Basic framework of urban design based on natural resources

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Abstract. To establishment of the city always begins because the availability of natural resources that meet the basic needs of its inhabitants, but after that the city relies on the sustainability of those basic need, which is primarily dependent on transportation. Transportation becomes the main needs of the city. Transportation, however, results in the potential for the city’s discomfort with noise and pollution, which mixes with the frenetic city life. Therefore, this paper reveals a basic framework using natural resources to reduce the noise and the pollution.

1. Introduction

In modern life, a city is not only a common home of its inhabitants-human, but also a bulwark of natural against man-made, or inconvenient disruption [1]. A city that continues to experience floods, animal attacks, dirty, no beauty or disturbances that psychologically degrades comfort is a city not habitable systematic [2]. The city system consists of components that are connected to another, and if one of them is not good then overall the system disturbed [3].

Transportation is one component that connects the city with out of town. In this case, they as the lifeblood of city life. However, irregular transport may result in the absence of a major function of the city, and this transportation psychologically reduces the ability of each occupant to move well. A lot of studies have been conducted to reduce the adverse effects of transportation technology on the city, but a few of researches about the role of natural resources related to urban transport [4]. This paper intends to reveal a basic framework of a design involving natural resources (trees, shrubs and bushes) to reduce the impact of transportation technology (vehicles).

2. Review and Motivation

Natural resources are generally expressed as materials available in nature that have not received a touch of human activity [5]. Indonesia has abundant natural resources and they as a curse if not used properly [6]. Resources such as sunlight, atmosphere, water, and land continue to exist throughout the year so that Indonesia has a rainforest. However, natural resources such as water, air, soil, mountains, rocks, minerals, organisms, fishes, animals, and other entities can all be obtained wherever not yet become welfare advocates in Indonesia. Not a few cities in Indonesia, including the capital city of Jakarta,
degraded its convenience due to misuse of natural resources, such as the misuses of groundwater that causes the descent of the land surface [7].

The welfare of a city involves structuring the use of natural resources [6]. The modern cities are generally polluted by the pollution. The pollution is generally derived from human activities, including air pollution that applies physically, biologically and chemically. Physically, dust, foul odour, and hot temperature affect air quality [9]. This pollutant is easy to feel and so easy to avoid. Biologically, the germs that fly in the air affect the health environment. Chemically, the exhaust gas, factory smoke, excessive combustion (waste) affect the quality of the living environment. Generally, chemical and biological pollutants are not easily perceived as a result and are not easily avoided, especially chemical pollutant such as motor vehicle exhaust gases and factory smoke are more dangerous because they contain toxins [10]. In addition, human activity also produces a generally recognizable sound as a noise, which is quite disturbing to humans. Some studies show that traffic noise can increase psychologically high blood pressure [11].

Table 1. Threshold of vehicle emission based on year release.

| Number of wheels | Type of gases | CO (%) |
|------------------|--------------|--------|
| 2 or 3           | HC (max)     | 4.5%   |
|                  | CO (max)     | 12% - 15% |
| 4 or more        | CO2          | 1.5%   |

The transportation directly produces two destructions of comfort to nature: pollution and noise. Air pollution is caused by carbon monoxide (CO), carbon dioxide (CO₂), hydrocarbon (HC), and other gases discharged by motor vehicles. Threshold of vehicle emission for year of manufacture ≥ 2010 based on regulations of Indonesia like Table 1 [12,13]. (, while comparison of mixture of some kinds of gas in clean air: nitrogen (N₂) is 78%, Oxygen (O₂) is 21$, and others (argon (Ar), carbon dioxide (CO₂), helium, neon, krypton, hydrogen, ozone, xenon) are 1% [14].

In addition, transportation also produces unwanted sounds or called noisy. Noise is an undesirable sound from a business or activity in a certain level and time that may cause health and environmental disturbance [15]. The traffic noise level can be expressed as follows

\[ L_{eq} = 10 \log \frac{1}{N} \sum n_i 10^{[x/10]} \text{dB}, \]

where \( n_i \) = number of observations with \( L_i \) noise level, and \( N \) = total of observations [16].

As far as the development of transportation technology, the bad effects of motor vehicles are still around air pollution and noise. The only solution to this problem is to organize urban areas with parks and trees, and build open spaces with natural resources such as urban forests. However, the failure to switch natural resource functions such as trees can cause other disruptions such as tropical diseases caused by mosquitoes, for example.

3. An Approach

As an approach, several entities are defined to derive a model that can express the behavior of natural resources. For the natural resource entity \( E \) is given the basic function \( F = \{ f_i; i=1,\ldots,J \} \), i.e. \( f_i(e_j) \) for each \( e_j \) in \( E, j=1,\ldots,J \), with the limit function \( C = \{ c_k; k=1,\ldots,K \} \) or \( c_k(e_j) \). Basic functions are valuable characteristics given by nature as electrical, gravity, heavy, magnetic, and strength properties, all of which are innate properties of natural resources [10,18]. The nature of water is flowing, the nature of solid objects are static, and the nature of air is moving. They are the basic functions of the related entity. While the function limitations associated with the number of resource entities in a particular area. For example, the entity being discussed are trees, shrubs and bushes that have basic functions: Each as an entity to fill the city street or open space garden, the basic function of the tree is to protect the road in order to shade, the basic function of the shrubs is to decorate the empty space, while the basic function of the bushes is to polish and beautify every empty space. Each also has a function of limitations, for
example, the number of trees that can be planted in a particular range of roads is limited following a good plant spacing for the tree [19].

The value-added function is related to the value of the touch that may be given by man to the related entity in order to have more value than the basic function, that is $av(e_j)$. Furthermore, contrary to that, each entity has a destructive function $dv(e_j)$ that reduces the value of basic functions for a given number of natural resource entities. Each small tree requires intensive maintenance to be sturdy, while when it has grown up bigger trimmed so that the branches do not overflow out of the road, including throwing the weathered branches. A time length of intensive maintenance becomes the burden of maintenance costs that must be borne by the city. Pruning should be planned and special teams should be deployed, and the calamity caused by the urban park tree becomes the responsibility of city insurance. In addition, every day the trees will abort the leaves that must be cleared from the road and the garden, workers in a certain range of roads should be placed. Structuring shrubs should also be done regularly to keep the beauty awake. While the bush requires pruning to look neat and do not disrupt the road.

| $E$ | $f(e_j)$ | $av(e_j)$ | $dv(e_j)$ | $E_1E_2$ | $E_2E_3$ | $c_k(e_j)$ |
|-----|---------|-----------|----------|---------|---------|---------|
| $e_1$ | ?       | ?         | ?        | ?       | ?       | ?       |
| $e_2$ |           |           |          |         |         |         |
| $e_3$ |           |           |          |         |         |         |
| ...  |           |           |          |         |         |         |
| $e_1$ |           |           |          |         |         |         |

In general, the value-adding and destructive functionality can also be expressed through the collaboration function between the entities. Every natural resource entity affects its environment well or not. Internal collaboration is the ability to influence the environment simultaneously between the same entities, while external collaboration is the ability to influence the environment collectively between different entities. Collaboration can generally be expressed through $\Sigma p(e_j) = p(e_1) + p(e_2) + \ldots + p(e_j)$ internally $(E_1E_2)$ and $p(e_j) = e_j/e_1$ externally $(E_1E_2)$, where $p(e_j)$ is a probability of an entity influencing the extent of the environment against open space, $p(e)$ is a probability of an entity’s influence on another entity [20]. In addition, the value of collaboration can be built using the possible similarities between entities. Therefore, through the Table 2, each entity can be assigned a value according to the function that may be applied to that entity.

4. Design and discussion

Urban design to overcome the adverse effects of transportation technology can be done by designing city parks and open spaces available, especially the roadside as the main buffer facing directly with sources of pollution and sources of noise. The inhabitants of the city, whether human beings or animals need oxygen and get rid of CO$_2$, only plants that produce O$_2$ by using CO$_2$ during the day. Moreover, research results in several different places indicate that pollution (CO, CO$_2$, NO$_2$, O$_3$, etc.) can be removed by using urban trees and shrubs and shrub from urban crops [8,9,14]. Therefore, we can assume that all trees, shrubs and bushes have a role to overcome air pollution as their primary function. Because although efforts to build renewable energy based transportation equipment continue to be done, but until now the stable transportation still involves fossil fuels as an energy source.

City dwellers also need comfort and are not distracted by unwanted or noisy sounds. Therefore, it should be statistically disclosed that trees, shrubs and bushes have the ability to muffle noise, of course with the collaboration between entities to fill the city park. Collaboration between entities is the ability to support each other in a single location [16]. The tree has a leafy nature with long lasting leaves, and able to grow tall for the under which shaded. Such a tree, certainly able to retain groundwater, evaporation is not high, and maintain the moisture of the surrounding soil. Selective shrubs are determined by the ability to adapt to shade, as well as bushes. So, the tree that can hold moisture soil, adapted by bushes and bushes well, so that when the dry season comes shrubs and bushes can survive.
However, the property of each natural resource entity, needs to be explored and recorded so that the same properties become a support for collaboration and different properties into factors of reducing the value of collaboration in urban parks, such as the collaborative design in Fig. 1.

![Diagram of natural resources on the road](image)

**Figure 1.** Design of natural resources on the road.

The similarity between entities can be expressed by using

\[
\text{Sim} = \frac{|E_1E_2|}{(|E_1|^2+|E_2|^2)}
\]

(2)

where by \(|E_1E_2|\) is the value of the same properties of two entities or the value of mutual support between entities [21]. The value of two entities is derived from the number of identical properties of entities or values converted to a benefit. The same properties of both entities, for instance, are equally capable of reducing noise and can equally reduce pollution. The difference lies in the benefit (value added): the benefit of the tree is much better than the shrubs, as well as the bushes, but some shrubs or bushes may be equivalent to a tree. Based on the different tasks between trees, shrubs, and bushes, the beauty of a city or park can be well built. Bushes also have the support of shrubs or reduce the support with the emergence of annoying insects, but the choice of certain bushes supports the park better, such as bushes that become anti-mosquito or other insects, so that if there are public facilities such as a stop bus no small disturbance for passengers.

In general, trees have solid stems, whereas shrubs may have hollowed stems, hollowed stems generally give higher absorbance to noise. Meanwhile, the independent value of any entity is derived from the distinct nature of the entity about the benefits given by that entity. However, to obtain the exact
value of each entity involved in filling the city park requires experimentation on each entity. Measurements for the absorption of trees, shrubs, or bushes against pollution or noise can be determined. Statistically, the larger the tree, the leaves are more dense, or the thicker the shrub will be able to better absorb noise and reduce pollution.

Conclusions
By deriving the functions of natural resources as recordable and value-added traits, the collaboration of natural resource entities can be composed in such a way through the principle of similarity to tackling pollution and noise within a city. However, the benefits gained under this design require experimentation to get the benefit every entity involved. Therefore, the next research to get the added value for each entity based on the experiment.

References
[1] M Kaika and E Swyngedouw 2000 Fetishizing the modern city: the phantasmagoria of urban technological networks *International Journal of Urban and Regional Research* 24 (1)
[2] M Gandy 2004 Rethinking urban metabolism: Water, space and the modern city *City* 8 (3)
[3] D A Smith, M Timberlake and D A Smith 1995 Conceptualising and mapping the structure of the World System’s City System *Sage Journals* 32 (2)
[4] D J Nowak, J C Stevens, S M Sisinni and C J Luley 2002 Effects of urban tree management and species selection on atmospheric carbon dioxide *Journal of Arboriculture* 28 (3)
[5] T Gylfason 2000 Natural resources, education and economic development *Centre for Economic Policy Research*
[6] J D Sachs and A M Warner 2001 The curse of natural resources *European Economic Review* 45
[7] R Repetto, W Margrath, M Wells, C Beer and F Rossini 1989 Wasting assets: Natural resources in the national income accounts *World Resources Institute*
[8] F I Khan and A Kr Ghoshal 2000 Removal of volatile organic compounds from polluted air *Journal of Loss Prevention* 13
[9] D J Nowak, D E Crane and J C Stevens 2006 Air pollution removal by urban trees and shrubs in the United States *Urban Forestry & Urban Greening* 4
[10] L M McKenzie, W M Hao, G N Richards and D E Ward 1995 Measurement and modelling of air toxins from smoldering combustion of biomass *Environ. Sci. Technol* 29 (8)
[11] G W Evans, M Bullinger and S Hygge 1998 Chronic noise exposure and physiological response: A prospective study of children living under environmental stress *Psychological Science* 9 (1)
[12] J F Dwyer, E G McPherson, H W Schroeder and R A Rowntree 1992 Assessing the benefits and costs of the urban forest *Journal of Arboriculture* 18 (5)
[13] Peraturan Menteri Negara Lingkungan Hidup Nomor 05 Tahun 2006 tentang Ambang Batas Emisi Gas Buang Kendaraan Bermotor Lama Kementerian Negara Lingkungan Hidup 2006
[14] D J Nowak, K L Civerolo, S T Rao, G Sistla, C J Luley and D E Crane 2000 A modelling study of the impact of urban trees on ozone *Atmospheric Environment* 34
[15] Keputusan Menteri Negara Lingkungan Hidup Nomor 11 Tahun 1996 Tentang Baku Tingkat Kebisingan
[16] E A Morsen and D J Oldman 1977 Traffic noise reduction due to the screening effect of balconies on a building façade *Applied Acoustics* 10
[17] S Giljum, A Behrens, F Hinterberger, C Lutz and B Meyer 2008 Modelling scenarios towards a sustainable use of natural resources in Europe *Environmental Science & Policy* 11 (3)
[18] M K M Nasution 2017 Modelling and simulation of search engine *Journal of Physics: Conference Series* 801 (1)
[19] S Campbell 1996 Green cities, growing cities, just cities? Urban planning and the contradictions of sustainable development *Journal of the American Planning Association*
[20] I Lubis and K M N Mahyuddin 2017 Probability model for designing environment condition *Journal of Physics Conference Series* 801 (1)
[21] K M N Mahyuddin, O S Sitompul, S Nasution and H Ambarita 2017 New similarity *IOP Conference Series: Materials Science and Engineering* **180** (1)