health indicators were in Saparua Park with score 0.72 while the minimum number of health indicatros were in Cilaki Park is 0.28. The maximum number of ecological indicators were found also in Saparua Park is 1 and the minimum number of ecological indicators were found in Pet Park is 0. The maximum number of Socio-Cultural indicators were found in Maluku Park is 0.70, while the minimum number of socio-cultural indicators were found in Cilaki Park is 0.16.

Based on initial result of indicator mostly found in the preliminary survey, a more comprehensive proposed indicators set was obtained in order to carry out evaluation of Bandung city thematic parks performance. Table 2 below shows a proposed indicators set, including 18 performance indicators and 73 assessment components. Each assessment components also completed with parameters and criteria to make it quantitative.

| PERFORMANCE INDICATORS                                      | Assessment Components                              |
|-------------------------------------------------------------|----------------------------------------------------|
| **ECOLOGICAL INDICATOR**                                   |                                                    |
| C1 Climate & microclimatic modifications                    | Regulation of solar radiation                      |
|                                                             | Lowering air temperature through evapotranspiration and shading |
|                                                             | Wind breaking/wind speed modification              |
| C2 Reduced building energy use                              | shading by trees                                    |
|                                                             | covering building by green roof and green wall     |
| C3 Hydrological regulation                                  | Biopore holes                                      |
|                                                             | Natural Swale                                      |
|                                                             | Drainage system                                    |
|                                                             | Permeable pavement                                 |
|                                                             | Retention pond                                     |
|                                                             | Detention pond                                     |
|                                                             | Water reuse and recycling                          |
| C4 Waste decomposition and cycling                          | Waste sorting                                      |
|                                                             | Waste container                                    |
|                                                             | Waste treatment facility                           |
|                                                             | Waste treatment system                             |
|                                                             | Garbage collector                                  |
| C5 Biodiversity enhancement                                | Vegetation and Planting                            |
|                                                             | Wild animal                                        |
|                                                             | searing area                                       |
| H1 Improving physical-well-being                           | sport/ physical exercise facility                  |
|                                                             | Jogging/running track                              |
|                                                             | playground                                         |
|                                                             | play equipment                                     |
|                                                             | stairways                                          |
| H2 Improving social-well-being                             | social interaction                                 |
|                                                             | social integration and community cohesion          |
|                                                             | reducing mental fatigue                            |
|                                                             | healthier feeling                                  |
|                                                             | emotional benefit                                  |
|                                                             | spiritual benefit                                  |
| H3 Improving mental-well-being                             | Land and property price per m²                     |
|                                                             | Local visitor (from Bandung)                       |
|                                                             | non-Bandung visitor                                |
|                                                             | street vendor                                      |
| E1 Increased property values                                |                                                    |
| E2 Supporting local economic activity                       |                                                    |
To assess each parameter of indicators, likert scale method was used to value parameters, ranged from 1 to 5, in which the minimum score/ worst value is 1, and the maximum/best value is 5 (Table 3). To find the suitable parameter and criteria, each assessment component was reviewed and through literature reference, all performance indicators could be valued quantitatively by the likert chart. After preliminary survey and further discussion through the result, the survey was re-conduct using criteria and parameters to give score to each assessment component. But the assessment was done not only by scoring but also be given description to each component based on surveyor’s perspective.

| PERFORMANCE INDICATORS | Assessment Components |
|-------------------------|-----------------------|
| S1 Urban farming        | urban farming          |
|                         | kitchen or medicinal garden |
|                         | community garden       |
| S2 Opportunities for recreation, tourism, and social interaction | public toilet |
|                         | Shelter/gazebo         |
|                         | Plaza/stage            |
|                         | art installation       |
|                         | pets area              |
|                         | water fountain         |
|                         | interactive water play |
|                         | pond/lake              |
|                         | colorful planting/ flowery landscape |
|                         | entertainment          |
|                         | aromatic plants        |
|                         | landscaping beds       |
| S3 Improving pedestrian ways and connectivity | walkway inside park |
|                         | sidewalk               |
| S4 Improving accessibility | entrance/gate          |
|                         | bike rack/shelter      |
|                         | vehicle parking space  |
|                         | bus and angkot shelter |
|                         | map                    |
| S5 Supporting education and research | historical monument/ historical feature |
|                         | information board      |
|                         | plant identification board |
|                         | park library           |
|                         | thematic garden        |
| S6 Reduction of crimes and fear of crime | lamp at walkway, park area, sitting area, shelter, entrance |
|                         | park border            |
|                         | visibility and openness within the entire park, to the street and surrounding |
|                         | regulation board       |
|                         | park/security officer  |
| S7 Attachment to place and sense of belonging | historical mark |
|                         | landmark               |
|                         | historical story of the park/city |
| S8 Enhancing attractiveness of cities | enhancing attractive view |
|                         | restricting undesirable view |
|                         | vantage point          |

| Item | Item Description | Score range |
|------|-----------------|-------------|
| 5    | Very good/ highly suitable to parameter | 4.21 – 5.00 |
| 4    | Good/ partly suitable to parameter      | 3.41 – 4.20 |
| 3    | Moderate/ fair                            | 2.61 – 3.40 |
| 2    | Bad/ low suitability                      | 1.81 – 2.60 |
| 1    | Very bad/ component is not existed        | 1.00 – 1.80 |
The second observation was conducted in Lansia Park, located on Jalan Diponegoro Bandung. This park was selected because it has complete data, especially climate data. Beside of that, this park was considered as one of the most popular park in Bandung, widely known not only by the citizen but also by visitors from other regions. On this phase, the assessment was conducted to value the assessment components. The parameters assigned to each component, however can be quantitatively assessed and thus, can be compared with other park performance evaluation results.

Table 4. Evaluation of Lansia Park based on ecological indicator category C3-C5.

| PERFORMANCE INDICATORS | ASSESSMENT COMPONENT | CRITERIA/PARAMETERS | score | OBSERVATION RESULT |
|------------------------|----------------------|---------------------|-------|-------------------|
| **C3 Hydrological regulation** | Biopore holes | availability of biopore holes with n amount. n= (rain intesity mm/day x impermeable area m²): velocity of water infiltration per hole. | 1 | no biopore holes |
| | Natural Swale | natural/bioswale that infiltrate run-off, slope 1:4, channel width 0.5-2.5 m | 1 | no natural swales |
| | Permeable pavement | all pavement area using porous/permeable material | 3 | pedestrian way pavement is impermeable. Plaza and seating area using paving block which is porous material (but the lower layer is unknown) |
| | Retention pond | retention pond with sedimentation pond, water plants on slope, depth >1.8 m | 2 | 2 retention pond, 1 was leaked, 1 was functioning with sluice-gate to control waterflow |
| **C4 Waste decomposition and cycling** | Waste sorting | waste sorting container based on waste type, at least 2 containers for organic and non-organic waste | 2 | some types of bin had 2 separated compartments |
| | Waste container | 1 waste bin per radius <25m, garbage bin at certain area; sitting area, dining area, smoking area, entrance, parking, plaza; Durable and strong material. Harmony with park visual quality, Aesthetic and Minimize vandalism. | 3 | 20 waste bins in entire park. Some were broken. No unifying design (many different types and material) |
| | Waste treatment facility | waste collecting and treatment facility to compost/treat waste without disturbing visual quality of the park and visitor comfort | 1 | no waste treatment facility |
| | Garbage collector | at least 1 garbage collector or waste manager, for 100 m² park area | 3 | garbage collector also as caretaker |
| **C5 Biodiversity protection and enhancement** | vegetation and planting | enhancing local vegetation, non-toxic, not dangerous to visitors (thorn, big fruit/branches falling), easy to maintain, enhancing visual quality | 4 | local plants species, various height and ages. Tree branches should be trimmed to let sunlight in |
| | wild animal | wild animal found living/transit in the park without threaten visitor or animal itself | 4 | species of birds, reptiles, insects, etc. were found. Park and trees also is a green corridor |

6. Conclusion
In order to evaluate the sustainability performance of the revitalized Bandung’s Urban Green Open Space, Indicators and Parameters are needed. Those indicators and parameters make the evaluation
process can fulfill various aspects of sustainability, so that the success or failures of the revitalization result are no longer seen partially.

From the result of various literature studies, that used to explore the aspects and indicators of park’s sustainability performance evaluation, verified by observing the presence of those indicators in revitalized parks. There are 28 performance indicators, assessment components, and parameters for each of assessment component.

Further and deeper researches are still needed for more measurable parameters development by involving interdisciplinary science fields in both engineering and social fields against each element directly related to the science fields.

References

[1] Ari MM, Zulkaidy D, Pratiwi WD 2016 Evaluasi dampak penyediaan taman-taman tematik kota bandung berdasarkan persepsi masyarakat sekitar Prosiding temu ilmiah IPLBI Bandung

[2] Bottero M 2011 Indicators assessment systems Landscape indicators: assessing and monitoring landscape quality Springer 15-29

[3] Bruni D 2016 Landscape quality and sustainability indicators Agriculture and agricultural science procedia 8: 698–705

[4] Cassatella C and Voghera A 2011 Indicators used for landscape Landscape indicators: assessing and monitoring landscape quality Springer 31-46

[5] Ilmiayanti F, Dewi DIK 2015 Persepsi pengguna taman tematik kota bandung terhadap aksesibilitas dan pemanfaatannya RUANG Volume 1 Nomor 1: 21-30 Universitas Diponegoro

[6] Pakzad P and Osmond P 2016 Developing a sustainability indicator set for measuring green infrastructure performance Urban planning and architecture design for sustainable development UPADSD 14-16 October 2015 Procedia - social and behavioral sciences 216: 68 – 79

[7] Ozyavuz M 2012 Landscape planning Urban landscape design Memluk Murat Z Ankara University Turkey

[8] Gavrilidis A et.al 2016 Urban landscape quality index – planning tool for evaluating urban landscapes and improving the quality of life International Conference – Environment at a Crossroads: SMART approaches for a sustainable future Procedia environmental sciences 32 ( 2016 ) 155 – 167.

[9] Dipa A 2017 Teenagers happiest people in Bandung: survey (http://www.thejakartapost.com/news/2017/09/09/teenagers-happiest-people-in-bandung-survey.html)