Analysis of climate impact on urban landscape design adaptation (Case study: Green Lake View, Depok, West Java)

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Abstract. Global climate change threatens the structure and function of the ecological and economical system of urban landscape. The urgent need to mitigate and provide an adaptable urban landscape to climate change is becoming more widely understood, since the urban landscape allows a liveable environment for the well-being of urban dwellers and acts as a significant role in providing habitat for wildlife. The aim of this paper is to point out which urban design will able to adapt and mitigate future climate change that is applicable to Green Lake View and other similar climate countries. This paper will firstly discuss the fundamental relationship between the urban landscape design and climate. Then, it will analyse which urban landscape design that are able to not only adapt but also mitigate the climate change, by focusing on five main aspects which are: water cycle, green infrastructure, material selection, sustainable drainage system and plant species selection. The different aspects that deal with different climate will then be evaluated to show the definite impact of the design. The result of this paper produced will be focusing on design recommendations within climate change and ways to mitigate and adapt throughout the years.

1. Introduction
The Earth’s climate has always changed throughout the history, however the current climate change since the mid-20th century is of particular significance because it is 90% likely to be the result of human activities. For millennia, the atmospheric carbon dioxide has never been above 300 parts per million until the 1950s [1], which are the years of the human industrialization. Moreover, the rapidly increasing of the urbanization rate of people moving in to cities become a significant aspect that affects climate change, the trend in population increase has led to an increase in housing demands. This means there will be undesirable thermal effects and other unwanted changes when the natural lands are replaced by artificial surfaces. This issue together with the expanding industries caused a deteriorating effect on the urban environment. In tropical countries like Indonesia, hot climate together with high humidity and high solar radiation often causes a high stress urban environment for urban dwellers.

Although previous studies have added new knowledge and provided new insights, they have been mainly focusing on the bigger image of mitigating climate change [2,3]. Little research has been conducted specifically in high density urban areas in tropical countries such as Indonesia. Therefore, the aim of this paper is to analyze each five aspects that contributes to urban landscape design, which are: plant species selection, water cycle, green infrastructure, hard material selection and sustainable drainage system. Studying the relationship between each aspects and climate change, and provide guidance or a set of criteria that is much more adaptable to the climate and sustainable for the future.
1.1. Study area
The case study is a 13-hectare mixed-use urban district located at Depok, West Java in Indonesia as shown in Figure 1. This district has 5 housing clusters with a total of 223 units of houses, 4 units of apartments, 3 units of condo homes, mall center and a waterpark. It has a borrowed view of a Rawa Kalong lake across the district—thus the name Green Lake View. Depok is the second metropolitan city after Jakarta which has the second highest density of population and a very high increasing rate of urbanization. With the continuous rate of population keep increasing over time, the demand of housing areas need to be met.

![Figure 1. Masterplan of the study area in Depok.](image)

2. Research methods
This research will be using a descriptive qualitative method with the support of questionnaires for the residents and site survey for documentation. The questionnaires were conducted at the study area from 25 April to 30 April 2020 and site survey on the first week of May 2020. The purpose of questionnaires is to get primary data from perception of the residents as well as the owner of the Green Lake View district, to see their perception about the site and also validate the initial conditions of the site. The questionnaires given will be using Likert scale as a rating system to quantify the perception of the residents towards their feelings on Green Lake View urban landscape design. The scale ranges from 1 as the least and 5 being the most. The questionnaires’ topics include their knowledge and experience in the frequency, quality, importance and atmosphere of being in the green open space of Green Lake View. Table 1 shows the average respond from 35 respondents from the questionnaires about their perception on the existing urban landscape design of Green Lake View.

3. Results and discussion

3.1. Site survey and questionnaire results
The survey conducted on the first week of May is a month where the climate in Indonesia changes from rainy season to drought season, as the study area is located in Java island which is one of the 38.3% region that is going through that transition [4]. During transition season, the changes in temperature and air humidity are drastically changing and that affects the way people respond to their environment, this showed from the questionnaire results on Table 1 where the majority of respondents are very uncomfortable with the environment they are living in. Figure 2 is documentations from the site survey that represents the problem on site.

![Figure 2. Photos of the site (a) plants grow well in the site (b) choice of trees are poor (c) little greenery on the pedestrian (d) lack of natural area on site (e) shows little greenery in main circulation area.](image)
Table 1 shows, the average respond of each topic that has few questions on its own, and from this table itself there are a few things that can be concluded, which are: (1). 74.2% respondents agree that an urban landscape should be well-designed and suitable in their environment; (2). only 5.7% respondents has experience in doing outdoor activities, this means that either the open space did not support outdoor activities at all or the open space is poorly designed that people did not want to do engage activities outdoor; (3). 28.5% respondents agree that the quality of the open space on site is really poor and should be redesigned; (4). 97% respondents agree that it is extremely important to have facility that supports outdoor activities; (5). the same 97% respondents wants a comfortable outdoor environment.

| Topic | Agreement in the importance of a well-designed urban landscape design | Experience in outdoor activities and using the outdoor facilities | Quality of visual, facilities and management | Importance of having a complete facility, being able to do outdoor activities | Atmosphere or ambience that are needed (peaceful, shady, aesthetic, etc.) |
|-------|-------------------------------------------------|-------------------------------------------------|---------------------------------|---------------------------------|---------------------------------|
| A     | 2                                               | 19                                             | 10                              | 0                               | 0                               |
| B     | 0                                               | 8                                              | 8                               | 1                               | 1                               |
| C     | 3                                               | 3                                              | 7                               | 0                               | 0                               |
| D     | 4                                               | 2                                              | 3                               | 15                              | 5                               |
| E     | 5                                               | 2                                              | 2                               | 29                              |                                 |

3.2. Impact on the water cycle

Water sensitive urban design (WSUD) may be the answer to the problems that people are facing, it is the process of integrating water cycle management with the built environment through planning and urban design [5]. In Green Lake View, most of these designs can be applied to mitigate and adapt to future climate changes, it is also very suitable since the site has a waterbody next to it, which is Rawa Kalong Lake.

3.3. Impact on building green infrastructure

As the climate change increased the intensity and frequency of climate related disasters such as flooding, sea level rise, drought and UHI effects, the need to explore other urban infrastructure strategies becomes required [6]. As the study area is on a neighbourhood scale, green infrastructure that can be formed includes: local parks, constructed wetlands and green streets. Moreover, it can include site scale green infrastructure which are: stormwater planters, rain gardens, green roofs and living walls [7-9]. Through this study, it is very possible to apply these designs to the study area since it has many high-rise buildings and empty open spaces that can be built to support the interlinked green infrastructure. Therefore, it is important to note that green infrastructure is not just merely a program, a panacea, a short-term solution but it is a long-term ecological goal of systematic greenways that is supported by the coordination of everyone in the community.
Table 2. Water sensitive urban design and its purpose and effects on climate.

| Recommended design | Purpose and effects |
|--------------------|---------------------|
| Blue-green roof    | It has the capability to retain and detain large amount of rainfall runoff, reduce urban heat islands, reduce the energy consumption of a building by cooling roofs, and create habitats for plants and animals that also improve urban biodiversity and improves aesthetic appeals [10]. Thus, providing a better environment and micro-climate to urban dwellers living in both houses and high-rise buildings. A good bio retention system can remove a wide range of pollutants, such as suspended solids, nutrients, metals, hydrocarbons and bacteria from storm water runoff. It can be used to reduce peak runoff rates and increase storm water infiltration when designed as a multifunctional facility [11]. As an example on the study area where the rainy seasons are in a short period of time, bio retention can be a good choice because they are effective in controlling peak runoff in small storms of short durations [12]. Rain gardens are an area planted with native plant species, they also increase water retention which is a great importance in the context of adapting to climate change and the reduction of damage cause by intense rain [13]. Besides the primary purpose of quantity and quality control of stormwater, rain garden can also increase biodiversity, visual amenity, improve the local air quality and restore groundwater supply. |
| Bio retention       | Porous surfaces refer to paving or other surfacing materials that are permeable and allow the passage of water through the surfacing material into the ground beneath. This includes: porous asphalt, pervious concrete, porous turf and open-jointed blocks [14]. Studies indicate permeable surfaces can reduce rainfall peak flow by 95% and lower total rainfall by 95% in an event of 5mm rainfall and have the ability to curb flooding as less runoff will flow [15]. |
| Rain garden         | |
| Permeable surfaces  | |

3.4. Impact on material selection
On previous studies about the sustainability assessment of pavements, it is concluded that recycled aggregates were economically more efficient than virgin aggregates when the total life cycle is considered and it is also evident that recycled aggregates with higher elastic modulus would be influential in obtaining higher economic and environmental benefits [16,17]. Therefore, from this study we can recommend an urban landscape design adaptation in pavements, street furniture and walkways that every material use should be considered the following: (1) Pavements must be a permeable surface to lessen stormwater runoff on surfaces to avoid puddle or local flood. (2) Materials for street furniture and street pavements should consider using local on-site materials (efficient on budget and better for the environment). (3) Not using paint for street furniture, using the natural colour and texture from the material itself to last longer and not having to re-paint every few months. (4) Not only choosing out the right materials but it must be built according to the standard, lessening the materials can reduce its capability of performing well. Thus, pavements damage easily and more need to be spent on re-constructing it.

3.5. Impact on drainage system
Due to global warming, heavy precipitation events are expected to increase in frequency and intensity. Pavement of the surfaces, along with a possible climate change induced increase of rainfall intensifies is one of the key factors accountable for the increase flooding in urban areas [18]. Drainage networks that are designed based on historical climate regimes may be defunct in the future. SUDs are a range of drainage techniques allowing runoff attenuation and mitigation, pollutants reduction and amenity construction [19]. In order for SUDs to be able to adapt to future changing conditions, climate change and urbanization changes need to be incorporated into the design. Table 3 is the key design principles for designing sustainable urban drainage system for mixed-use district like the study area Green Lake View, this can also be applied to any housing district, parks and green spaces, streets, new developments and schools [20].
Table 3. Designing SUDs for people and wildlife.

| Key design principles                                  |
|--------------------------------------------------------|
| - Water quality must be controlled as it is critical for the development of SUDs. Poor water quality reduces the likelihood of creating valuable wildlife habitat and amenity value. |
| - Design should be easy to understand for those using it for recreation and also those responsible for maintenance to be easy. |
| - Structures should be simple, attractive and easy to maintain. |
| - Ensure that plants are native and local species, never introduce non-natives. |
| - Plants used should not be an invasive species, liable to spread and impact on sensitive habitat |
| - Where possible, retain existing habitats and incorporate them into landscape design. |

Source control

- Green roofs, living walls, rain garden, permeable surfaces, filter strips, bioretention areas

On-Site control

- Detention basins and retention basins

3.6. Impact on plant species selection

The restoration of trees remains among the most effective strategies for climate change mitigation [21]. This shown on Table 4, are the criteria to select the right plant species to be planted on urban areas, specifically on Depok, West Java, Indonesia.

Table 4. Criteria on plant species selection.

| Local name          | Scientific name          |
|---------------------|--------------------------|
| Angsana             | Pterocarpus indicus      |
| Akasia              | Acacia mangium          |
| Mahoni              | Swietenia macrophylla   |
| Tanjung             | Minusops elengi         |
| Trembesi            | Samanea saman           |
| Matoa               | Pometia pinnata         |
| Jati putih          | Gmelina arborea         |
| Asam jawa           | Tamarindus indica       |
| Akalipa merah       | Acalypa wilkesiana      |
| Dadap kuning        | Erythrina variegata     |
| Saga                | Abrus precatorius       |
| Cemara angin        | Casuarina equisetifolia |

4. Conclusion

The conclusions are the list of the recommended design that are able to mitigate and adapt to future climate change and could be applied to urban landscape design for mixed-use site Green Lake View in Depok, West Java: 1. Build blue-green roof if possible, bio retention or rain garden, and use permeable surfaces as much as possible that covers the ground. 2. Build green infrastructure such as stormwater planters, pocket parks, living walls and green roofs. 3. Choose local materials, use less paint and permeable pavements for streets. 4. Drainage system should be planned a head, both source control and on-site control must be calculated and designed for current climate and not use conventional drainage systems. 5. Plant species selection should be native plants and able to reduce carbon dioxide, absorbs pollutants at high rate (see Table 4).

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