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Research Article

Rainwater Storage Engineering based on Water-Sensitive Urban Design in *Lapangan Pancasila*, Semarang City

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Abstract

LapanganPancasila is a public open space that located in Jln. SerojaDalam III no. 9 Semarang City. Flooding is often occurs at LapanganPancasila in rainy season. Floods in Semarang City are caused by the occurrence of land subsidence and water catchment area decreases. Rainwater harvesting system with water sensitive urban design(WSUD) basic, is one of plenty solution that can be applied to reduces flooding at LapanganPancasila. The research was conducted using a descriptive methodology which refers to the spatial and ecological approach. A spatial approach is used to determine the physical condition of the site, while an ecological approach is used to determine the components required for engineering rainwater storage. Based on the calculations that have been carried out, the discharge from the calculation of the planned rainfall is 0.003886 m3/s. Rainwater collection engineering at LapanganPancasila was built as a complex system that combines various components of rainwater treatment such as rainwater catchment areas, macro water filtration tanks, sand filter tanks to filter mud and purify water, clean water reservoirs, sprinkle landscape irrigation systems, and infiltration wells.

Keywords: Flood, Rainwater harvesting, Semarang City, Stormwater management, Water Sensitive Urban Design(WSUD)

Introduction

Infrastructure and facilities contruction in one of another indicator that increase urban cities growth. A good construction being held for providing urban society needs in an area. However, good construction also providing another new problems, such as rapid urbanization. As a result, area that have a better infrastructure and facilities will attract people from various surrounding areas to find work in the main urban area (Harahap 2013). Semarang City, Indonesia, which is developing as a center of government services and trade, as well as a provincial capital, has a role and attraction not only on a local scale but also regionally (Arsandi *et al.* 2017). Rapid urbanization at Semarang City can be directly connected to population growth and yearly flooding potention. Water-Sensitive Urban Design(WSUD) in every construction aspect can be an alternative recommendation for Semarang City to decrease flooding potention. Stormwater management and rainwater harvesting aretypes of WSUD to preventing and handling floods in urban area. Stormwater management is an alternative that can be done by collecting and reusing rainwater through absorption, filtration, and storage process. Rainwater harvesting is a strategy to harvesting rainwater in various scales, such as rooftop gardens or under road networks.

This research has several objectives in realizing a public park based on WSUD, including:

1. Analyzing and knowing the spesific condition that required for stormwater management and rainwater harvesting;
2. Determining an engineering model for rainwater storage in Semarang City;
3. Forming an engineering model that can be a solution to handling and tackling flooding in Semarang City.

This research is expected to be a consideration for coastal cities to manage rainwater by using infrastructure that supports the environment in urban areas.

Materials and Methods

This research has been done in *Lapangan Pancasila*, Simpang Lima, Semarang, that located at Seroja Dalam III Street No. 9 Semarang City (Figure 1). This research was conducted using descriptive methodology that refers to spatial and ecological approach.

The spatial approach is carried out to determine the physical conditions of the site such as site area, site boundaries, topography, slope, soil type, hydrology, climate, and vegetation. The data that formed trough spatial approach are the form of setting goals and location areas, assessing the components and final selection components used in rainwater harvesting.

The ecological approach requires hydrological data, water balance analysis, and hydraulic analysis. The data that used in ecological approach were analyzed quantitatively to determine various components of rainwater harvesting system. The final result obtained through spatial and ecological approaches is conceptual image analysis for rainwater harvesting engineering. The research phase includes inventory, analysis, and synthesis. An inventory is carried out to understand the specifications and site characteristics needed for the construction of rainwater harvesting infrastructure. Inventory will be the basis for determining areas used in site development. Analysis phase is carried out to process inventory data related to engineering process of rainwater storage. Analysis phase was carried out according to spatial and ecological approach. The rainwater storage component choices are related to:

1. The harvesting area;
2. The storage tank location;
3. The pipeline flow;
4. The storage tank material and type, based on rainwater capacity;
5. Rainwater treatment system;
6. The component availability in the area surrounding the site.

Synthesis phase is the final process of conclusions from analysis phase. Synthesis phase produces data that will be implemented in engineering drawings of rainwater harvesting.

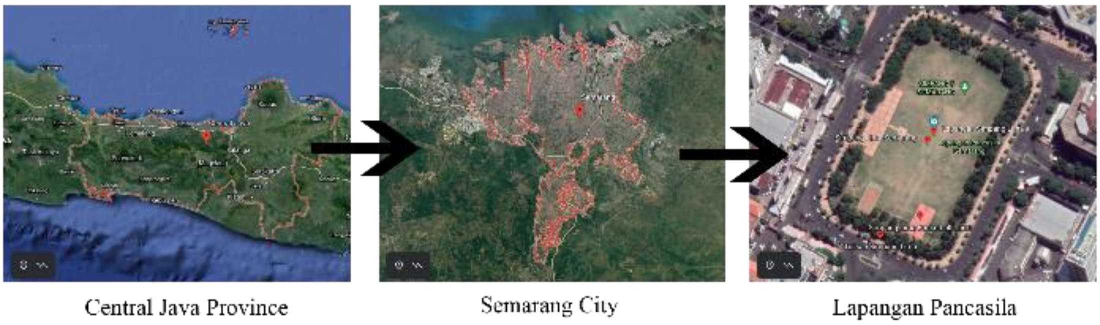

Fig.1. Research site location

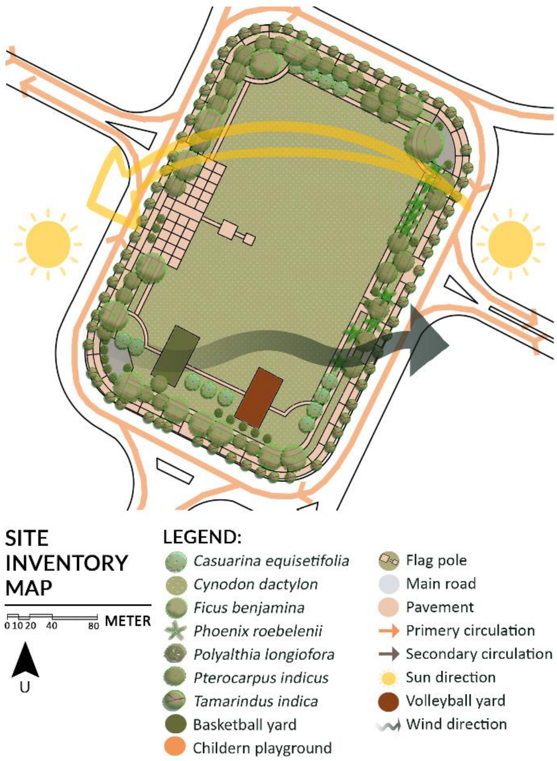

Fig. 2. Site inventory map

Inventory

*Lapangan Pancasila*is an important public space for Semarang citizens. *Lapangan Pancasila* has an area of 33,684.25 m2 (3,368425 ha) and a circumference of 706.5 m. This situation makes *Lapangan Pancasila* equipped with various facilities such as badminton court, volleyball court, children's playground, jogging track, and flagpole. *Lapangan Pancasila* has an important function for Semarang citizens as a gathering place in their spare time. Various large events are often held at *Lapangan Pancasila*such as live music performances, state ceremonies, and sports event (Tisnaningtyas 2012). As a traffic island, *Lapangan Pancasila*is one of Semarang City's icons that located in a strategic area and surrounded by Simpang Lima Street, which is one of the main roads in Semarang City.This is indicated by vehicles circulation that made around the field. The flow of vehicle circulation is regulated clockwise to reduce the level of congestion around the field (Figure 2).

Analysis

Analysis used in this researchare focuses on getting the maximum amount of rainwater. This analysis contains of hydrological data analysis, water balance analysis, and hydraulic analysis.

Hydrological Data Analysis

Hydrological data analysis is carried out to obtain and process data related to engineering making and designing process.

Climate and rainfall data

Lapangan Pancasila, located in the center of Semarang City which has a tropical climate. In the dry season, the average temperature in a year is around 25°C to 33°. In the rainy season, the average temperature in a year is around 24°C to 30°C. Semarang City has a humidity level of 92-100% and an average wind speed of 9.7 km/hour. The rainfall data of Semarang City was obtained from *Staklim I Semarang*. The obtained data are monthly rainfall data of Semarang City from 2012 to 2021. Rainfall in Semarang City classsified as low category in July to August. On the other hand, the rainfall in Semarang City is classified as high in January and February. This is factor causing high level of water rise in Semarang during the rainy season and lead to flooding. Monthly rainfall data (mm) of Semarang City for the last 10 years are listed in table 1.

Table 1. Monthly rainfall data (mm) of Semarang City for the last 10 years

Year	**MONTH**											
	JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AGT**	**SEP**	**OKT**	**NOV**	**DEC**
2012	498	274	220	170	90	110	2	0	3	272	261	328
2013	468	380	154	298	218	312	115	82	20	100	114	225
2014	734	380	155	76	181	130	185	10	0	45	197	220
2015	238	278	213	223	186	70	11	8	0	0	277	183
2016	269	208	133	259	188	120	188	138	439	258	267	125
2017	269	404	214	185	105	190	31	15	106	488	382	281
2018	351	538	230	214	18	45	0	0	20	133	261	252
2019	217	224	178	205	116	1	1	2	10	8	72	234
2020	301	394	232	294	270	23	72	56	91	164	128	355
2021	273	635	122	131	205	134	15	65	199	119	349	173
Monthly average rainfall	361.8	371.5	185.1	205.5	157.7	113.5	62	37.6	88.8	158.7	230.8	237.6
Rainfall category	H	H	A	A	A	A	L	L	L	A	A	A

Monthly rainfall category:

1 – 100 mm	: Low (L)
101 – 300 mm	: Average (A)
301 – 500 mm	: High (H)
> 500 mm	: Very high (V)

Source: Staklim I Kota Semarang (2022)

Hydrological and existing drainage analysis

The amount of surface runoff is influenced by land use, soil type, and slope. In an area with dense development, the level of water infiltration will decrease and most of the water will become surface runoff. This condition makes the runoff capacity exceeded and caused flooding (Muharomah and Putranto 2014). Around *Lapangan Pancasila* there is a small and shallow ditch that connected to the drainage river on the northeast side of the field. The drainage river carries water from the ditch to the Sub-Seroja River. The hydrological cycle in the center of the field tends to follow the slope of the contour of the *Lapangan Pancasila* which is getting lower towards the coast or to the north.

Soil type and contour data

Soil type in *Lapangan Pancasila* is coastal alluvium deposit. It is characterized with clay characteristics, containing organic material, easy to excavate, low permeability, and saturated with water. The slope of the *Lapangan Pancasila* tendsto have flat characteristics. Based on *DEMNAS* data, it was found that the lowest elevation of*Lapangan Pancasila* is 6 meters, which is in the middle of the Field. On the other hand, the highest elevation is on the west side of the field, at a height of 10 meters.

Existing vegetation data

Most of the *Lapangan Pancasila* area is dominated by a grass area in the middle and surrounded by planting boxes, containing shade vegetation and various types of ground cover vegetation. The existing vegetation has main functions as a sign of *Lapangan Pancasila* and Simpang Lima Street's boundary and shades provider for *Lapangan Pancasila's* visitors from the sun. The iconic plant at *Lapangan Pancasila* is topiary of tamarind plant (*Tamarindus indica*). Tamarind plant has become an icon of Semarang since ancient times. Other plants that can be found around the *Lapangan Pancasila* area are coastal plants and cambium plants.

Land use data

Lapangan Pancasila was located at the center of Semarang City and often visited by local citizens. This is due to many facilities that can easily access by surrounding community. Explanations related to landuse area, wide, and percentage are explained in table 2.

Table 2. Landuse area, wide, and percentage

Landuse area	Percentage	Wide (m2)
Basketball court	1.64%	552.67
Childern playground	0.29%	99
Grass area (main yard)	56.06%	18882.29
Jogging track	11.61%	3911.79
Planting area	23.41%	7886.76
Utility building	0.59%	197.16
Volleyball court	1.64%	552.67
Welcome Area	4.76%	1601.91
Total		33684.25

Based on table 2, it can be seen that the utilization of the widest area is grass area with a percentage of 56.06%. The grass area is often used when there are special event, such as independence ceremonies, music events, and *TNI* car shows. On the other hand, the use of the narrowest area in *Lapangan Pancasila* is children's playground with a percentage of 0.92%.

Based on inventories and hydrological data analysis through spatial approach, the obtained data are developed into the temporary zoning of rainwater harvesting engineering design that will be formed.Temporary zoning data are explained in figure 3 and table 3.

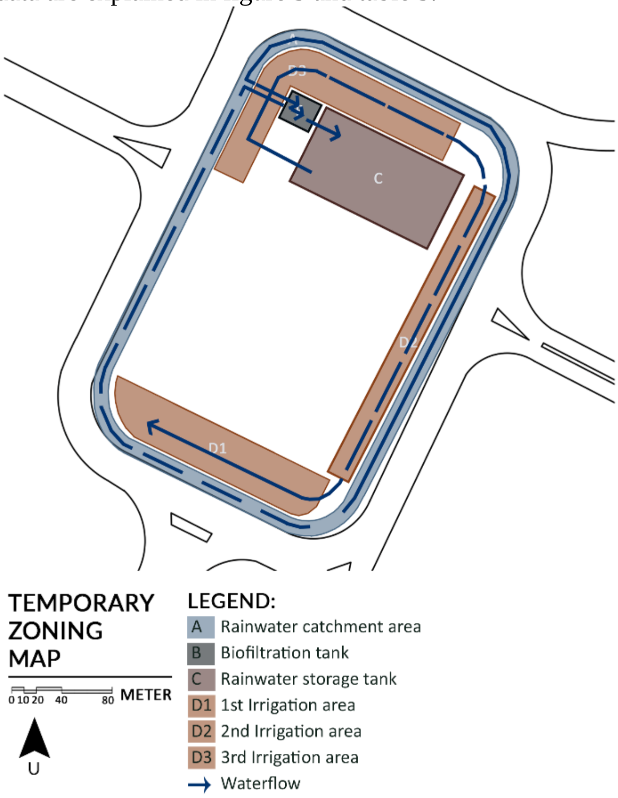

Fig. 3. Temporary zoning map, based on inventories and hydrological data analysis

The rainwater catchment area is placed at pavement area with 0-8% of slope. This area is considered stable for capturing rainwater. At *Lapangan Pancasila*, the rainwater catchment area is planned to surround the field on the outside with a length of 706.5 m and an area of 3911.79 m2. Rainwater storage containers are placed under the *Lapangan Pancasila*, that is not filled with pavement areas. The size of the storage container will adjust the rainwater discharge that can be captured by the rainwater catchment area.

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Table 3. Temporary zoning based on characteristic and function

Code	Area	Characteristic	Function
A	Rainwater catchment area	Pavement area with 0-8% of slope	To collects and directs rainwater to distribution pipes
B	Bio-filtration tank	Transition area between distribution pipes and rainwater catchment area	Filtrate rainwater that enters distribution pipes from macro debris
C	Rainwater storage containers	Large area without any pavement on it	Collects and manages rainwater before reuse/irrigates
D	Irrigation area	Planting area / Area with a lot of vegetation	Reuse the rainwater that have been harvested before

Water Balance Analysis

Water balance analysis was carried out to find related information about rainwater storage capacity based on rainwater inflow from catchment area. Studies related to water balance analysis will produce data of water discharge that produced in an area.

Calculation of expected rainfall frequency distribution. Water balance analysis begin by measuring the rainfall in an area. Rainfall frequency analysis in *Lapangan Pancasila* uses Log Person Type III distribution, because the*Cs* value(drag coefficient value) is close to 0 or is in the range 0 to 0.9. The distribution of log person type III method is used for the calculation of expected rainfall by converting the maximum annual rainfall data into logarithmic form.Log Person Type III method is the basis for calculating expected rainfall where the lowest rainfall occurs in a 2-year return period with a rainfall value of 2.271544, while the highest expected rainfall occurs in a 10-year return period with a rainfall value of 2.414522 (Table 4).

Table 4. Expected Rainfall with Specific Return Period

Return Period (year)	Factor Frequency(Kt)	Rainfall (Xtr)	Expected rainfall
2	0.116	2.271544	186.8718995
5	0.857	2.370838	234.8756527
10	1.183	2.414522	259.7299309

Calculation of rainfall intensity
Rain intensity is the height or depth of rainwater per unit time. Rain intensity tends to be higher if it rains in a relatively short time and it rains with a high repeat period. Rain intensity can be calculated using the mononobe equation if only design rain data (X_{Tr}) and time of concentration (*tc*) are available. The calculation is carried out using the Kirpich formula in formula 1 as follows:

$$I = \frac{X_{Tr}}{24}\left[\frac{24}{t}\right]^{2/3} \quad \text{(Eq.1)}$$

Explanation:
I = Rain intensity (mm/hour)
X_{Tr} = Maximum rainfall per day (mm)
tc = Rainfall time concentration (hour)

Calculation of zoning plan area and runoff coefficient(*C*): The runoff coefficient (*C)* is defined as the ratio between the peak runoff rate and the rainfall intensity. The main factors that affect the value of runoff coefficient are soil infiltration rate, cover crops, and rainfall intensity (Arsyad 2006). Rainwater harvesting process is only focused on jogging areathat surrounding around *Lapangan Pancasila*. The surface area is a pavement used as a road. Then the runoff coefficient used is the pavement coefficient for roads with a number between 0.7 to 0.9.

Calculation of rainwater discharge: Based on the three calculations that have been done, the analysis can be continued using the rational method. Rational Method is used to calculate the planned discharge in a watershed. Rational method has three parameters, such as runoff coefficient (*C*), rain intensity (*I*) and watershed area (*A*) (Fitriani *et al.* 2020). Practically, the rational method describes the relationship between runoff discharge and the amount of rainfall that applies to watershed areas below 5000 hectares. The data that being calculated in rational method required minimum of 10 years and maximum of 20 years. The main components used in the rational method are concentration time (*tc*) and rainfall intensity (*I*). According to *SNI 03-2415-1991*, the equation used is formula 2 as follows:

$$Q = 0{,}00278\ CIA \quad \text{(Eq.2)}$$

Explanation:
C = Runoff coefficient
I = Rain intensity (mm/hour)
A = Watershed area (ha)
Q = Maximum flood debit (m^3/s)

Based on the equation according to SNI 03-2415-1991, the results of the calculation of peak flood debit (*Q*) are shown in table 5.

Table 5. Result of Q value calculation

Yearly repeat	A	I	C	Q
2	0.0039	303.40293	0.85	0.002796
5	0.0039	381.34123	0.85	0.003514
10	0.0039	421.69434	0.85	0.003886

Hydraulic Analysis
Hydraulic analysis is carried out to determine the size of various components and irrigation pipes from catchment outlet to storage tankbased on gravitational energy and pumping requirements. Hydraulic analysis calculations require information about design discharge, pipe length, slope, and roughness by factoring the hydraulic flow equation used for pipe size estimation.

Analysis of water collective pipe calculation from rainwater catchment area outlet to rainwater storage tank: Collective pipe calculation is carried out to determine the pipe size that will be used to connect rainwater from catchment area to storage area. The collective pipe size can be estimated using Darcy-Weisbach Equation. Darcy Weisbach equation is systematically derived that the pressure loss is proportional to waterflow squared velocity and pipe length. It also inversely proportional to pipe diameter (Fathurrohman 2012).

The total pipes length that connected catchment outlet to rainwater storage is 31.35 meters. The shear coefficient on outlet pipe is calculated by laminar flow. This calculation concluded that the shear coefficient value is 2.36 for pipes with diameter of 10 cm.Darcy-Weisbach calculations state that the surface resistance figure obtained is 9.25 m2.When compared with water catchment areas size, the percentage of water lost is 0.24%. It can be conclude that efficiency value water stored is 99.76% or 336.1514 m3 per day.The results of calculations using the Darcy-Weisbach equation are listed in table 6.

Table 6. Result of Darcy-Weisbach equation and shear coefficient equation

Q (m^3/s)	L (m)	D (m)	g (m^2/s)	F	hf (m^2)	Efficiency
0.0038	31.35	0.1	9.78	2.36	9.25	0.24 %

Hydrological water balance modeling analysis for water runoff: Rainwater harvesting engineering at *Lapangan Pancasila* are supposed to watering plant at planting box around *lapangan* or other areas if possible. Rainwater from the catchment area are collected into a closedunderground runoff tank using the force of gravity without an additional pumps at the outlet. This reduces other mechanical requirements and additional costs involved in engineering rainwater harvesting.

The storage tank model is made sealed to reduce evaporation in the afternoon. In the manufacture, rainwater tanks also need to pay attention to volumetric reliability. Volumetric reliability is the ratio of annual rainwater use for irrigation and annual irrigation water requirements. According to Day and Sharma (2020), the properties of volumetric reliability are:

- Increases value when the tank size increases.
- Has greater value on closed storage tank models.

The volumetric reliability value is sensitive to the length of the rainfall record, the inter-annual variability of seasonal demand and the type of storage surface (Mitchell *et al.* 2008). Volumetric reliability increases with larger tank capacities and in closed tanks. If volumetric reliability increases, the availability of additional water will increases as well. There is a wide variety of options that can be used in the construction of rainwater storage tanks such as onsite concrete tank construction, part prefabrication, and installation using a modular system of onsite commercial geocellular runoff storage tanks.

Selection of filter models and rainwater filtration: Rainwater quality is influenced by weather conditions or air quality, storage materials or materials, and storage time in the reservoir. Based on *Staklim I* Semarang's data, rainwater that falls in the Semarang area has a lower parameter value than the quality standard. This proves that the rainwater in Semarang City is clean and does not contain many harmful physical, chemical, or microbiological materials.Therefore, the filter models that can be applied at *Lapangan Pancasila* is the slow sand filter system. The slow sand filter system is a simple water treatment technology that can produce clean water in a good quality. This slow sand filter system has not requiring chemicals materials. The main process is carried out with sand as the media which has a filtering speed of 10 m3/m2/day.

Measurement of water requirements for crop irrigation systems: Calculation of water demand is using CROPWAT 8.0 application. CROPWAT 8.0 is a Windows based program used to calculate crop water and irrigation requirements based on soil, climate, and crop data. CROPWAT 8.0 can be used to calculate potential evapotranspiration, actual evapotranspiration, and irrigation water needs to make irrigation water supplies planner (Shalsabillah *et al*. 2018). The type of data inputted in CROPWAT 8.0 is obtained with the help of CLIMWAT 2.0 application. Based on the calculations that have been done, the average value of solar radiation is 20.7 MJ/m²/day, the evapotranspiration rate is 4.35 mm/day, and the total precipitation is 2210.6 mm/year or 6.140 mm/day. Based on the total value of precipitation and the method used, the total value of effective rainfall is 1381.0 mm/year or 3.836 mm/day. Landscape irrigation needs calcutation continued using the WUCOLS method obtained in the journal Costello and Jones (2014) in Synder *et al.* (2015) in formula 3 as follows:

$$ET_L = ET_0 \times K_L = ET_0 \times K_P \times K_D \times K_{MC} \quad \text{(Eq. 3)}$$

Explanation:
ET_L = Landscape irrigation needs
ET_0 = Average evapotranspiration
K_L = Landscape plant coefficient
K_P = Type and plant water requirements coefficient
K_D = Plant canopy density coefficient
K_{MC} = Micro climate coefficient

Based on the calculations that have been made, the value of landscape irrigation needs (*ETL*) is 2.262 mm/day, total precipitation *(P)* is 6.140 mm/day, and effective rainfall (*Re*) is 3.836 mm/day. The value that has been obtained is processed in NFR calculation in formula 4 to get total irrigation needs in *Lapangan Pancasila* as follows:

$$NFR = ET_L + P - Re \quad \text{(Eq. 4)}$$

Explanation:
NFR=Total landscape irrigation needs
ET_L= Landscape irrigation needs
P = Total precipitation
Re = Effective rainfall

Based on the results of analysis using CROPWAT 8.0application, CLIMWAT 2.0 application, and WUCOLS method, the total landscape irrigation requirement data obtained was 80.332 mm/day. If the rainfall discharge obtained is 0.003886 m3/s, it can be estimated that the water can irrigate the entire *Lapangan Pancasila* and leave a rainwater discharge of 256.62 m3/day. The results of landscape irrigation needs calculation can be seen in table 5.

Selection of the model of the water delivery pipe for the irrigation system

The irrigation area at *Lapangan Pancasila* is divided into two categories, the edge planting box area and the grass area. In the grass area, the appropriate irrigation system will be applied is sprinkler irrigation, because the target is grass that grows on soil with low permeability. The sprinkler that being used is non-permanent sprinkler. It is necessary to adjust the layout of the sprinkler every day to obtain maximum watering results.

Table 5. Landscape irrigation needs calculation

Presipitation	Effective rainfall	Average evapotranspiration	Total landscape irrigation needs					ETL	NFR
			Area	Kp	Kd	Kmc	Size		
6.14 mm/day	3.836 mm/day	4.35 mm/day	Planting box area	0.4	1.3	1	7886	2.262	4.566
			Grass area	0.1	0.1	1	18882	0.0435	2.347
Total irrigation needs at *Lapangan Pancasila* (m/day)									80.332971
The remaining water discharge generated after the daily irrigation process of *Lapangan Pancasila*(m3/day)									256.627029

Non-permanent sprinklers are chosen to avoid damage to the irrigation system, if *Lapangan Pancasila* is used for special events that use heavy equipment such as military vehicle exhibitions. Unlike the grass area, the edge planting box area of *Lapangan Pancasila* tends to be dominated by larger trees. Therefore it is less effective if sprinkler irrigation system is implemented. The form of irrigation applied is surfaceirrigation which is considered suitable for large trees.

Selection of infiltration well model

Infiltration wells in rainwater harvesting engineering are used to accommodate excess rainwater from storage tank when they have reached the maximum limit. According to Bahunta and Waspodo (2019), based on the distance requirements set by SNI 03-2453-2002 are:

At least 5 meters distances between infiltration well and septic tank.
At least 3 meters distances between infiltration well and dig well.
At least 1 meters distance between infiltration well and foundation of another buildings such as houses and fences of at least 1 meter

Based on these requirements, infiltration wells will be built with a minimum distance of 3 meters from rainwater reservoirs and 1 meter from other foundations such as planting boxes and jogging tracks. Infiltration wells are built with a diameter of 3.5 meters and a depth of 10 meters, to accommodate excess water that is not received by rainwater reservoirs with a volume capacity of each well of 67.375 m3 (Figure 4).

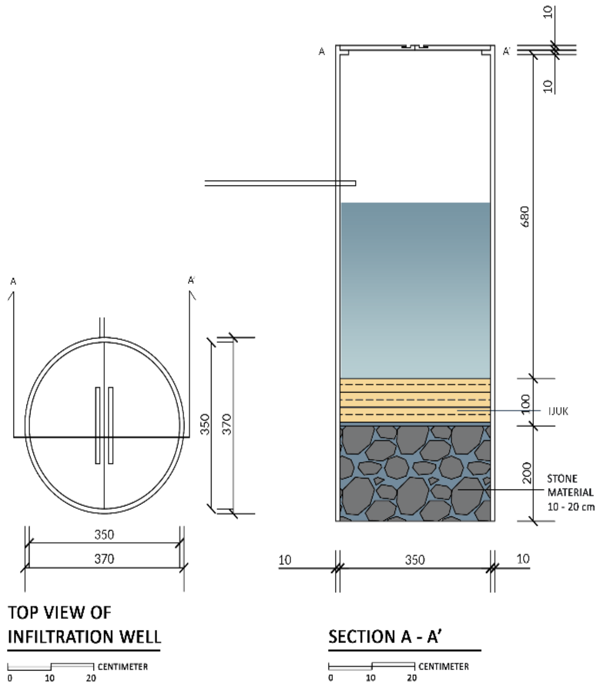

Fig. 4. Infiltration well

Syntesis

Based on inventory data, *Lapangan Pancasila* has an area of 33684.25 m2 and a circumference of 760.5 meters.*Lapangan Pancasila* often experiences flooding in the rainy season that caused by various factors, such as:

1. Faraway drainage system from the main watershed of Kali Seroja.
2. Coastal alluvium soil type with water-saturated characteristics and low permeability.
3. Flat contour that continously subsidence every year.

Water balance analysis was carried out to analyzing Monthly rainfall data from BMKG Staklim I Semarang City. From this analysis, relative rainfall and intensity score at Semarang City will increase for the next 10 years. The highest score was obtained in the 10th test period with a value of 61259.73 mm for relative rainfall and 421.7 mm/hour for rainfall intensity. Therefore, the highest rainfall discharge was obtained in the 10th test period with a value of 0.003886 m3/s or equivalent to 336.96 m3/day. From hydraulic analysis using Darcy-Weisbach equation, the surface resistance of outlet pipe is 9.25 m2. It can be concluded that the amount of water lost during the entry process of rainwater from the rainwater harvesting outlet is 0.24%, then the water discharge that can be accommodated is 336.15 m3/day.Rainwater storage tanks use a closed underground storage model. The closed underground storage model is considered effective in preventing reduced storage water due to evaporation and decreasing the volumetric reliability value. Rainwater filtering is done by using an upflow sand filtering system. The sand filtering system was chosen to purifying water from sludge and another micro waste. It also chosen to simplify management and repairment of rainwater filtration system if needed. The value of landscape irrigation needs, using WUCOLS method is 4.566 mm/day. If the rainfall discharge obtained is 0.003886 m3/s, it can be seen that the collected water can irrigate an area of 74880 m2.The type of irrigation used is sprinkler irrigation in the grass area and surface irrigation in the planting box area on the edge of the field. The remaining water that is not used during the irrigation process will be channeled back into the ground using infiltration wells.

Result

Rainwater storage engineering is built as a complex system unit that combines various components of rainwater treatment such as: Rainwater catchment areas, Macro water filtration tanks, Sand filter tanks for filtering mud and purifying water, , Clean water reservoirs,, Landscape irrigation systems for *Lapangan Pancasila*, Infiltration wells (Figure 5). Rainwater storage is directed towards the north side of the field, following decreased contour of *Lapangan Pancasila*.

There are 3 types of sprinklers used in Pancasila Field, namely:

1. Permanent sprinkler irrigation placed in the southern area of the volleyball and basketball courts, with a sprinkler rotation radius of 7 meters and an NFR value of 4.566 mm/day

2. Non-permanent sprinklers irrigation placed on grass, with a sprinkler rotation radius of 15 meters and an NFR value of 2.3475 mm/day
3. Non-permanent sprinklers irrigation placed on grass, with a sprinkler rotation radius of 30 meters and an NFR value of 2.3475 mm/day (Table 6)

In the calculations, it was found that the daily water discharge that can be captured in *Lapangan Pancasila* is 336.15 m3/day. The small amount of water needed forirrigation in *Lapangan Pancasila*, causes the majority of water, as much as 303.7 m3/day, need to re-absorbed into the soil with the help of infiltration wells (Figure7).

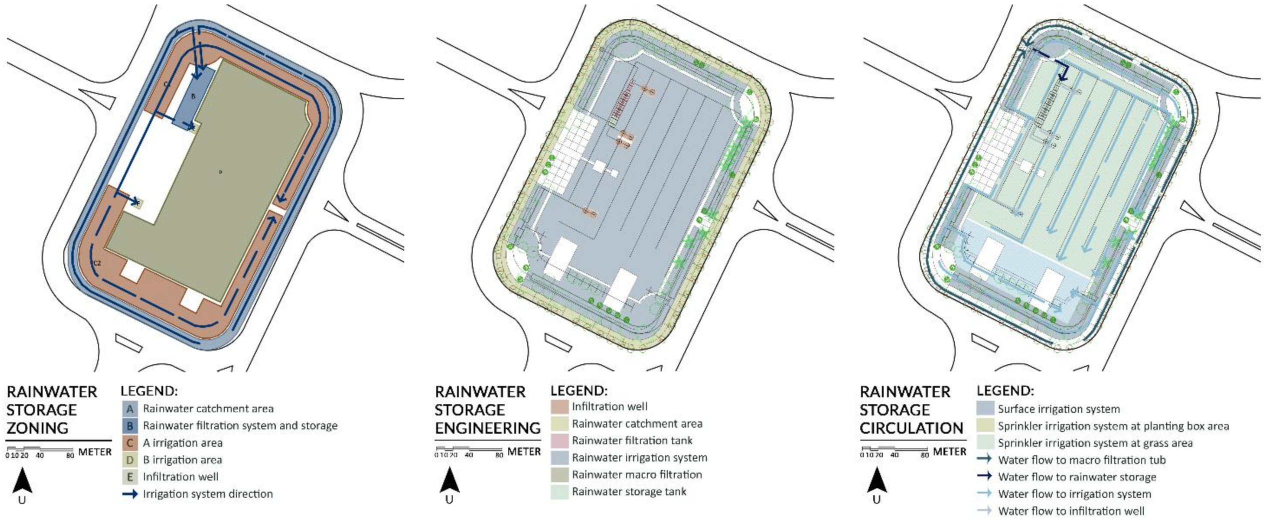

Fig.5. Rainwater storage zoning, engineering, and circulation map

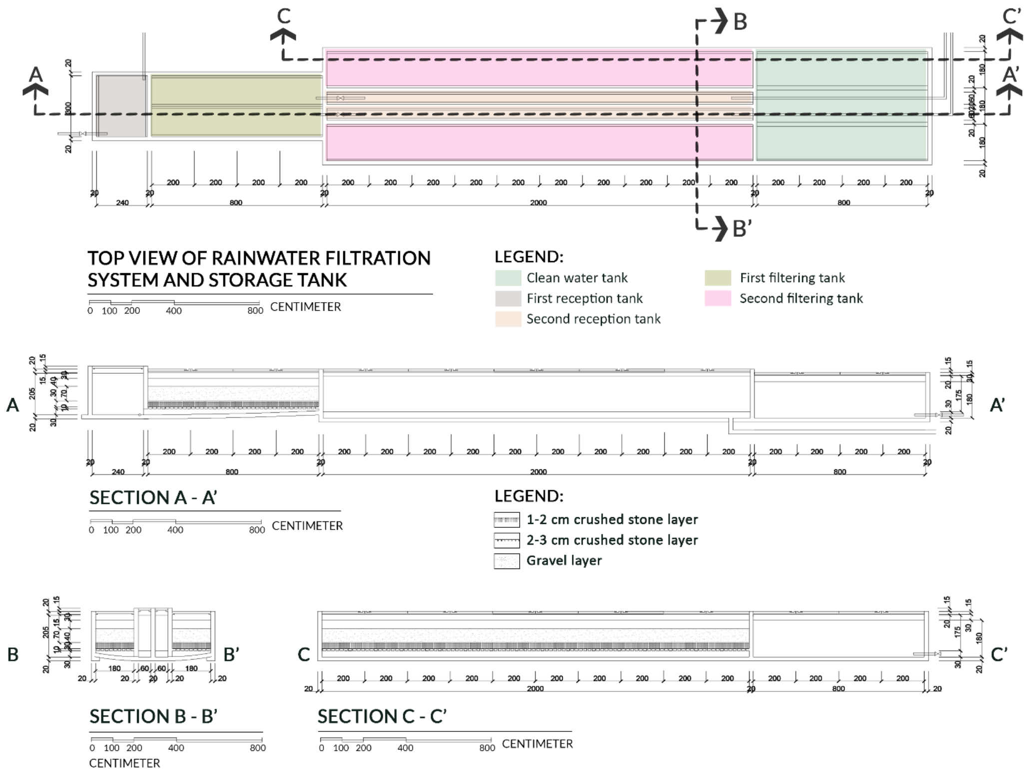

Fig. 6. Rainwater filtration system and storage tank

Table 6. Placement of irrigation systems, types of irrigation systems, and NFR values

No.	Placement of irrigation systems	Types of irrigation systems	NFR values (mm/day)
1	Planting box area	Surface irrigation	4.566
2	South area of basketball and volley yard	Permanent sprinkler irrigation with rotation radius of 7 meters	4.566
3	Grass area	Non-permanent sprinklers irrigationwith sprinkler rotation radius of 15 meters	2.3475
4	Grass area	Non-permanent sprinklers irrigation with sprinkler rotation radius of 30 meters	2.3475

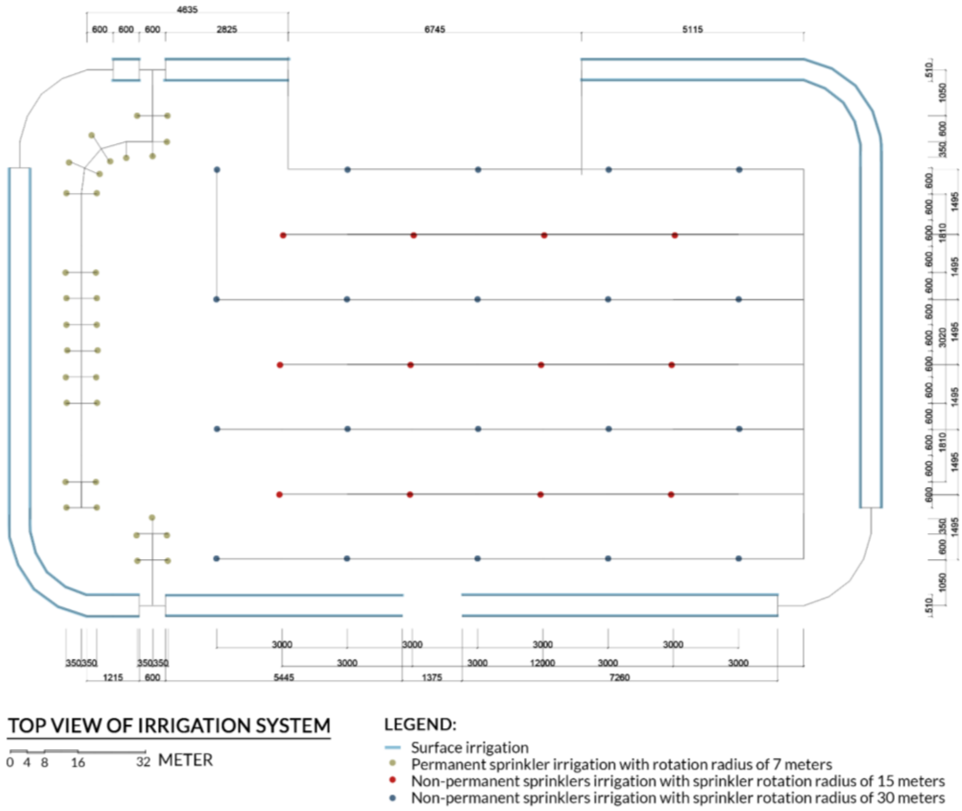

Fig. 7. Top view of irrigation system engineering

A well can hold 67.375 m3 of excess water. In anticipation of the excess water in Pancasila Field, 8 wells have been prepared with a diameter of 3.5 meters and a depth of 10 meters. 6 wells in the north are the main infiltration wells, while 2 wells in the south are reserve wells. Infiltration wells are made closed to avoid accidents if there are field visitors who step on the top of the well (Figure 5).

Discussion and Conclusion

Lapangan Pancasila has a pavement area of 3911.79 m2 or 11.61% of the total field area, which is located around the field. The area has a suitable slope to collect and direct rainwater to the rainwater catchment outlet pipe. Based on the calculation of rainfall and the area of rainwater catchment, the design rainwater discharge is 0.03886 m3/s. The amount of discharge obtained in the process of capturing rainwater can be used to irrigate a park area in Semarang City with an area of 74880 m2.

At *Lapangan Pancasila*, the anticipation taken to overcome the characteristics of alluvial sedimentary soil is to regulate the sprinkler irrigation system so that the water can be well received by the surrounding vegetation. The irrigation systems used are sprinkler irrigation at grass area and surface irrigation at planting box area. The irrigation system and rainwater storage tanks at *Lapangan Pancasila* are supported by the construction of infiltration wells, which is also one of the anticipations that can be done in helping the process of infiltrating water into the soil.

Rainwater collection engineering in *Lapangan Pancasila* focuses on rainwater storage tanks which are placed on the north side of the field. The reservoir is a combination of an up flow sand filtration system and a clean water tank. At *Lapangan Pancasila*, the rainwater storage is built to accommodate water with a capacity of 400 m3/day. Clean water is channeled into irrigation canals that are made at *Lapangan Pancasila*. When the water in the rainwater reservoir has reached its maximum capacity, the water will be reabsorbed into the ground with the help of 8 infiltration wells built not far from the clean water reservoir.

Acknowledgements

The research is expected to be a consideration for manager of *Lapangan Pancasila* to take advantage of the existing losses around the field into a potential ecological site. This research is also expected to be a consideration for urban areas in Indonesia, especially coastal areas to manage rainwater as an effort to control and overcome floods by using infrastructure that supports urban areas

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