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GREEN CITY DEVELOPMENT CONCEPT PILOT PROJECT IN SERPONG URBAN RESIDENTIAL

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ABSTRACT

In recent times, continuous population growth and rising urbanization in many countries have made some considerable impact on the quality of life of people living in the urban area and in the environment itself. The increasing number of people in an area will create a scarcity of resources and also degrade its environmental condition, especially the water resources. In order to counter these negative impacts, a sustainable urban development concept is put in place. This study uses three main focuses related to green city development concept, which are low water footprint, low carbon footprint, and zero/less delta runoff. The object of study is the implementation of the three main focuses selected in Serpong Urban Residential, as a pilot project of an integrated modern and rapid-growing residential area. This study includes the water balance produced from the calculation, and the strategic recommendation proposed for managing the water resources based on the review of the aspects. From the water balance, it is known that the area will have a water deficit in initial forecasted years. In this case, the amount of forecasted water deficit can be covered by utilizing either a rainwater harvesting method or water recycling method. Therefore, Serpong Urban Residential can become a pioneer for developers with its integrated study related to the green city development concept.

Keywords: Green city development concept; Rainwater harvesting; Serpong urban residential

1. INTRODUCTION

The continuous growth of population is the biggest challenge that will continue to be faced by the rest of civilization on this earth. The predictions of the global population in 2025 is predicted to be from 7.6 billion to 8.1 billion (United Nations, 2013). In this case, Indonesia is expected to bear a population burden of 278 million from the current population which has reached 249.8 million. It is estimated that by 2025, the largest population in Indonesia that will be active in urban areas will reach 60%. This will directly have an impact on many things ranging from supply, water, food, energy, space, and housing or settlements to controlling pollution loads. Meanwhile, the standard living condition to support the comfort and productivity of people who live in urban areas is urged to be guaranteed by various parties.

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Despite the comprehensive approach in urban planning, most of the urban problems remained as irresolvable and is becoming beyond the control of planners which in-turn brings down both quality of life and the natural environment (Pankaja & Nagendra, 2015). Hence, the green city concept emerged. The Directorate General of Spatial Planning, Ministry of Public Works and Housing, had released a Green City Development Program in 2016. The program has stated eight attributes of a green city and is expected to be fully adopted by many cities in Indonesia as part of a low impact development strategy that is also sensitive to the impact of climate change. The impact of climate change in Indonesia is also being taken on by developing areas such as urban entities with the green city concept (National Spatial Planning Coordinating Agency or Badan Koordinasi Penataan Ruang Nasional, 2012).

Serpong as one of the buffer zones for the Special Capital Region of Jakarta has experienced tremendous and rapid development and resulting in the overloaded carrying capacity and capacity of its environment. The problems that Serpong face are the high numbers of land conversion from unconstructed land to constructed land and the decrease of green space area (Dwihatmojo & Giyarsih, 2015). The conversion has an impact on the increasing amount of runoff and the decreasing amount of water infiltration. Hence, resulting in a decrease in groundwater availability, even though the need for clean water keeps increasing (Sujatini, n.d.).

Serpong Urban Residential has a total amount of built area of 1,500 Ha, with around 12,000 property units which include housing areas, commercial area, automotive center area, office towers, golf course, and several mini clubhouses. Serpong Urban Residential also has several crucial public infrastructures such as schools, universities, modern market, and hospital. In 2013, Serpong Urban Residential was classified as a metropolitan city with the population reach of around 1 million people, which makes the area an integrated modern residential area and thus selected as the object of study.

The area is set to implement the green city concept in its development and also create some strategy to enhance the green value of the area. Low water footprint, low carbon footprint, and zero/less delta runoff are the main focuses of this study which is related to the green city development concept. Through this study, Serpong Urban Residential can become a pioneer for developers with its integrated study related to green city development.

2. LITERATURE STUDY

A sustainable urban development concept, also known as the green city concept, was introduced by some urban developers and supported by local governments. This is a practical solution needed in order to maintain the quality of life of the people living in the urban area, as well as to protect the environment. Green city planning concept, not a new concept, but it is a new approach in the urban planning processes to overcome current inabilities in handling the urban problems which were treated as complex and un-resolvable to make urban planning more sustainable without damaging the urban ecology and environment (Pankaja & Nagendra, 2015).

In Indonesia, The Directorate General of Spatial Planning, Ministry of Public Works and Housing, has released a Green City Development Program in 2016 which has 8 attributes: green planning and design, green open space, green waste, green transportation, green water, green energy, green building, green community (Kirmanto et al., 2012). Serpong Urban Residential has performed some significant implementation of green city concepts in development and also has created some plans that can be set into reality in order to enhance the green city value of its area. Three main focuses selected as the base for implementing the green city concept in Serpong Urban Residential are low water footprint, low carbon footprint, and zero/less delta runoff. By considering the water scarcity, solid waste generation, land conversion, and also environmental degradation that caused by high population.

The first factor that is needed to implement the green city concept is to develop an area to emit a low water footprint. The water footprint of an area can be seen from its pattern and level of water consumption, as well as the generated wastewater. A water footprint can also be lowered by the recycling of wastewater and also by rainwater harvesting. The second factor is the area's low carbon footprint, a concept where a said area has a low fossil-fueled energy consumption and a low greenhouse emission. The third factor is performing "less or zero delta runoff" concept. The purpose of this concept is to significantly decrease, or even obviate, runoff of rainwater on the ground and to increase the capacity of rainwater infiltration or to increase the capacity of rainwater harvesting.

3. METHODS

This study conducts a descriptive method, which consist of qualitative and quantitative analysis. The quantitative approach is used to analyze the data obtained, i.e., for water balance calculation. A qualitative approach is used to depict the implementation of green city development concept in the area of study. Hence, the review of environmental systems and components is conducted for the area. This study also supported by the theory related to the green city development concept, including technology development.

3.1. Water Balance Calculation

3.1.1. Water needs projection

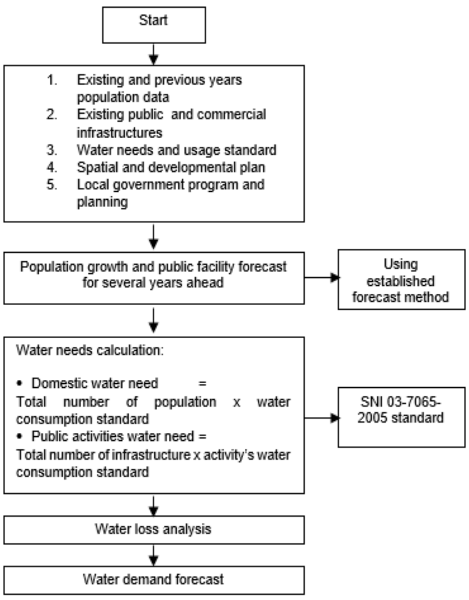

Figure 1 Flow diagram of water needs projection

The flow diagram for projecting the water needs can be seen in Figure 1. Population in Serpong Urban Residential will be projected by integrating the regional development master plan with the arithmetic method. To calculate the availability of water in meeting the need of clean water, analysis and evaluation of surface water, rainwater, groundwater, and used water balance is carried out by using the calculation of projection and numerical simulation model by determining boundary conditions for each available water source. The data and strategic plans for water resources management in Serpong Urban Residential will affect the pattern of water availability and its utilization in forming the water balance calculation. In this case, water balance calculation refers to the macro equation as follows:

$$P + R_{si} + R_{ui} = E + R_{so} + R_{uo} + R_s + R_g + \Delta + \varphi \qquad (1)$$

Where,

P : Precipitation (the amount of rainwater that drops on a specific area);

E : Actual evaporation (the amount of water that evaporated into the atmosphere);

ΔS : The change of total water supply backup in the system;

R_{si}&R_{ui} : The amount of water (on and under the surface) that enter the system;

R_{so}&R_{uo}: The amount of water (on and under the surface) that exit the system;

R_s&R_g : The amount of runoff (on and under the surface);

φ : The deviation in the forecasting calculation.

The standard water needs that will be used is 180 L/person/day. This value is obtained from the data of water usage in the area in 2012-2013 and also 180 L/person/day is the average water usage in the area. The standard water requirements for various urban activities or facilities refers to Indonesian National Standard (Standar Nasional Indonesia or SNI) 03-7065-2005.

3.1.2. Water loss level analysis

The magnitude of water loss level in a calculation of water demand is a quantitative value related to the estimated amount of water loss in the urban clean water service system, especially for piped water. The water loss is determined by multiplying specific factor (ideally between 15-20%) with the total number of water production. The water loss can be divided into three categories, which are planned water loss, incidental water loss, and administrative water loss.

3.1.3. Water allocation for other purposes

The calculation of the amount of clean water needs to anticipate various needs other than for household, commercial, education, social, worship, flushing of city channels, gardening, and health are also for firefighting. The calculation approach for water needs for firefighting is set to 20% of the reservoir capacity of local water company (Perusahaan Daerah Air Minum or PDAM) or 5% of domestic needs, based on Technical Guidelines for Clean Water Supply System-Department of Settlements and Regional Infrastructure 1998.

3.2. Review of Environmental Systems and Components

The Decree of the Minister of Settlement and Regional Infrastructure Number: 534/KPTS/M/2001 about Guideline of Standard Minimum Service on Space Layout, Housing and Settlements, and Public Works is taken, which were later updated with the Regulation of the Minister of Public Works Number: 14/PRT/M/2010 about Standard Minimum Service on Public Works and Space Layout as the primary reference. The management aspects that will be reviewed are clean water, wastewater, drainage, solid waste, and green space area.

The benchmark for clean water percentage of the served population is 55-70%, service allocation is 60-220 L/person/day, quality of water obtained meets quality standards required by the government which in this case is the Regulation of the Minister of Health Number: 492/MENKES/PER/IV/2010 about Drinking Water Quality Requirements. For wastewater, the percentage of served population is 55-70%, or 80-90% for areas with a population density of more than 300 persons/ha, and effluent quality of wastewater treatment system that meets the quality standards required by the government. For drainage, the percentage of inundated areas is 50-80%, with an inundation height less than 30 cm, maximum inundation time for 2 hours, and with a frequency of 2 times a year.

For solid waste, the percentage of waste products handled is 60-80%, with details of 80-90% for commercial waste, 50-80% for settlements, and 100% for settlements with a density of 100 persons/ha. For green space area, the area of green space is 0.3 m^2/population with designation as a park, sports, and playground; environmental park for every 250 persons; open space facilities must be clean, easily accessible, maintained, beautiful, and comfortable.

3.3. Recommendation of Green City Development

The increase of runoff caused by the decrease in the capacity of land infiltration in the built area has led to severe water crisis (flood/inundation and drought). Therefore, implementation of one of the base green city concepts is to develop an area that significantly gave impact in reducing the amount of runoff (less/zero delta runoff). This will be done by carrying out a rainwater harvesting system to increase the capacity of rainwater infiltration in the built area.

4. RESULTS AND DISCUSSION

4.1. Low Water Footprint Residential Area

After performing data collection, it is concluded that Serpong Urban Residential has the potential of the rainfall catchment area of 1,500 ha, and net rainfall potential of 37,000,000 m^3 annually. It is also known that in theory, up to 60%-80% of total clean water consumption of an area can be treated as recycled clean water. The recycled clean water has potential as an alternative sustainable clean water supply for the residential area. The total of clean water consumption in Serpong Urban Residential is 5,172,850 m^3 annually, thus making potentially 3,620,995 m^3 (70% of the total) wastewater available to be treated into recycled water.

The next step after determining Serpong Urban Residential water supply potential from rainfall and recycling of wastewater is to set up several scenarios for forecasting. These scenarios are created to take into consideration several supporting and opposing factors that might occur in the period of forecast. The scenarios are made from the best possible situation to the worst one.

Table 1 Serpong Urban Residential scenario water balance

No.	Water Needs Component	Unit	Forecasted Year			
			2013	2020	2025	2030
1	Total population	Person (s)	12,150	25,350	38,025	60,840
2	Targeted tap water consumer	%	100	100	100	100
3	Groundwater usage percentage	%	0	0	0	0
4	Total of population served	Person (s)	12,150	25,350	38,025	60,840
5	Clean water consumption level	Person (s)	180	190	180	165
6	Households water needs	L/person/day	25.31	57.21	90.22	151.4
7	Offices water needs	L/s	1.04	1.13	1.22	1.3
8	Commercials water needs	L/s	3.41	4.28	5.56	6.83
9	Hospitals water needs	L/s	1.07	1.25	1.43	1.43
10	Schools water needs	L/s	1.05	1.21	1.32	1.42
11	Gardening water needs	L/s	1.27	1.33	1.45	1.74
12	Backup for hydrant water needs	L/s	0.45	0.94	1.41	2.25
13	Recreational clubhouse water needs	L/s	0.25	0.35	0.35	0.35
14	Water loss/Non-revenue water	%	15	10	10	5
15	Water loss/Non-revenue water	L/s	5.08	6.62	9.19	6.58
16	City X total water needs	L/s	38.95	72.86	101.4	138.09
17	Daily peak factor (1.1Q)	L/s	42.84	80.15	111.25	151.89
18	Hourly peak factor (1.5Q)	L/s	64.26	120.23	166.87	227.84
19	Total water production (business as usual)	L/s	50	125	175	250
20	Water supply deficit/surplus	L/s	-14.26	4.77	8.13	22.16

Table 1 presents one of the scenarios of Serpong Urban Residential water balance from 2013–2030, where every house is occupied with initial water needs 180 L/person/day and is attempted to reduce water needs gradually after the forecasted year 2020. Total water needs in 2013, 2020, 2025, 2030 are 38.95; 72.86; 101.4; 138.09 L/s, respectively. In this scenario, the amount of produced water also increases gradually according to Serpong Urban Residential developer initial plan. Then, the amount of deficit/surplus of water can be known, which estimated deficit/surplus in 2013, 2020, 2025, 2030 are -14.26; 4.77; 8.13; 22.16 L/s, respectively.

It is known from the calculation that if Serpong Urban Residential developer only produces clean water with the development as usual approach, the area will have water deficit condition for the following years (2013-2020). One of the best sustainable solutions for this problem is to use potential water sources of rainwater harvesting and recycled water as mentioned above. The total of raw water supply from these sources amounted to ±40,620,995 m^3 annually. The amount of forecasted water deficit can be covered by utilizing either by rainwater harvesting method or water recycling method.

Another aspect that needs to be paid attention to in order to create sustainable water management is by water loss rate analysis. A water loss is a disadvantage, technically and economically. Thus, an effort to minimize unplanned water loss is needed in an urban residential area. After establishing the water demand, urban residential area developer may create several methods in order to fulfill it. Aside from the use of conventional water treatment plant, several methods can be used in order to lower the area's water footprint.

4.1.1. Rainwater harvesting

Using rainwater as an alternative option is a lot more sustainable and have a smaller water footprint. The standard rainwater harvesting system utilizes a building's roof as the catchment area of rainwater, then channels it into a gutter that will stream into storage tank above/underground after it passes a bar screen to prevent debris, leaves, and other unwanted materials entering storage tank. Another method to catch rainwater is to utilize an infiltration well on ground/topsoil that will channel rainwater directly through bar screen into a storage tank. By placing the harvested rainwater storage tank underground, it also enables the possibility of its on-site installation in an area with small free space such as in urban residential area.

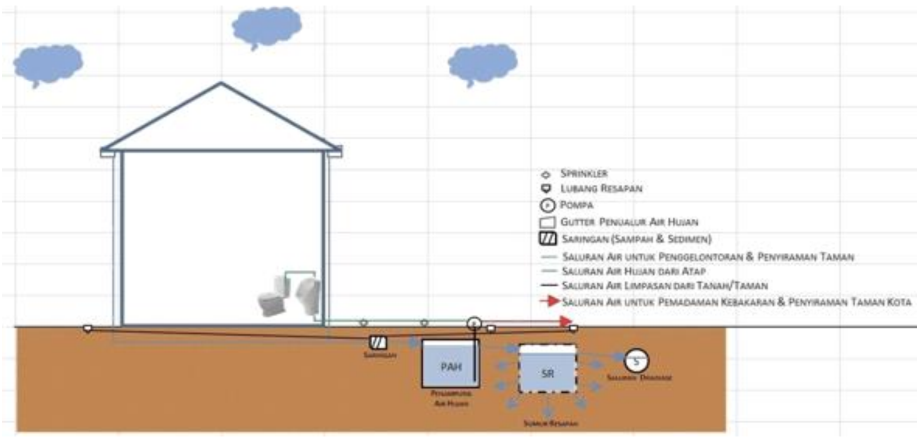

Figure 2 Rainwater harvesting house design

The rainwater that got caught in the catchment area is first used for a first flush to clean gutter and pipes which can be dirtied by debris and leaves that might get into the pipes. After the first initial flush, the rest of the caught water is streamed down. The harvested rainwater which is stored in the underground water storage tank can be used at any time by using an electric pump to lift water into the house and home appliances. The possible applications of harvested rainwater: as a flusher of toilets/urinary; to water plants and gardens; as additional reserve water for hydrant usage; as an extra supply for drinking water. Figure 2 illustrated the rainwater harvesting design which can be implemented in a house.

Currently, Serpong Urban Residential only has rainwater harvesting catchment area in their clubhouses. However, this rainwater harvesting method is not yet applied to every house in the area, thus making Serpong Urban Residential yet to utilize rainwater potential fully. Serpong Urban Residential with an annual rainfall rate of 27,000,000 m^3, if they could harvest 20% of it, it could be added as an extra supply for their raw water supply. By looking at Table 1, it could potentially fulfill their deficit of water supply.

4.1.2. Reusing wastewater

Urban domestic wastewater has the potential to be treated into recycled water that can be used as non-potable clean water supply. Domestic wastewater has better quality than industrial wastewater and more accessible to treat as recycled water. By utilizing recycled wastewater as another source of water supply (not for drinking water), the amount of natural clean water (groundwater or surface water) used can be minimized significantly. The process of utilizing recycled wastewater can also become a means to control land subsidence as this process decreases the amount of groundwater extraction. The amount of wastewater that can be used as recycled water is already mentioned in the water balance section, which is 3,620,995 m^3. The recycled domestic wastewater can be utilized as a flusher of toilets/urinary, to water plants and gardens, as cooling system/air conditioner system make-up water, and as additional reserve water for hydrant usage.

4.2. Low Carbon Footprint Residential Area

The implementation of green city/residential area is a significant factor that contributes to reducing greenhouse gas (GHG) emission as one of the main factors that cause global warming and climate change. To have less impact on global warming or reducing carbon footprint, several alternatives to the energy source and the ways society handle waste treatment can become a vital factor to achieve that goal. Electricity use and solid waste treatment are two of the seven categories which is focused on accounting GHG emissions (Lin et al., 2013). The amount of GHG generated can be calculated by using emission factors which are guided by the Intergovernmental Panel on Climate Change Emission Factor Database (IPCC EFDB). However, carbon footprint calculation for Serpong Urban Residential is yet to be made, so it is not known precisely how much of carbon pollution is released into the environment.

4.2.1. Renewable energy utilization

Installation of solar panel can enable human to utilize solar energy, and by installing windmills, wind energy can be harnessed as well as renewable energy. Residential area, in this case, Serpong Urban Residential, can adopt this theory by installing the solar panel in their houses, buildings, and several other infrastructures such as street lighting. By installing solar panels and windmills, people that live in the area can reduce their electrical energy consumption. Also, to reduce an area's carbon footprint, even more, LED lighting can be utilized as it consumes much less energy than multicolored lights. Figure 3 illustrated the design of street lamp which uses renewable energy.

Solar panels and windmills can also be incorporated into every house in residential areas. By using both or either of the technology, total electrical energy consumption of a household might decrease quite significantly, thus decreasing the total energy consumption of residential areas if these technologies are utilized in every household. Normal street lighting requires around 40-80 wattages for lighting purpose during the night. Modern solar panel with a size of 165cm×99cm has energy conversion efficiency as much as 20% and produces 250 watts of electrical energy (Zientara, n.d.). A single modern solar panel could practically power up 3 to 6 lamp posts.

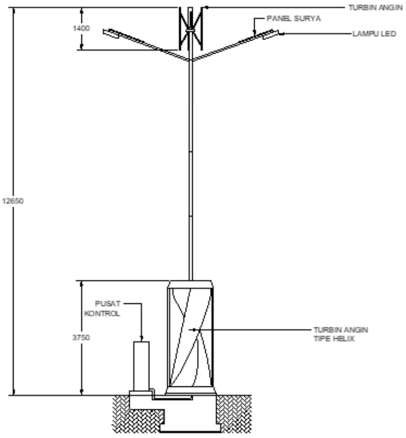

Figure 3 Streetlamp with renewable energy technology design

4.2.2. Reduce, reuse, recycle (3R) method and waste-to-energy plant (WTE) utilization

Solid waste can be used as an alternative energy source when it is treated correctly. This is made possible by enhancing & giving a lecture to local communities about 3R and utilizing WTE installations. In order to ensure that 3R is fully implemented in society, encouraging and enhancing local communities about the benefits of this method plays a crucial role. Another purpose of 3R method implementation is to increase the caloric value of solid wastes that are sent into the WTE treatment plant. Thus, it emphasizes the point in needing synergy between the implementation of 3R with the effective operation of the WTE treatment plant.

Hydrothermal solid waste treatment installations can treat and reduce the volume of solid wastes in a short period and are capable of turning it into usable energy. In this case, Serpong Urban Residential has its WTE treatment plant. Hydrothermal solid waste treatment is installed in order to treat up to 100 tons of wastes a day that creates pellets by-product that can be used as fuel for the installation itself, making it almost self-sufficient in term of energy. The excess of pellets can be used as fuel for other purposes. The exact amount of electrical energy produced is yet to be known, considering the fact it is still a pilot project in Serpong Urban Residential. Figure 4 illustrated the process of hydrothermal solid waste treatment.

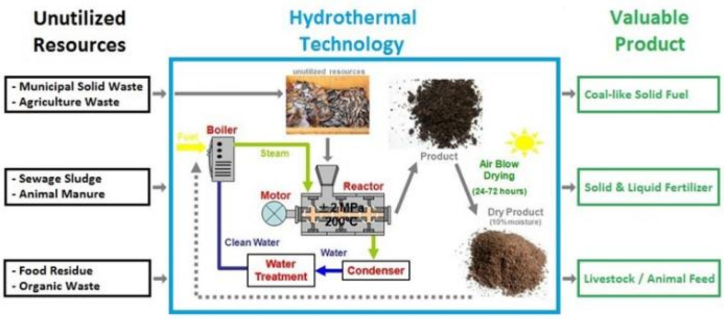

Figure 4 Hydrothermal technology process
Source: Serpong Urban Residential's Developer Concept

4.3. Less/zero delta runoff

The zero delta Q policy (ZDQP) is regulated in Regulation of The Government Number 26 of 2008 about National Spatial Plan, which it attributed ZDQP to control flood. This policy is implemented to ensure that outgoing surface runoff of an area equals or better than its natural condition. Theoretically, it is possible to reduce runoff amount of area until zero. However, this requires space and effective drainage technology (Sarbidi, 2015). If it is impossible to make the area acquire a total zero runoff, it is recommended to limit the stormwater runoff up to 3% so that the area can still recharge its groundwater and surface water resource. It is hypothetically possible for Serpong Urban Residential to completely absorb an annual of 37,000,000 m^3 rainfall, by harvesting it and passing it into the groundwater table. The three effective ways that can decrease surface runoff significantly are rainwater harvesting, infiltration wells utilization, and open green area creation.

4.3.1. Infiltration well utilization

Infiltration well is a human-made water infiltration system that can contain rainwater that became surface runoff that is caused by the building-covered or asphalt-covered soil. Surface runoff can be streamed down from buildings' roof or retention wells by using gutter or direct infiltration. In designing infiltration wells of the area, the developer needs to consider the efficiency of each infiltration wells, the volume of stormwater runoff according to area's rainfall rate, and the total amount of catchment area covered by infiltration well. Currently, Serpong Urban Residential has infiltration wells installed in 2 clubhouses with a volume of 8 m^3 each. These practices provide two fundamental functions in stormwater management: attenuation of runoff volume and treatment of runoff. These functions may ultimately reduce stormwater pollutants, increase groundwater recharge, decrease runoff peak flow rates, and decrease the volume of stormwater runoff.

4.3.2. Open green areas creation

Open green area/space is an open piece of land that is undeveloped (has no buildings or other built structures) and is accessible to the public (retrieved in epa.gov, n.d.). Open green spaces are a great benefit to the environment. They filter pollutants and dust from the air, provide shade and lower temperature in urban areas, even reduce erosion of soil in waterways. These are just a few of the environmental benefits that green spaces provide (retrieved in projectevergreen.org, n.d.). However, in current time, the price of land and properties is on a continuous rise, especially in the urban core part of the city, such as Serpong Urban Residential. One of the alternative options to make local neighborhoods just green enough is to convert grey spaces (such as roads, rooftops, and stormwater drains) into functional, yet affordable, green spaces that the people can use for active and passive recreation. Some benefits of having open green areas in residential areas are: urban advantages, water quality protection, reduced soil erosion, improved air quality, natural resource conservation, green roofs cool urban hot spots, reduced pollution. Figure 5 illustrated the open green area in Serpong Urban Residential.

Figure 5 Open green area in Serpong Urban Residential
Source: Serpong Urban Residential's Green City Concept

5. CONCLUSION

In order to effectively implement the green city concept, Serpong Urban Residential as the object of study use the three main focuses related to the concept, which are low water footprint, low carbon footprint, and zero/less delta runoff. The selected main focuses regarded the character of the area and sensitive impact of climate change. The study produced a water balance and proposed the strategic recommendation for managing water resources in the area.

From water balance calculation, it is known that the area will have a water deficit in initial forecasted years. In this case, the amount of forecasted water deficit can be covered by utilizing either by using the rainwater harvesting method or water recycling method, which area can supply a great amount of raw water. By performing these three main focuses, Serpong Urban Residential as the urban area can be recognized to have implemented green city and have created sustainably developed urban areas which can become a pioneer for developers with its integrated study related to green city development. The need for cheaper and more feasible options in some cases in order to make urban area development sustainable is needed as some of the commonly offered solutions can sometimes be impossible to be performed (i.e., construction of many parks in urban areas). From this study, it can be said that the key in creating green cities is to reduce raw natural resources exhaustion and smart management in resources handling, as well as an effort to recharge depleted natural resources if possible and utilizing renewable energy.

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