



# Analysis of the Effectiveness of Rainwater Harvesting in Reducing Flooding: Case Study in the Governor's Housing Complex, Makassar

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## ABSTRACT

Flooding in residential areas remains a recurring problem in Makassar City, particularly in the Governor's Housing Complex, Kassi-Kassi Subdistrict. This study aims to analyze the effectiveness of rainwater harvesting (RWH) systems in reducing flood risks. The methodology includes hydrological and hydraulic analysis, as well as catchment area mapping. The RWH system design is based on estimating the potential rainwater volume from annual rainfall intensity and rooftop catchment areas. The results show that the average flood volume in the study area is 61.66 m<sup>3</sup>. The effectiveness of the rainwater harvesting system varies with storage capacity and roof area. In the first scenario (8 m<sup>3</sup>), flood volume is reduced by 4.61-60.06%; in the second scenario (10 m<sup>3</sup>), it achieves a 5.77-75.08% reduction; and in the third scenario (15.6 m<sup>3</sup>), it results in a 9.01-80.12% decrease. Differences in rooftop size influence the variation in percentage reduction, which affects the volume of harvested rainwater. The third scenario demonstrates the highest effectiveness, indicating that rainwater harvesting is a feasible and efficient strategy for urban rainwater management and flood mitigation. The study concludes that integrating rainwater harvesting (RWH) systems is a practical and sustainable solution for urban flood mitigation, especially in flood-prone areas such as Kassi-Kassi, Makassar.

## 1. INTRODUCTION

Makassar City, as the fourth-largest metropolitan city in Eastern Indonesia, is experiencing rapid population growth, with a total population of 1,454,956 people in 2023 (Central Bureau of Statistics of South Sulawesi Province 2023). This increase has not been accompanied by adequate clean water services, causing difficulties in fulfilling water needs, especially in densely populated areas. In addition, the expansion of development and the increase in built-up areas have resulted in a decrease in land absorption capacity, leading to an increase in runoff into drainage channels (Kharisma et al. 2016). If not managed properly, this runoff has the potential to cause flooding in the rainy season and drought in the dry season (Hermon & Barlian 2012). Based on the Makassar City RTRW (2006–2015), this area is categorized as flood-prone due to its low topography and the presence of two large river estuaries, the Jeneberang and Tallo Rivers. A major flood event in early 2023 resulted in 1,869 residents being displaced to 21 evacuation centers (Anirwan & Almuhammad Haris 2023).

One promising approach to addressing flooding and water shortages in urban areas is rainwater harvesting (RWH) technology. This system utilizes the roof of the building as the main catchment area, as it is relatively cleaner than other surfaces (Fewkes 2014, Lee et al. 2012). According to Raharjo (2019), the more rainwater that can be collected and utilized, the lower the potential for flooding. Several previous studies have shown that RWH systems are highly effective in reducing rainwater runoff. For example, a study by Kustyaningrum and Lasminto (2023) in Surabaya showed a reduction in inundation of up to 80.16% with an RWH



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system. In Palangka Raya, Kamiana et al. (2024) found that the application of RWH reduced main drainage discharge by 58.15%. In Watampone, Ali et al. (2017) noted that rainwater harvesting was able to reduce surface runoff by more than 85%. At the international level, sponge city approaches, such as those in Guangxi, China, show that a combination of green space, bio-retention, and RWH can reduce runoff by up to 75% (Li et al. 2025). Technological innovations also support the optimization of RWH systems. Sharma and Ghosh (2021) highlighted that city infrastructure needs to be designed with adaptive safety factors, where RWH systems can be a vital component of urban climate resilience.

One of the areas in Makassar City that is consistently affected by annual flooding, even during low rainfall, is the Governor's Housing Complex in Rappocini Sub-district. This recurring flood issue is primarily due to a non-optimal drainage system and the increasing impervious surface area, which prevents rainwater from infiltrating into the soil, thereby increasing surface runoff. Flooding in this area typically occurs shortly after moderate to heavy rain. Based on field surveys and interviews with local residents, floodwaters can reach depths of approximately 15 to 30 centimeters and may persist for 1 to 2 hours, depending on rainfall intensity and the ability of the drainage system to discharge water. In some cases, particularly during prolonged rainfall, the inundation may last longer and extend to wider areas.

The drainage system in the Governor's Housing Complex is generally underperforming. Several factors contribute to this condition. First, many of the drainage channels are shallow and lack sufficient slope, which hampers efficient water flow. Second, there is frequent accumulation of solid waste and sediment, which clog the drainage paths and significantly reduce their capacity. Additionally, the system suffers from poor connectivity between drainage segments, resulting in stagnant water and localized flooding. The lack of routine maintenance further exacerbates the situation. Therefore, this study aims to analyze the effectiveness of rainwater harvesting (RWH) systems in reducing runoff volume in this flood-prone area. According to Harsoyo (2010), rainwater harvesting not only reduces surface runoff but also contributes to sustainable water resource conservation in urban environments.

While several studies have examined RWH applications in Indonesian urban contexts, few have assessed their performance in areas with limited space, non-retrofitable drainage systems, and dense residential housing, such as the Governor's Housing Complex in Makassar. Furthermore, most previous research applies generalized assumptions without integrating localized hydrological-hydraulic data

at the building scale. This study fills that gap by presenting a data-driven RWH simulation that combines spatial roof data, water usage estimates, and drainage analysis. The research contributes a novel approach that integrates RWH effectiveness simulation at the individual-building level, aiming to support urban flood mitigation planning under infrastructure constraints.

This study not only measures the effectiveness of RWH but also introduces a spatial model for flood volume reduction at the building and neighborhood levels. The main scientific contribution lies in the integration of primary field data (roof area, drainage capacity, household water demand) with three RWH simulation scenarios, offering a localized planning tool for decentralized urban water management.

## 2. MATERIALS AND METHODS

### 2.1 Study Area

This research was conducted in the Governor's Housing Complex, located in Kassi-Kassi Subdistrict, Rappocini District, Makassar City, Indonesia. Geographically, the site is situated between 119°27'13.69"–119°27'16.69" E longitude and 5°10'08.88"–5°10'12.491" S latitude. The area was selected due to its frequent annual flooding and limited water supply infrastructure. The location of the study area is shown in Fig. 1.

### 2.2 Research Methodology

This study employs a descriptive-quantitative approach, which combines numerical analysis (quantitative) with a systematic description of observed conditions (descriptive). This approach is chosen because the research aims not only to process numerical data but also to describe the existing drainage conditions and runoff behavior in the study area. Although this study applies a descriptive-quantitative framework, the research is grounded in original field data collection and site-specific hydrological analysis. Primary data include building roof measurements and drainage dimensions, which are combined with 10-year rainfall records to simulate runoff and flood volume. The study employs standard hydrological modeling techniques (Log-Pearson III, rational method) and hydraulic capacity analysis using Manning's equation. The scenarios simulate flood volume reduction across 215 buildings, providing a comprehensive and original assessment that goes beyond descriptive statistics and meets the requirements for empirical research.

### 2.3 Types and Sources of Data

This study utilizes two main types of data: primary data and secondary data. Primary data were obtained through



the planned drainage meets the technical requirements. A dynamic control approach to drainage systems, when coupled with rainwater harvesting, increases the effectiveness of real-time flood control (Wong & Kerkez 2022). The flow discharge ( $Q$ ) in the channel is calculated using Equation (3).

$$Q = V \times A \quad \dots(3)$$

Where,  $Q$  = discharge that occurs ( $\text{m}^3 \cdot \text{s}^{-1}$ ),  $V$  = channel velocity ( $\text{m} \cdot \text{s}^{-1}$ ),  $A$  = cross-sectional area ( $\text{m}^2$ )

### 2.7 Rainwater Harvesting Analysis

Rainwater runoff from the building's roof will be collected through a rainwater harvesting system to minimize runoff discharge. The mandatory volume to be managed in rainwater harvesting is determined by calculations based on the Regulation of the Minister of Public Works of the Republic of Indonesia Number 11/PRT/M/2014 concerning Rainwater Management in Buildings and Persil.

$$V = 0.855 \times C \times A \times th \quad \dots(4)$$

Where,  $V$  = volume ( $\text{m}^3$ ),  $C$  = Coefficient of runoff of building cross-section,  $A$  = Projected area of building cross-section against horizontal plane ( $\text{m}^2$ ),  $th$  = rainfall height (mm)

Rainwater demand is the volume that will be used by the community for daily needs for one month, calculated with the following equation:

$$B = D \times P \quad \dots(5)$$

Where,  $B$  = Total water demand in one month ( $\text{m}^3$ ),  $D$  = Water demand of one person in one day ( $\text{m}^3$ ),  $P$  = Number of users (people)

### 2.8 Analysis of Rainwater Harvesting Effectiveness

The effectiveness of using rainwater harvesting against flooding is obtained from the storage volume compared to the runoff volume:

$$\text{Surface Flood Inundation Volume Reduction Rate (\%)} = (V_s) / (V_{ab} + V_n) \times 100\% \quad \dots(6)$$

Where,  $V_s$  = Storage water ( $\text{m}^3$ ),  $V_n$  = Daily water demand ( $\text{m}^3 \cdot \text{y}^{-1}$ ),  $V_{ab}$  = Flood inundation ( $\text{m}^3$ )

The inclusion of  $V_n$  in this formula accounts for the volume of harvested rainwater used to meet household water needs throughout the year. It assumes that water stored in tanks is retained and used for non-potable purposes such as toilet flushing, washing, and irrigation. By incorporating  $V_n$ , the calculation reflects the additional reduction in runoff due to water actively drawn from storage for daily use, thus decreasing the potential for future surface runoff. This annualized approach offers a more complete estimate of the rainwater harvesting (RWH) system's role in flood mitigation

by linking storage capacity with actual consumption patterns. It captures a realistic scenario where harvested rainwater offsets both immediate flood volumes ( $V_{ab}$ ) and helps reduce overall runoff through continuous utilization ( $V_n$ ).

## 3. RESULTS AND DISCUSSION

### 3.1. Analysis of Maximum Rainfall

Rainfall analysis was conducted to determine the magnitude of the Governor's housing return period rainfall. The rainfall data used is from the last 10 years, from 2014 to 2023, obtained from BMKG Region IV Makassar. The data are presented in Table 1.

### 3.2. Frequency Distribution and Return Period Analysis

The frequency distribution analysis was conducted using the Log-Pearson Type III distribution. The suitability of this distribution was verified using the Chi-Square and Smirnov-Kolmogorov goodness-of-fit tests. Subsequently, it will be used to calculate planned rainfall. The results of the rainfall calculation are presented in Table 2.

### 3.3. Flood Discharge Analysis

Discharge calculations are carried out for hydrological conditions where discharge conditions are influenced by

Table 1: Annual maximum rainfall of BMKG region IV Makassar station.

No	Year	Rmaks [mm]
1	2014	878
2	2015	1041
3	2016	651
4	2017	1026
5	2018	787
6	2019	565
7	2020	915
8	2021	1050
9	2022	796
10	2023	1064

Table 2: Rainfall depth for each return period.

Return period [year]	Rainfall [mm]
100	1234
50	1204
25	1167
10	1103
5	1035
2	888

rainfall and conditions that occur in the field. The following is an example of calculations for the A1-A31 channel using equation 2

$$Q_{\text{hydrology}} = \frac{1}{3.6} C.Cs.I.A =$$

$$\frac{1}{3.6} \times 0.7 \times 0.587 \times 1477.22 \times 0.00209 = 0.35 \text{ m}^3.\text{s}^{-1}$$

### 3.4. Hydraulic Analysis

At the hydraulic analysis stage, determining the geometric dimensions of each drainage channel is essential for evaluating flow capacity. In this study, a field survey was conducted to collect dimensional data for the channels. Additionally, the degree of drainage blockage was quantified to assess the extent of obstruction that could reduce the effective flow area. Blockage was measured using graduated rods to estimate the percentage of the channel's cross-sectional area obstructed by debris, sediment, or vegetation. This obstruction percentage was then used to adjust the effective area in hydraulic calculations. For example, the hydraulic discharge calculation for the A1–A31 channel segment is presented using Equation (3) with the following parameters:

$$\text{Width (b)} = 0.45 \text{ m}$$

$$\text{Depth (h)} = 0.34 \text{ m}$$

$$\text{Water depth, (h}_a\text{)} = 0.20 \text{ m}$$

$$\text{Slope (I)} = 0.03\%$$

$$\text{Cross-sectional area (A)} = b \times \text{water} = 0.45 \times 0.34 = 0.154 \text{ m}^2$$

$$\text{Wetted perimeter (P)} = b + 2\text{water} = 1.13 \text{ m}$$

$$\text{Hydraulic radius (R)} = A/P = 0.1354 \text{ m}$$

$$\text{Manning coefficient (n)} = 0.014 \text{ (concrete)}$$

$$\text{Mean flow velocity (V)} = 0.326 \text{ m}.\text{s}^{-1}$$

$$Q_{\text{hydraulics}} = V \times A = 0.326 \times 0.154 = 0.049 \text{ m}^3.\text{s}^{-1}$$

The results show that the hydraulic discharge capacity ( $Q_{\text{hydraulics}}$ ) is lower than the hydrological discharge ( $Q_{\text{hydrology}}$ ). Specifically, in the A1–A31 segment,  $Q_{\text{hydrology}}$  is  $0.354 \text{ m}^3.\text{s}^{-1}$  while  $Q_{\text{hydraulics}}$  is only  $0.0499 \text{ m}^3.\text{s}^{-1}$ . This significant disparity indicates that the channel does not have sufficient capacity to accommodate peak discharge, rendering it prone to localized flooding. A broader analysis was carried out for all drainage segments within the study area. The comparison of hydrological and hydraulic discharge for each segment is summarized in Table 3, which highlights several channels that lack adequate hydraulic capacity. These deficiencies contribute to recurrent flooding in key areas.

Table 3: Recapitulation of drainage channels that experience flooding.

Drainage Channel	Q_Hydr [m <sup>3</sup> .s <sup>-1</sup> ]	Q_Hydraul [m <sup>3</sup> .s <sup>-1</sup> ]
A1 - A31	0.354	0.0499
A31 - A30	0.502	0.4749
A4 - A30	0.369	0.1321
A30 - A29	0.871	0.2495
A5 - A29	0.368	0.1412
A29 - A28	0.513	0.4160
A6 - A28	0.375	0.3351
A28 - A27	1.759	0.4012
A7 - A27	0.331	0.2913
A27 - A26	0.463	0.3406
A8 - A26	0.330	0.2090
A26 - A25	2.552	1.9038
A9 - A25	0.349	0.2416
A25 - A24	0.489	0.3553
A10 - A24	0.349	0.1623
A24 - A23	3.391	0.0019
A11 - A23	0.380	0.1868
A23 - A22	0.528	0.2209
A12 - A22	0.390	0.0865
A22 - A21	4.309	0.1548
A13 - A21	0.328	0.1842
A21 - A20	0.484	0.1062
A20 - A19	4.793	0.1384
A13 - A15	0.192	0.1321
A19 - A17	4.902	0.3515
A17 - A16	5.150	0.2256
A32 - A18	0.476	0.1043
A2 - A14	0.418	0.1998

To better visualize the differences between hydrological and hydraulic discharge across each drainage segment, Fig. 2 is included. The chart clearly shows that in most segments, especially from A24–A23 to A17–A16, hydrological discharge vastly exceeds hydraulic capacity. The most notable discrepancies appear in segments A24–A23, A22–A21, and A20–A19, indicating an urgent need for redesign or capacity upgrades of these drainage systems.

### 3.5. Rainwater Harvesting Analysis

#### 3.5.1. Calculation of Roof Area

To determine the roof area of buildings in this study, ArcGIS 10.8.2 software was used. Tables 4 and 5 present an example of roof area measurements for buildings located along a drainage channel that frequently experiences flooding.

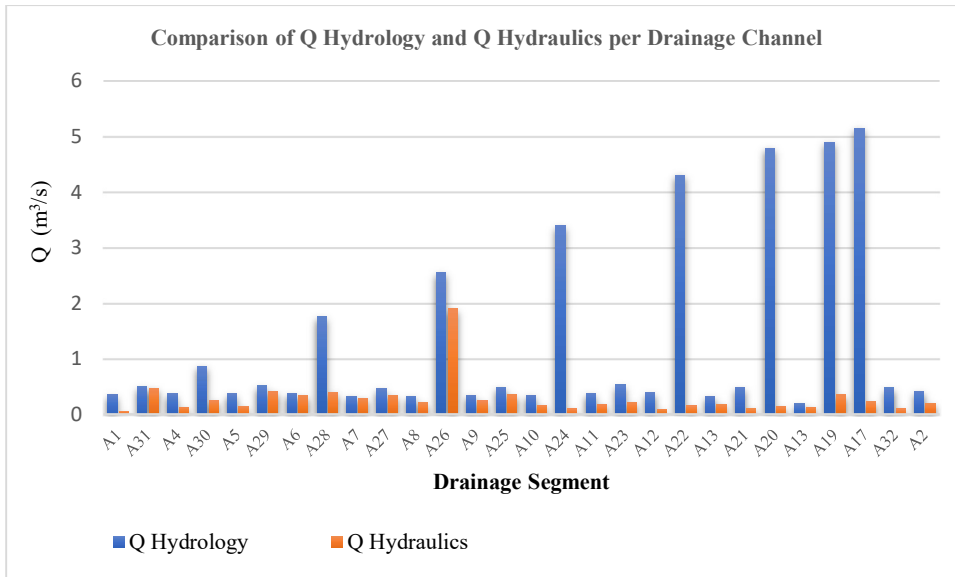


Fig. 2: Comparison of Q Hydrology and Q Hydraulics per drainage channel.

The rainwater harvesting calculation aims to determine how effectively the collected and stored water in a reservoir or ground tank reduces the flood inundation volume (VAB).

Table 4: Building roof area on channel drainage, Beringin 2.

Channel	Building Name	Roof Area [m <sup>2</sup> ]
Beringin 2	22	161.61
	23	136.4
	24	99.79
	25	118.69
	26	149.9
	27	108.97
	28	93.13
	29	159.88
	30	139.34
	31	97.24
	32	161.54
	33	136.85
	34	72.94
	35	86.1
	36	90.58
	37	100.48
	38	97.69
	39	107.08
	40	93.38
	41	83.54
	42	86.54
	43	116.07
	44	76.19
	45	96.89

Table 5: Recapitulation of building the Beringin 2 rainwater harvesting system.

Channel Drainage	Building Name	Roof Area [m <sup>2</sup> ]	Vab [m <sup>3</sup> ]
Beringin 2	22	161.61	85.873
	23	136.4	72.478
	24	99.79	53.025
	25	118.69	63.067
	26	149.9	79.651
	27	108.97	57.902
	28	93.13	49.486
	29	159.88	84.954
	30	139.34	74.040
	31	97.24	51.670
	32	161.54	85.836
	33	136.85	72.717
	34	72.94	38.758
	35	86.1	45.750
	36	90.58	48.131
	37	100.48	53.391
	38	97.69	51.909
	39	107.08	56.898
	40	93.38	49.619
	41	83.54	44.390
	42	86.54	45.984
	43	116.07	61.675
	44	76.19	40.484
	45	96.89	51.484

The flood inundation volume (VAB) is the volume of rainwater runoff and is calculated using the Indonesian National Standard 03-2453-2002.

An example of a flood inundation volume calculation for Building No. 22 using the Indonesian National Standard 03-2453-2002 formula is as follows:

$$C = 0.7$$

$$A = 161.61 \text{ m}^2$$

$$R = 888 \text{ (L.m}^{-2} \text{ day)}$$

$$V_{ab} = 0.855 \times 0.7 \times 161.61 \times 888 = 85.873 \text{ m}^3$$

**3.5.2. Use of the Rainwater Harvesting System**

The rainwater harvesting system is an eco-friendly water management approach designed to collect, transport, filter,

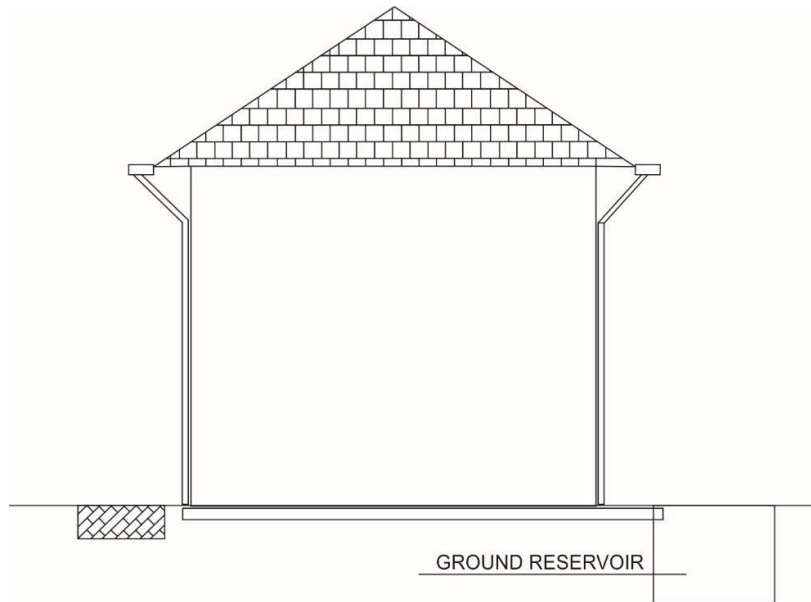


Fig. 3: Concept of rainwater harvesting system. (National Standardization Agency of Indonesia 2015)

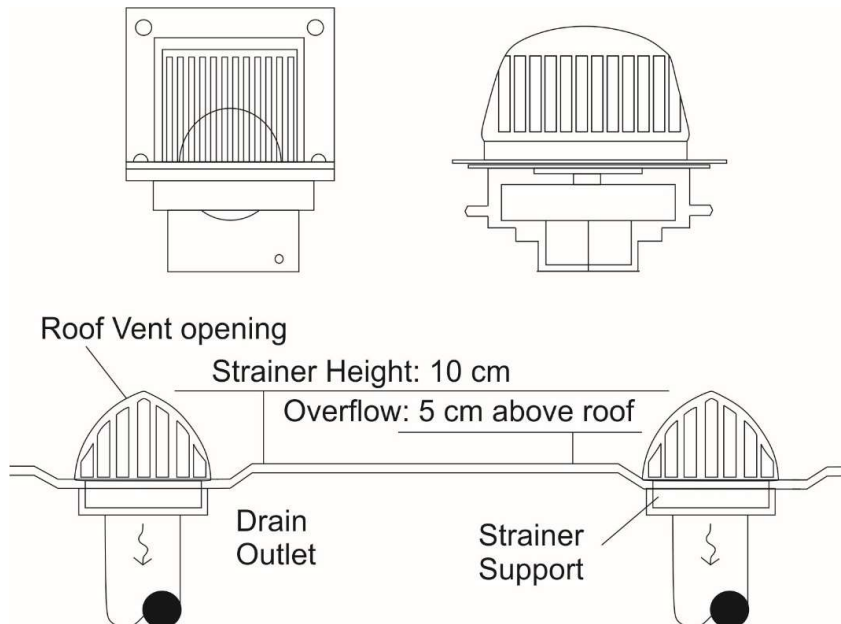


Fig. 4: Filter on the roof gutter. (National Standardization Agency of Indonesia 2015)

and store rainwater gathered from building rooftops for non-potable uses and, in some cases, for drinking after proper treatment. The typical system layout is shown in Fig. 3. To ensure the quality of the collected rainwater, a filtration unit is installed at the inlet. This filter is crucial for removing large debris such as leaves, dust, and other particles before the water reaches the storage tank. According to Indonesian National Standard 8153-2015, the filter must be installed at least 10 cm above the roof or gutter level, measured vertically from where the water enters. Additionally, the total surface area of the filter should be at least 1.5 times the cross-sectional area of the vertical gutter to provide enough hydraulic capacity, as illustrated in Fig. 4.

The selection of gutter and pipe specifications in this study follows Indonesian national standards 8153-2015, which outlines plumbing system standards for buildings. Based on the average rainfall intensity and roof area, the recommended specifications include a gutter with a 1% slope and a diameter of 6 inches, and a downpipe with a diameter of 3 inches.

### 3.6 Domestic Water Demand

Estimating the necessary amount of rainwater involves considering various aspects, such as daily water consumption, rainfall intensity, available storage capacity, and the potential of rainwater as a substitute for clean water (Yulistyorini 2011). The amount of water usage for the needs of people per day, according to Poediastoeti (2013), can be seen in Table 6 below.

The assumption of water demand per house in the study area is as follows:

- a. Number of occupants = 4 people
- b. Water demand/person = 120 L.person<sup>-1</sup>.day<sup>-1</sup>
- c. Total water demand = 4 x 120 = 480 L.day<sup>-1</sup>  
= 480 x 30 = 14.400 L.month<sup>-1</sup>

Table 6: Per capita daily water consumption.

Purpose	Percentage [%]	Volume [L]
Bathing	66.42	79.70
Laundry	13.06	15.67
Washing kitchen utensils	2.84	3.41
Floor cleaning	0.76	0.91
Ablution	13.45	16.14
Watering plants	0.83	1.00
Vehicle washing	0.32	0.38
Others	2.32	2.78
<b>Total</b>	<b>100</b>	<b>120</b>

The ground reservoir's stored water is intended for reuse in daily non-potable activities such as irrigation, vehicle washing, floor cleaning, and similar tasks. The estimated daily water requirement is 5.07 L per person. For a household of four, the total daily consumption is 20.28 L, leading to an annual usage of approximately 7.4 cubic meters.

### 3.7 Analysis of Rainwater Harvesting Effectiveness

To evaluate the effectiveness of the rainwater harvesting (RWH) system in reducing surface runoff, calculations were conducted, taking into account both water demand and flood volume reduction. The percentage reduction in surface flood inundation volume is calculated using the formula in equation 6:

$$\text{Surface Flood Inundation Volume Reduction Rate (\%)} = (V_s)/(V_{ab}+V_n) \times 100\%$$

So, for the calculation of the rainwater harvesting system for scenario 1 with Building Name 22, the surface runoff volume reduction rate is obtained as follows

$$\text{Storage water volume (} V_s) = 2 \times 2 \times 2 = 8 \text{ m}^3$$

$$\text{Daily water demand (} V_n) = 7.4 \text{ m}^3 \cdot \text{y}^{-1}$$

$$\text{Flood inundation volume (} V_{ab}) = 85.873 \text{ m}^3$$

$$\text{Surface flood inundation volume reduction rate} = (8)/(85.873+7.4) \times 100\% = 8.58\%$$

Fig. 5 illustrates the differences in surface flood reduction rates for each building under the three designated scenarios.

Fig. 5 depicts the surface flood inundation reduction rates across three different scenarios for each building within the study area. The analysis reveals that Scenario 3 consistently achieves the highest reduction rates compared to Scenarios 1 and 2, with maximum values reaching approximately 0.75 for several buildings, particularly between buildings 140 and 180. Overall, Scenario 1 shows the lowest reduction rates, while Scenario 2 demonstrates moderate effectiveness. The uneven distribution of reduction rates across buildings indicates that the success of each scenario heavily depends on the specific location and characteristics of individual structures. These results suggest that the more intensive measures in Scenario 3 are markedly more effective in reducing surface flood inundation in the area.

Fig. 6. above compares the flood conditions before and after the implementation of rainwater harvesting systems. The left panel (Before Rainwater Harvesting) shows the presence of significant surface flooding, with a flood volume of 61.66 m<sup>3</sup>. In contrast, the right panel (After Rainwater Harvesting) illustrates the absence of surface flooding, indicating that runoff has been effectively reduced through the installation of water storage systems. The simulation

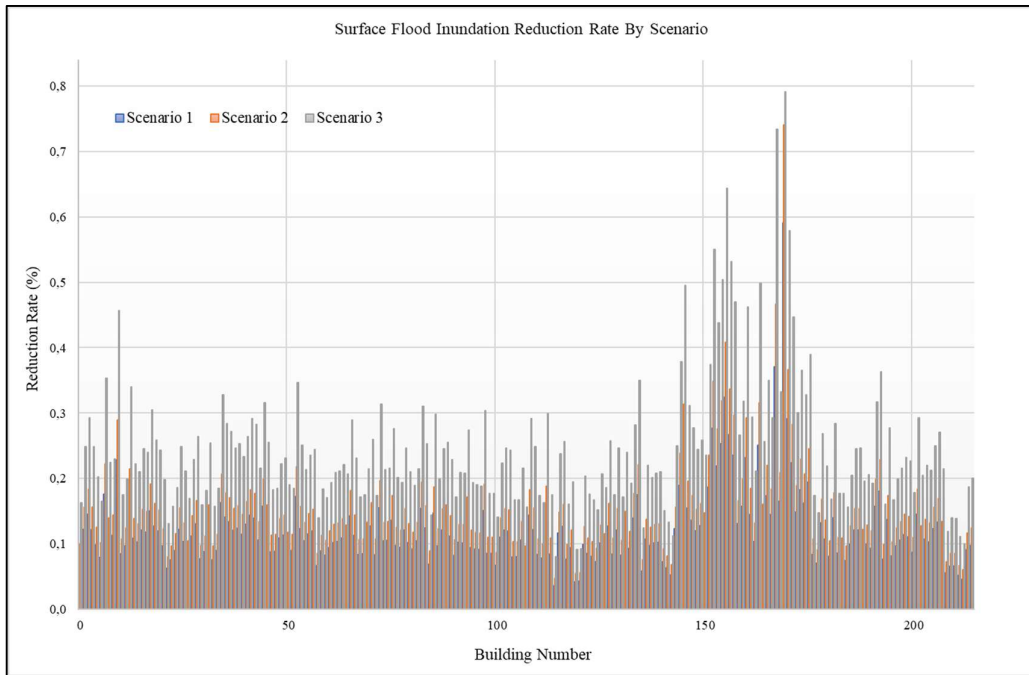


Fig. 5: Surface flood inundation volume reduction rate.



Fig 6: Comparison before and after rainwater harvesting.

includes three scenarios, with runoff volumes reduced to 46.25 m<sup>3</sup> (Scenario 1), 44.25 m<sup>3</sup> (Scenario 2), and 38.62 m<sup>3</sup> (Scenario 3), respectively. These results demonstrate that rainwater harvesting can significantly reduce surface runoff and mitigate flood risks in the area.

The wide range in flood reduction rates across all three scenarios (ranging from 4.61%–80.12%) is primarily attributed to differences in rooftop area, tank storage volume, and household water usage. Smaller houses with limited roof catchment and storage capacities showed lower effectiveness, whereas larger buildings demonstrated significant reductions due to greater rainwater collection potential. Despite some low-performance outliers, over 65% of buildings achieved more than a 40% reduction in surface runoff volume. This confirms that, when implemented across a residential neighborhood, rainwater harvesting (RWH) has practical and measurable impacts on reducing flood volumes, even without altering the existing drainage network (Ali et al. 2017, Campisano et al. 2017).

The findings of this study highlight the significant role that RWH systems can play in reducing surface runoff and mitigating localized flooding in densely populated residential areas. The implementation of RWH in the Governor's Housing Complex demonstrates that even under limited space conditions, optimized roof catchment and storage systems can reduce peak runoff volume by up to 30.68%, depending on the storage scenario. This provides strong evidence supporting the application of decentralized water management strategies in urban flood-prone zones (Oyebode & Umar 2024, Xu et al. 2020).

However, several limitations of this study should be acknowledged. The analysis was based on historical rainfall data and assumed uniform tank performance and water usage patterns, which may not fully reflect real-world variability, such as tank overflow, leakage, or seasonal fluctuations in rainfall intensity. Additionally, the model did not account for potential constraints in retrofitting RWH systems in existing infrastructure, including space availability and economic feasibility.

Future research should explore the integration of RWH systems with other Sustainable Urban Drainage Systems (SUDS), such as infiltration wells, green roofs, or permeable pavements. Moreover, dynamic modeling under climate change scenarios and cost-benefit analysis of large-scale adoption would provide more comprehensive guidance for urban planners and policymakers in Indonesia and other tropical regions (Berndtsson 2010, Fletcher et al. 2015).

#### 4. CONCLUSIONS

The results of the study indicate that the average flood

volume in the Makassar Governor's Housing Complex is 61.66 m<sup>3</sup>. The rainwater harvesting system demonstrated varying levels of effectiveness in reducing this volume, depending on storage capacity. In the first scenario (8 m<sup>3</sup> storage), the reduction ranged between 4.61% and 60.06%, in the second scenario (10 m<sup>3</sup> storage), the reduction ranged between 5.77% and 75.08%, and in the third scenario (15.6 m<sup>3</sup> storage), the reduction ranged between 9.01% and 80.12%. Among the three, the third scenario, with a storage capacity of 15.6 m<sup>3</sup>, was the most effective in mitigating flood risk. These findings support the feasibility of implementing rainwater harvesting systems as a practical and sustainable solution for flood control in urban residential areas.

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