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Water Management Program in Telkom University: Planning and Best Practice

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Abstract. This research aimed to examine water management conducted by Telkom University, including the fundamental considerations, the implementing organization, the design methods for rainwater systems, and practical experiences in constructing Rainwater Harvesting systems. Subsequently, the management was aware of the conditions and situations related to clean water users, estimates of clean water requirements, potential water sources, and campus environmental situation. Based on various investigations and supported by rainfall data from the Meteorology, Climatology, and Geophysics Agency, a simple calculation was used to derive the design of the Rainwater Harvesting system (RWH), which was implemented. Some of the observations from this implementation included the need for improvements in the foundation structure of soak pits, recommendations for the construction of ground tanks during the dry season, and the flexibility of ground tank size depending on the availability of funds.

Keyword:
Rainwater Harvesting, Clean Water, Raw Water, Catchment Area, Filtration, Water Management

1. Introduction

Telkom University established on August 14, 2013, is a distinguished private institution in Indonesia resulting from the merger of four educational entities supervised by Telkom Education Foundation (YPT). Two of these institutions have marked their 33rd anniversary. As a subsidiary of PT Telkom, a state-owned telecommunications company, the university is committed to its vision of becoming a research-oriented and entrepreneurial institution by 2023. Additionally, it actively engages in advancing technology, science, and the arts within the context of information technology. All educational programs and initiatives produced and developed by the university are in line with this overarching vision. Consequently, the recruitment of lecturers, and educational staff, and the establishment of management and operational systems prioritize criteria that are closely in line with the vision. Despite this commitment, there is a possibility that the need for environmental experts or specialists might not have received adequate attention in the pursuit of this vision.

In honour of its founder, Cacuk Sudarjanto, campus consists of a total area of approximately 50 hectares, with 48 hectares in the southern campus in the Dayeuhkolot area of Bandung District and the remaining 2 hectares forming the northern campus in the Gegerkalong area. The south campus accommodates 18 dormitory buildings, offering housing for about 6,800 students. This serves as essential housing for students from 34 provinces in the country and abroad. The dormitory setting fosters cultural diversity, providing a platform for experiential learning, social network expansion, and skill development. Additionally, living in these dormitories facilitates experiential learning, fostering adaptation, expanding social networks and friendships, enhancing communication skills, and even facilitating business opportunities. This setting offers a unique environment for anticipating future shifts in job skill requirements [2], acknowledging that not all essential skills can be acquired solely in a classroom. Examples of sought-after job skills include complex problem-solving, people management, effective collaboration, emotional intelligence, critical thinking and decision-making, service orientation, negotiation abilities, and cognitive flexibility. Consequently, living in the dormitories is expected to foster the development of essential soft skills, preparing students for future challenges.

In order to support all activities on campus, adequate infrastructure and superstructure are required. This infrastructure includes electrical and telecommunication networks, clean water, sanitation, and other public facilities. Therefore, this research aims to address the challenge of providing clean water, to a significant population engaged in daily activities, with approximately 35,000 individuals [3], 10% of whom reside in dormitories in campus area. The objective includes estimating the amount of water required, assessing the current capacity to provide clean water, and exploring potential new raw water sources.

Currently, raw water is obtained by pumping from 11 deep wells located within the campus area, a practice that raises concerns about potential land subsidence in Dayeuhkolot District where campus is situated. During 2021-2022, measurements showed a significant annual decrease in land elevation in this area, amounting to 13 cm [4]. This decline contributes significantly to frequent flooding incidents, impacting the area. Subsequently, the presence of textile industries in a section of Dayeuhkolot, relying on groundwater for production, raises the possibility that concerns about land subsidence have contributed to authorities rejecting proposals for additional production well in campus area. Therefore, it is crucial to urgently explore affordable new water sources that can be used as raw water, and a potential source identified is rainwater harvesting (RWH) [5]. Information regarding rainfall volume can be obtained online and free of charge through data provided by the Meteorology, Climatology, and Geophysics Agency (BMKG). To calculate the amount of clean water needed, the standards set by WHO were used [6].

2. Research Methodology

Figure 1 shows the research methodology flow used. Firstly, climate and weather data were collected from the Indonesian National Weather Agency, BMKG, referring to the weather station in Bandung City. The collected online data consisted of monthly rainfall from 2010 to 2022. In March 2023, BMKG released pH measurement results. These data were processed to determine the amount of rainfall that occurred in campus area. The authorities, represented by the Directorate of Logistics, provided production well maps, including supplementary well, along with the respective production capacity data. In the planning process, data on human activities, including status categories and estimated water usage, were required to obtain the volume of water needs for each status category. Due to budget limitations, several considerations were made to determine the location of RWH construction. Subsequently, the design and implementation of RWH were determined based on technical and cost considerations. During the rainy season, the performance of RWH system was evaluated for future improvements.

Figure 1. The flow of research methodology

3. Organization, Estimated Water Demand, and Existing Water Source Conditions

In terms of organization, the responsibility for managing the availability of clean water on campus falls under the Assets and Sustainability (Asus) Directorate since 2023, previously known as the Logistics and Assets Directorate (Logas). This strategic move aims to consistently incorporate elements of sustainability in every decision made.

To effectively address both short and long-term aspects of raw water and clean water provision, it is recommended to implement a planning process that includes the following steps:

1. Estimating the demand for clean water for the academic community during the activities on campus.
2. Determining the capacity and capability of the deep-well pumps.
3. Investigating various potential sources of raw water that can be processed into clean water.
4. Developing a monitoring dashboard for tracking the provision of clean water.
5. Implementing filtration and sedimentation processes for the raw water entering campus area.
6. Exploring the use of treated wastewater for maintaining gardens and agricultural areas.
7. Improving the infiltration of water into the soil is in line with the concept of the hydrological cycle.

By following these steps, the availability of clean water and raw water can be ensured, while also promoting water conservation efforts.

The next discussion focuses on the necessity for clean water. Table 1 shows the estimated daily demand for clean water in the academic community of Telkom University. Various parties involved in activities in campus area include students, faculty members, administrative staff, cleaning personnel, and mosque congregants. Individuals naturally consume food and water to sustain the livelihoods, producing waste as a by-product of bodily metabolism. Subsequently, all biological processes require water, as biochemical reactions cannot occur without it. The estimation of clean water demand is in line with WHO standards for clean water requirements, adapted to suit the lifestyle habits of Indonesians. For example, Indonesia, an archipelagic country located near the equator, experiences high temperatures and humidity, leading to increased perspiration. Therefore, Indonesians are accustomed to bathing twice a day, having one bowel movement a day, urinating approximately every 4 hours in accordance with the body chemical reaction cycle, and performing ablution five times a day as a requirement for Muslims to perform the obligatory five daily prayers. Muslims constitute 80% of the population. Muslim residents residing around campus engage in congregational prayers at the mosque. Considering the COVID-19 pandemic, it is advised to frequently wash hands after activities and interactions with a large number of people. Therefore, the estimated demand for clean water is approximately 1356 m^3/day.

Table 1. Prediction of clean water demand to support academic activities.

Category	Amount	Bathe (m^3)			Defecate (m^3)			Urinate (m^3)			Ablution (m^3)			Handwash (m^3)			Total (m^3)
		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	
Students living in dormitories	3,400	25	2	170	10	1	34	5	4	68	3	5	41	0.5	5	9	321
Lecturers	1,000			-	10	1	10	5	4	20	3	5	12	0.5	5	3	45
Educational staff	200			-	10	1	2	5	4	4	3	5	2	0.5	5	1	9
Students active on campus	28,000			-	10	1	280	5	2	280	3	5	336	0.5	5	70	966
Cleaning service staff	100			-	10	1	1	5	4	2	3	5	1	0.5	5	0	4
Mosque congregation	300			-				5	5	8	3	5	4	0.5		-	11
Total	33,000			170			327			382			396			82	1,356

Description columns: A: Intake B: Frequency C: Amount

The next topic of discussion is the capacity of clean water production on campus. The total monthly production of clean water from all wells is shown in Figure 2. The production graph varies in response to fluctuating demand. In 2020, amid the initial phase of the COVID-19 pandemic, uncertain government policies influenced activity patterns on campus, with some activities continuing despite disruptions. However, in 2021, water demand stabilized at a low level, primarily for environmental maintenance. From the graph, it can be seen that the total production is nearly 2000 m^3/day. This shows that the basic need for clean water can still be met by well in campus. Additionally, well water is used for campus environmental maintenance. The clean water has been produced from 11 deep wells located in campus, close to the user locations, which facilitates and saves distribution routes, as shown in Figure 2. Therefore, an appropriate solution is needed to ensure that campus can quickly and affordably meet the demand for clean water. The use of clean water must be conserved, thereby a raw water source is needed for environmental maintenance.

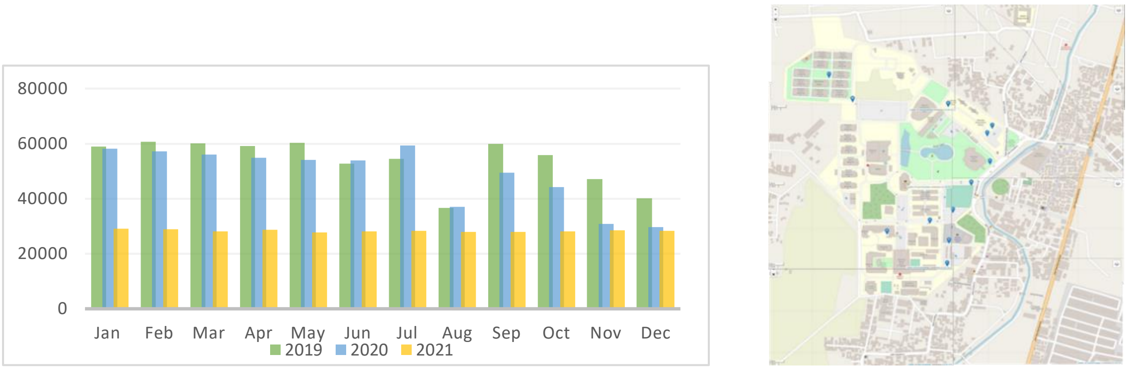

Figure 2. Groundwater production in cubic meters (m^3) from 2019 to 2021 (left) and the production-well map (right).

4. Water management

Categorically, the raw water sources on campus can be divided into two types based on the source: surface water and groundwater. The surface water on campus is derived from irrigation water, rainwater, and wastewater. Irrigation water, sourced externally, serves to irrigate agricultural fields. The canal responsible for irrigation also carries water and waste, passing through campus area before eventually flowing into the Citarum River. The location of campus in Dayeuhkolot District was previously an agricultural area that was later raised for campus construction. However, the irrigation canal cannot be destroyed and must be continuously maintained. Another source of raw water is rainwater, abundant rainfall occurs during the rainy season. Rainfall data for Bandung area is obtained from Bandung Geophysics Station (BMKG) [7], as shown in Figure 3. From the graph, it can be observed that rainfall exceeding 200 L/month occurs from October to May, and this period can be considered the rainy season. On the other hand, from June to September, rainfall is very low, less than 200 L/month, and referred to as the dry season. The third type of surface water source is wastewater, which consists of treated and untreated wastewater. The treated wastewater is derived from toilets, mosques, and cafeterias, and the untreated wastewater includes toxic chemical waste produced from university laboratory experiments.

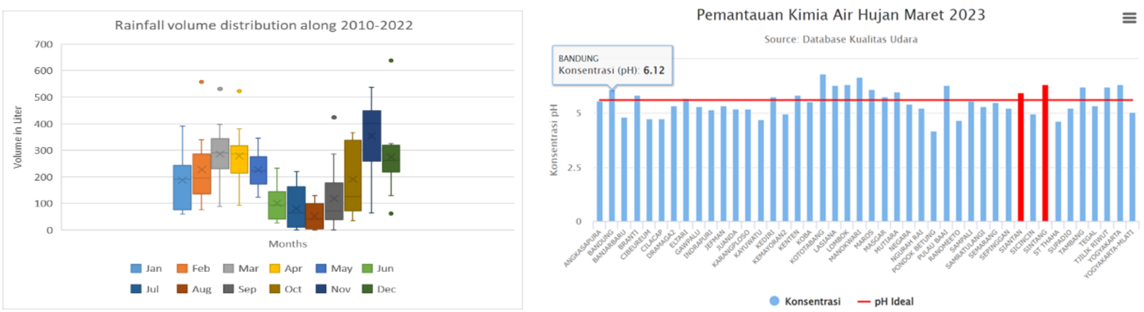

Figure 3. Distribution of rainfall volume in Bandung area during the period of 2010-2022 (left) and rainwater pH measurement in March 2023 (right).

Based on the description, the university is facing numerous challenges in providing clean and raw water. Therefore, a proper understanding of water management concepts is necessary. Referring to the definition [8], water management is defined as the control and movement of water resources to minimize damage to life and property and to maximize efficient beneficial use. Based on this definition, various raw water sources in campus environment are then identified and categorized. Table 2 shows the different origins of water sources and the treatment stages required to make the raw water usable for humans and the environment. The graph shows that groundwater, sourced from well, is the predominant water supply for numerous applications. Following closely is rainwater, emerging as a potential next water source deserving consideration for expanded use. Factors such as the level of complexity in implementation, resulting impacts, and budget availability are considered in determining the priority scale for handling these sources. The repeated use of water shows the gradual implementation of water conservation efforts.

Table 2. Raw water sources and treatment stages for various applications of use.

Water sources	End-Usage	Treatment stages		
		Stage 1	Stage 2	Stage 3
Deep-well water	Shower, toilet, garden, canteen, hand-wash taps, mosques	Well internal filtration	Pumping over rooftop tanks	
	Drinking water in gallons or bottles	Well internal filtration	Reverse osmosis filtration	Sterilization
	Canteen in front of campus	Well internal filtration	Water tank delivery	
Rainwater	Toilets, green house, waste composting, garden/forest watering, car wash, pinfold, fish pond, bio-pore, aviary, cleaning harvesting product	Filtration	Storage in (under/upper) ground tanks	Pumping to tower storage
Irrigation water	River, fish pond,	Garbage filtration	Mud deposition pond	Retention pond

Water sources	End-Usage	Treatment stages		
		Stage 1	Stage 2	Stage 3
Retention pond water	Fish pond	Filtration		
Sewage Treatment Plant (STP) water	Garden watering, planting land	Pumping	Piping	
	Garden watering, planting land	Pumping	Water tank delivery	
	WC-flush	Plumbing distribution change	Pumping to rooftop water tank	
Canteen treated waste water	Garden watering, planting land, fish pond	Filtration	Mud deposition pond	

5. Developing rainwater harvesting: policy and design aspects

The situation, where abundant unused rainfall water contributes to disasters while the demand for clean water remains unmet, is a matter of significant consideration. In the rainy season, abundant water leads to the formation of puddles, serving as stagnant breeding grounds for mosquitoes and contributing to the spread of deadly diseases such as dengue fever. Additionally, regular flooding in the vicinity of campus causes damage to houses and roads, sweeps away belongings, and even claims lives. The secondary effects include traffic congestion, air pollution, disrupted logistics distribution, and subsequently increase in the price of commodities. From the government perspective, the budget for handling disasters and refugees is increasing, leading to an increase in poverty. Therefore, by extensively harnessing rainwater, several problems can be simultaneously addressed.

In practice, there are several considerations for implementing RWH system, which are as follows:

- Rainwater puddles, if not promptly addressed, can result in negative impacts, potentially resulting in various issues such as diseases, disrupting people movements, causing accidents, and hindering vehicle traffic.
- Compliance with regulations set by authorized bodies or authorities, such as the environmental agency, and central and local government regulations.
- Addressing matters within the university's jurisdiction reduces the intricacy of planning, design, operational processes, and budget implementation costs.
- Due to the absence of a dedicated budget for environmental management, including RWH, the construction of RWH system is integrated into the operational budget of the Directorate of Assets and Sustainability or other planning and budgeting entities.
- Integrated development of RWH system across the entire campus area, including student dormitories, includes coordination with other parties, such as YPT and third-party dormitory management.

Campus has implemented several measures mentioned above. For example, addressing the issue of rainwater puddles with negative impacts in the Business Centre area and Telkom University Convention Hall (TUCH) area. These areas share common characteristics, including trapped rainwater with no drainage outlets. Consequently, a solution was devised to collect rainwater for subsequent use. Water flows into a collection pond, passing through the ground surface and eventually reaching the sewer. As a result, the rainwater becomes contaminated with debris such as leaves, soil/mud, and other impurities. Therefore, various filtration methods are needed, including coarse filters to remove debris, and fine filters to remove sediment/mud and balance the chemical content of the rainwater. In accordance with the filtration process, the filter materials used are coconut coir, activated sand, coral rock fragments [9], and zeolite [10,11]. The Meteorology, Climatology, and Geophysics Agency (BMKG) periodically measure air quality. In 2023, measurements were conducted in 52 cities using the Wet Deposition and Wet and dry Deposition methods with an Automatic Rain Water Sampler (ARWS) device. The rainwater samples were analyzed using an ion chromatograph, and the measurement results are shown in Figure 3. The figure shows that rainwater in Bandung area has a pH level of 6.12, categorized as very good and tends to be neutral [12]. Although the measured pH level is considered very good, due to the highly variable air quality depending on human and industrial activities. It was advisable to install filtration systems that are proactive in anticipating potential worsening conditions. RWH design model uses the catchment area, including the roof surface of buildings and surrounding yards where rainwater flows into a permanent underground tank.

Designing RWH system requires determining the volume of rainwater falling in campus area and the surface area of the buildings used as catchment areas. Subsequently, RWH volume in campus can be calculated based on the rainfall volume that occurs in the area and can be expressed using the following equation:

$$V_H^{Tot} = C_H \times L_k \tag{1}$$

Where:

V_H^{Tot} = The total volume of rainfall that occurs within the campus area.

C_H = Rainfall intensity in millimeters per square meter, data obtained from BMKG.

L_k = Campus area size in square meters or square kilometers.

Table 3 shows rainfall data in millimeters per cubic meter (mm/m^3) obtained from the website of BMKG for Bandung City from 2010 to 2022 [6]. On the other hand, Table 4 shows the volume of rainfall (m^3) that falls in campus area during the same period, considering a campus land area of 48 hectares based on Equation (1).

Table 3.Rainfall data for the period of 2010-2022 obtained from BMKG Bandung in mm/m2

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	353.3	557.1	531	93	345	131.9	220.8	106.1	424.4	292.2	401.4	237.5
2011	63	76.7	89.4	381.5	193.4	117.6	77.2	3.1	102.8	103.6	321.4	259
2012	82.9	303.7	155.5	290.8	257.1	60.5	34.2	0	27	125	537	636.9
2013	216.9	249.6	304.8	285.8	170.9	231.5	159.1	74.3	171.7	35.8	64.1	325.6
2014	253.9	81.5	246.6	195.1	176.7	173	164.8	119.8	0.6	60.8	246.8	235.5
2015	167.3	179.7	264.5	231	208.1	50.4	0.3	6.9	43.2	34.5	419.4	307.4
2016	391.5	194.3	376.2	523	317.8	139.3	182.3	128.7	286.2	362.3	442.5	62.1
2017	68.3	196.3	396.5	237.9	222.3	68.4	7.9	45.7	90.8	345.3	442	129.9
2018	190.8	239.3	292	297.5	123.9	33.4	0.3	38.9	40.8	124.8	483.2	322.9
2019	231.4	269.3	223.3	298.9	243	26.5	13.4	0.2	55	84.2	270.9	315.5
2020	207.6	340	290.8	271.4	292.3	30.3	63.7	41.6	35.9	327.3	207.3	261.8

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2021	148.6	153.9	309	177.2	238.9	92.4	33.2	91.8	73	218.4	454.3	198.5
2022	59.5	117.1	238.9	336.2	146.9	150.6	82.2	29.9	182.2	366.7	307.2	277.7

Table 4. Volume of rainfall in the campus area covering 48 hectares in thousands of cubic meters.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	169.58	267.41	254.88	44.64	165.60	63.31	105.98	50.93	203.71	140.26	192.67	114.00
2011	30.24	36.82	42.91	183.12	92.83	56.45	37.06	1.49	49.34	49.73	154.27	124.32
2012	39.79	145.78	74.64	139.58	123.41	29.04	16.42	0.00	12.96	60.00	257.76	305.71
2013	104.11	119.81	146.30	137.18	82.03	111.12	76.37	35.66	82.42	17.18	30.77	156.29
2014	121.87	39.12	118.37	93.65	84.82	83.04	79.10	57.50	0.29	29.18	118.46	113.04
2015	80.30	86.26	126.96	110.88	99.89	24.19	0.14	3.31	20.74	16.56	201.31	147.55
2016	187.92	93.26	180.58	251.04	152.54	66.86	87.50	61.78	137.38	173.90	212.40	29.81
2017	32.78	94.22	190.32	114.19	106.70	32.83	3.79	21.94	43.58	165.74	212.16	62.35
2018	91.58	114.86	140.16	142.80	59.47	16.03	0.14	18.67	19.58	59.90	231.94	154.99
2019	111.07	129.26	107.18	143.47	116.64	12.72	6.43	0.10	26.40	40.42	130.03	151.44
2020	99.65	163.20	139.58	130.27	140.30	14.54	30.58	19.97	17.23	157.10	99.50	125.66
2021	71.33	73.87	148.32	85.06	114.67	44.35	15.94	44.06	35.04	104.83	218.06	95.28
2022	28.56	56.21	114.67	161.38	70.51	72.29	39.46	14.35	87.46	176.02	147.46	133.30

The ideal RWH system involves capturing rainwater flowing from building rooftops, and the volume of captured rainwater depends on the roof surface area. However, not all rainfall directly enters RWH storage tank due to the impact of falling water on the roof hard surface. The velocity of water falling with Earth gravity (9.8 m/s) causes deflection and scattering, leading to some rainwater splashing outside the roof. Consequently, these splashes can reduce the volume of rainwater entering the storage tank. This condition can be expressed in the following equation.

$$V_{RWH} = C_H \times L_A \times k_A \quad (2)$$

Where:

V_{RWH} = The volume of Rainwater Harvesting (RWH) generated

L_A = The surface area of the roof used to capture rainwater is measured in square meters.

k_A = The coefficient of the roof, which is a dimensionless value with a maximum value of 1

Information on the roof areas of the buildings on campus can be obtained using the Google Earth application, and the results are shown in Table 5. From the table, it can be seen that the total roof area of the buildings on campus is 80,941 m^2. For ease and practicality of calculation, the roof area data is approximated to 81,000 m^2. By adopting the review in [13], which provides the coefficient value, and using the roof area data of 81,000 m^2, the calculation results using Equation (2) are shown in Table 6. Subsequently, the calculation involves determining the percentage of availability of RWH relative to the provision of clean water, as shown in Table 1. The calculation results are shown in Table 7. From the table, the fluctuation in RWH availability corresponding to the seasonal variations can be observed.

Considering these circumstances, the management recognizes the importance of proactive steps and implementing various preparatory measures.

Table 5. Data of building roof areas as rainwater catchment.

No.	Building names	Roof areas (m^2)	No.	Building names	Roof areas (m^2)
1	Deli	2,158	21	Tokong Nanas	4,068
2	Ararkula	706	22	Ghra Cacuk Sudarijanto A	2,763
3	Barung	2,420	23	Bangkit	1,695
4	Panambulai	1,142	24	Alor	725
5	Kultubai Utara	1,544	25	Asrama Mahasiswa	18,544
6	Kultubai Selatan	1,544	26	Kantin Teknik	2,030
7	Karang	2,471	27	Karaweira	1,244
8	Ghra Cacuk Sudarijanto B	2,561	28	Benggala	4,590
9	Mangudu	598	29	Lingian	1,695
10	Sebatik	2,080	30	Pelampong	3,633
11	Galeri Idealoka	544	31	Syamsul Ulum	1,825
12	Genset	188	32	Batek	4,400
13	Miossu	879	33	Student Mart	56
14	Marore	939	34	Sport Center	2,315
15	Manterawu	1,590	35	Pool KBM	84
16	Kawalusu	928	36	Green House	660
17	Intata	875	37	Genset	239
18	Selaru	2,607	38	Kantin Bambu	530
19	Panehan	1,067	39	TULT	2,300
20	Damar	704			
		Total			80,941

Table 6. Potential volume of Rainwater Harvesting (RWH) in cubic meters (m^3).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	22.894	36.100	34.409	6.026	22.356	8.547	14.308	6.875	27.501	18.935	26.011	15.390
2011	4.082	4.970	5.793	24.721	12.532	7.620	5.003	0.201	6.661	6.713	20.827	16.783
2012	5.372	19.680	10.076	18.844	16.660	3.920	2.216	0.000	1.750	8.100	34.798	41.271
2013	14.055	16.174	19.751	18.520	11.074	15.001	10.310	4.815	11.126	2.320	4.154	21.099
2014	16.453	5.281	15.980	12.642	11.450	11.210	10.679	7.763	0.039	3.940	15.993	15.260
2015	10.841	11.645	17.140	14.969	13.485	3.266	0.019	0.447	2.799	2.236	27.177	19.920
2016	25.369	12.591	24.378	33.890	20.593	9.027	11.813	8.340	18.546	23.477	28.674	4.024
2017	4.426	12.720	25.693	15.416	14.405	4.432	0.512	2.961	5.884	22.375	28.642	8.418
2018	12.364	15.507	18.922	19.278	8.029	2.164	0.019	2.521	2.644	8.087	31.311	20.924
2019	14.995	17.451	14.470	19.369	15.746	1.717	0.868	0.013	3.564	5.456	17.554	20.444
2020	13.452	22.032	18.844	17.587	18.941	1.963	4.128	2.696	2.326	21.209	13.433	16.965
2021	9.629	9.973	20.023	11.483	15.481	5.988	2.151	5.949	4.730	14.152	29.439	12.863
2022	3.856	7.588	15.481	21.786	9.519	9.759	5.327	1.938	11.807	23.762	19.907	17.995

Table 7. Potential fulfillment of clean water needs from processed Rainwater Harvesting (RWH).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2010	54%	95%	82%	15%	53%	21%	34%	16%	68%	45%	64%	37%
2011	10%	13%	14%	61%	30%	19%	12%	0%	16%	16%	51%	40%
2012	13%	50%	24%	46%	40%	10%	5%	0%	4%	19%	86%	98%
2013	33%	43%	47%	46%	26%	37%	25%	11%	27%	6%	10%	50%
2014	39%	14%	38%	31%	27%	28%	25%	18%	0%	9%	39%	36%
2015	26%	31%	41%	37%	32%	8%	0%	1%	7%	5%	67%	47%
2016	60%	32%	58%	83%	49%	22%	28%	20%	46%	56%	70%	10%
2017	11%	33%	61%	38%	34%	11%	1%	7%	14%	53%	70%	20%
2018	29%	41%	45%	47%	19%	5%	0%	6%	6%	19%	77%	50%
2019	36%	46%	34%	48%	37%	4%	2%	0%	9%	13%	43%	49%
2020	32%	56%	45%	43%	45%	5%	10%	6%	6%	50%	33%	40%
2021	23%	26%	48%	28%	37%	15%	5%	14%	12%	34%	72%	31%
2022	9%	20%	37%	54%	23%	24%	13%	5%	29%	57%	49%	43%
Average	29%	38%	44%	44%	35%	16%	12%	8%	19%	29%	56%	42%

6. Saving the runoff water by building Rainwater Harvesting: Best Practice

When it rains in areas where there is no available drainage, the water becomes trapped, accumulates, and eventually forms puddles. Such incidents occur in several places on campus due to poor integration and inadequate consideration of environmental impacts in the planning and construction processes. The basic construction of the RWH system is depicted in Figure 4. This RWH system consists of a catchment area, filtration system, collection tank, infiltration well, water pump, iron tower and water tank, feeder pipes, and distribution pipe network. If the amount of rainwater entering exceeds the tank's capacity, causing overflow, the excess water is directed to the infiltration well, returning it to the ground and completing the hydrological cycle. Currently, there are two RWH units constructed to address the issue of trapped rainwater and resulting puddles: one in the Business Center area or Alor Building, and the other in the Convention Center area or Benggala Building, as shown in Figures 5 and 6. In this case, the RWH design differs from equation (2) in that the catchment area includes not only the building roofs but also the surrounding grounds where rainwater falls. This rainwater becomes runoff. Consequently, debris on the ground surface, such as sand and mud, are also carried along and flow into the water canals that lead to the underground water tank. This condition affects the filtration system components. Therefore, various filters are required: coarse filters to remove debris, fine filters to remove sand and mud, and zeolite rock filters to adjust the pH level.

After constructing the 2 RWH units, several experiences were gained, which are outlined as follows:

- The infiltration-wells did not function properly due to the inability of the clayey soil foundation material to absorb water. The solution was to deepen the infiltration pipes for tens of meters until reaching the original soil layer.
- In Figure 5, the water in the tank appears turbid because the rainfall was very heavy, causing mixed overflow water to enter the RWH system. This occurred due to the malfunctioning infiltration wells.
- In Figure 6, during the construction of the RWH system, underground cables posed a

challenge, requiring the relocation of the RWH unit. Due to the susceptibility of the loose soil to landslides and continuous rainfall, the process of concrete pouring for the underground tank encountered difficulties such as concrete washout and wall collapse. It is advisable to choose the peak of the dry season for RWH construction.

- The size of the ground tank was determined based on design calculations, but during the execution, flexibility was allowed to adjust it according to the environmental conditions and available funding.

Despite the fact that the RWH system's results are not yet perfect, there is a need to expand the utilization of surface water such as rainwater. This can have the effect of reducing well water consumption and water collection due to rainwater runoff, which in turn decreases land-subsidence and even, flooding. In its initial stage, RWH can be utilized for environmental preservation purposes and compost processing.

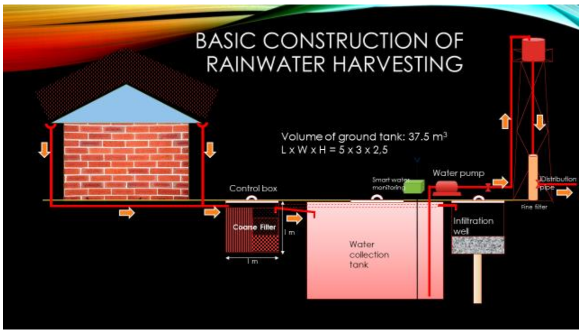

Figure 4. Conceptual design of rainwater harvesting system.

Figure 5. Implementation of rainwater harvesting construction in the area of Alor Building

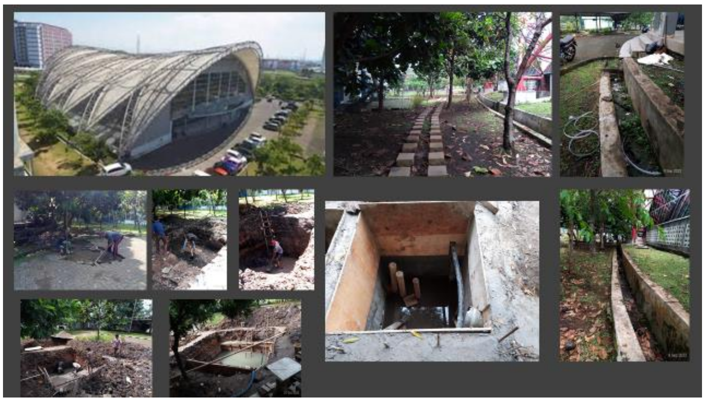

Figure 6. Constructing the second rainwater harvesting system in the Benggala Building area (TUCH).

7. Concluding remarks

In conclusion, Telkom University established an organizational structure and water governance plan. Subsequently, the volume of clean water from deep well dominated water usage for various needs, including environmental maintenance. The exploitation of groundwater posed the risk of land subsidence, showing the importance of water conservation and exploring alternative water sources. RWH system emerged as a potential solution, offering a fluctuating volume dependent on seasonal variations. Currently, two RWH systems had been constructed to capture trapped rainwater. There was a need for Improvements in the construction of RWH soak pits to ensure a well-functioning hydrological cycle. The construction of these systems was preferably carried out during the dry season, and the designs were highly flexible and depend on the available land and funding resources.

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