Potential of rainwater harvesting in Cimahi, West Java, Indonesia

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Abstract. Drinking water services in Cimahi City are only 18.6% of the population, lower than the average of West Java Province and the National figure of 80.82%. Population density 15,281 population/km$^2$ on the other hand the problem of lack of raw water sources, heavily polluted rivers, 47% of well water is not feasible as a source of drinking water causing a lack of drinking water services for its residents. This problem needs to get a solution, can efforts to use rainwater in Cimahi City be carried out? This study aims to identify water supply systems, the potential, and problems of drinking water supply through rainwater harvesting. The method used is descriptive through analysis of drinking water supply systems through rainwater harvesting including analysis of average drinking water demand, analysis of the potential and problems of drinking water supply, and identification of technical aspects of directives through rainwater harvesting in Cimahi City. The results obtained in this study are that the City of Cimahi has the potential to use a water harvesting system as an alternative for community drinking water supplies. From a technical point of view, Cimahi City can use a combination of individual and communal systems.

1. Introduction

Only 72.04% of population in Indonesia has access to proper drinking water, which 80.82% of it comes from urban population and 62.10% come from rural population [1]. The level of service for drinking water availability is largely concentrated in big cities and urban areas of influence. However the service of providing adequate drinking water for urban activities is very important because it does not have a recharge area like in rural areas. Efforts to achieve universal and equitable access to proper and affordable drinking water in 2030 which written as the number 6 goal of Sustainable Development Goals (SDGs) still need to be done intensively [2]. This problem was identified because of the carrying capacity and declining quality of raw water in several urban geographies [3,4], lack of attention to the preservation of water sources [5-7], conflicts between regions and the use of water sources that is not balanced between supply and demand [8,9].

This condition occurred in the Bandung Metropolitan Area, where Cimahi City as a spill over area of Bandung turned into a densely populated settlement. Clean water services are a problem today and in the future with clean water services at 18.6% of the city's population [10]. This figure is very low compared to the percentage of West Java Province and the national figure for a city that is 80.82% [1], [11]. The cause of the problem is the lack of adequate sources of raw water for urban housing, industry, trade and services. Based on the 2018 Cimahi City Environmental Management Performance Information Document, 47% of poor well water used as the source of drinking water, water quality in
Cimahi City’s river at the monitoring point that leads to the heavily polluted category, and limited access of groundwater. These problems are caused by the fact that Cimahi City is a densely populated city. In 2019 the population of Cimahi City estimated to have reached 614,304 people. With an area of 40.2 Km², the population density reaches 15,357 people/Km² [12]. If seen from the residential areas which is 16 Km², the population density reaches 38,394 people/Km² or almost 400 people/hectare. Cimahi City is also vulnerable to the risk of hydro-meteorological disasters such as floods, landslides and droughts. On the other hand, Cimahi City receives about 1,250 mm annual rainfall.

One current prescription is enable; Cimahi City can utilize rainwater as an alternative source of raw water for drinking water from the potential rainfall. This can also reduce the risk of flooding and be an alternative solution in the dry season in urban areas [3,13,14]. The basic concept of rainwater harvesting is an alternative solution to collect rain and use it as a reserve can be done within the authority of individuals, communities, or government through political will and policy [15]. On the other hand there are still gaps in their implementation in technical related communities such as the use of containers [16], its economic value [17], and the framework is based on environmental order [4]. Previous research seeks to provide a prescription for installation techniques, length of harvesting based on rainfall and the use of material economically. This research contributes to prescribing government decisions in an analytical framework for implementing rainwater harvesting. Further research in this study will consider politics, land use, the physical environment of the city, hydrology and installations that can be used by the community.

2. Research methodology

2.1. Study area
The research area covers the entire administration of Cimahi City covering an area of 4,103.73 Ha with coordinates 107°30’30” - 107°34’30” Longitude and 6°50’00” - 6°56’00” Latitude. The area includes land use where settlements are 1.609 Ha (39.21%), 375 Ha military function functions with a percentage of 9.14%, Industry 700 Ha or 17.06%, 326 Ha rice field use or 7.94%, Teg 382 Ha or 9.31%, Mixed garden area of 367 Ha or 8.94%, Trading area 140 Ha or 3.41% and infrastructure land use 204.73 Ha or 4.99%.

2.2. Methods
The methodology used in researching water harvesting descriptively, this method was chosen makes it possible to explain the research area and research objectives that reveal the importance of identification. Data collection method used is to use primary data such as observations and monitoring or ground check especially in combining GIS analysis using ArcView software. The use of GIS in measuring areas on the surface of the earth is very helpful [18], this can also be used to measure the area of various surfaces by multiplying the run off coefficient of water and the prediction volume of rainwater. Data collection was also carried out in a secondary way including population data, environmental physical data, slope and map of land cover information in 2018 with a scale of 1: 5,000 from the Public Works Department and Spatial Planning (PUPR) of Cimahi City.

Stages in the analysis include: analysis of drinking water supply (over view of supply and demand today and future) [13]; Projection of drinking water needs (statistical tools) [19,20]; The water quantity (Surface of roof and rain fall used GIS tools) [16,21]; The community willingness [22]; direction rainwater harvesting for drinking water [14].

3. Results and discussion

3.1. The portrait of drinking water supply
In terms of quantity and quality, the current drinking water supply system in Cimahi City is still very limited. The three operators that distribute piped drinking water system, Bandung District’s Tirta Rahaja PDAM, Bandung City’s Tirta Wening PDAM, Cimahi City’s BLUD only serve a small portion of the
Cimahi City community. As for the quality and continuity of the non-piping system in the form of individual wells and communal wells are found to be problematic. Based on Permen PU No. 1 of 2014, standard of minimum service in the Field of Public Works and Spatial Planning, drinking water services access in Cimahi City is leaning toward the medium cluster. Based on data from the Cimahi City environmental management information document in 2019, wells that meet standard quality can be used as drinking water source, while wells that do not meet standard quality is not suitable for drinking. 47% of well water in Cimahi City reported to not meet the standards quality. Thus, it is not suitable to be made as a drinking water source. This is indicated by the intensive use of groundwater/well drilling in some area. Facts regarding groundwater pollution due to intensive groundwater extraction in certain areas can lead to groundwater pollution embarking from shallow groundwater, resulting in the decrease of groundwater quality that was initially good and now cannot be used as raw material for drinking water. Apart from river water pollution, poor well water quality can also be caused by the possibility of sanitation household that does not meet standards, that is the absence of individual septic tanks or septic tanks that do not comply with regulations, thus polluting the soil and groundwater. Another thing that can also affect the quality of well water is the use of pesticides in agricultural activities in Cimahi City.

By around 53% of the existing proper wells, the number of adequate drinking water facilities in Cimahi City is 54,258 units. If each unit is for 1 household, with the number of occupants per household of 3.61, the number of residents who get proper drinking water in Cimahi City is 195,871 or only 33%. Looking into the cluster table of drinking water service levels, Cimahi City is included in the poor drinking water service level cluster.

3.2. Rainwater harvesting potential

The calculation of drinking water needs is done to determine how much water must be provided to meet the drinking water needs for residents in Cimahi City. Based on the results of a survey conducted by the Directorate of Drinking Water Development, Directorate General of human settlement, the Ministry of Public Works Indonesia in 2006, urban drinking water needs are 144 liter/person/day, with a minimum requirement of 70 liters/person/day (Table 1). Based on Table 1, drinking water needs in Cimahi City for domestic and non-domestic needs is between 471 l/sec - 824 l/sec in 2019 and 531 l/sec - 929 l/sec in 2029.

| No | Description                          | Units         | 2019    | 2024   | 2029   |
|----|--------------------------------------|---------------|---------|--------|--------|
| 1  | Population                           | person        | 615,105 | 652,979| 693,309|
|    | Population of Cimahi City            |               |         |        |        |
|    | Coverage of safe drinking water services | %             | 33.00%  | 33.00% | 33.00% |
|    | The Population is not served by safe drinking water | person      | 412.120 | 437.496| 464.517|
| 2  | Calculation of drinking water needs in Cimahi City | l/person/day | 144.0   | 144.0  | 144.0  |
|    | Domestic needs                        | l/sec         | 686.87  | 729.16 | 774.20 |
|    | Water consumption                     |               |         |        |        |
|    | Total drinking water needs            |               | 824     | 875    | 929    |
|    | Non domestic needs                    |               |         |        |        |
|    | Water consumption (20% from total domestic needs) | l/sec. | 137.37  | 145.83 | 154.84 |

The rainwater harvesting process for drinking water supply is obtained from rainfall analysis in every month for one year in Cimahi City and analysis of the catchment area based on building area using spatial analysis with GIS software. Then the spatial analysis is multiplied by the roof drain coefficient as the potential for rainwater that can be collected when harvesting rainwater. The output is a comparison
between the average water demand in Cimahi City and the water supply from rainwater harvesting, detailed in the following Table 2.

Table 2. An analysis of average drinking water needs in Cimahi in 2019.

| Month    | Monthly Rainfall (mm) | Roof Area (m²) | Amount of rainwater harvested (m³) | Monthly drinking water needs (m³) | Surplus/Deficit |
|----------|-----------------------|----------------|-----------------------------------|----------------------------------|-----------------|
| January  | 182.4                 | 16.368.119     | 2.687.035                         | 1.221.510                       | 1.465.525       |
| February | 220.51                | 16.368.119     | 3.248.432                         | 1.221.510                       | 2.026.922       |
| March    | 216.83                | 16.368.119     | 3.194.158                         | 1.221.510                       | 1.972.648       |
| April    | 188.57                | 16.368.119     | 2.777.878                         | 1.221.510                       | 1.556.368       |
| May      | 143.18                | 16.368.119     | 2.109.255                         | 1.221.510                       | 887.745         |
| June     | 67.63                 | 16.368.119     | 996.283                           | 1.221.510                       | (225.227)       |
| July     | 47.95                 | 16.368.119     | 706.433                           | 1.221.510                       | (515.077)       |
| August   | 35.72                 | 16.368.119     | 526.220                           | 1.221.510                       | (695.290)       |
| September| 60.65                 | 16.368.119     | 893.476                           | 1.221.510                       | (328.034)       |
| October  | 139.07                | 16.368.119     | 2.048.634                         | 1.221.510                       | 827.124         |
| November | 271.27                | 16.368.119     | 3.996.157                         | 1.221.510                       | 2.774.647       |
| December | 252.73                | 16.368.119     | 3.723.017                         | 1.221.510                       | 2.501.507       |

In order to find out the quality of rain water in Cimahi City, sampling is done at two points in the middle of Cimahi City, the High-Density Housing Area of Central Cigugur Village. The results of the rainwater quality analysis are for the rainwater itself, 10 out of 15 parameters of rainwater quality are in accordance with drinking water quality standards. 5 parameters that are not in accordance with the drinking water quality standard are the chemical parameters, Permanganate Value (KMnO₄). Whereas, if it seen from the microbiological parameters, drinking water source from rain water already has a better quality than the drinking water source Water distribution systems Piping Network and Water distribution systems Not Piping Network. It can be concluded that if viewed from the quality aspect, to make rainwater as drinking water only requires simple treatment in the form of filtering with sand.

The community willingness in the supply of drinking water with rainwater is obtained from the results of primary data collection, the distribution of questionnaires to respondents representing the population in Cimahi City that 88% of the population in Cimahi City, which is the sampling location, is willing to participate in the implementation of Drinking Water Supply with Rainwater Harvesting. Based on the results of primary data collection, the community's awareness of environmental issues, especially clean water, is the factor for the community participation. Whereas reason why some people are not willing to participate is that the source of water that they have received is sufficient for drinking water so that they are not interested in another Water distribution system other than those that have already exists.

3.3. Direction rainwater harvesting for drinking water

Based on the potential and problems above, technical direction concept for rainwater harvesting as an alternative to drinking water supply in Cimahi City is to use a combination of individual and communal systems. Individual Concept is intended to residential areas and industrial areas. Each house and housing support facilities, such as worship facilities, trade facilities (shops), and industrial areas will collect and utilize rainwater individually (Figure 1).
The communal rainwater harvesting concept can be applied in residential areas, industrial areas and in trade and service areas (Figure 2). Based on the Cimahi City land use map, the industrial estate is the second largest area after the residential area. With a total of 312 RW (Cimahi City in 2019), If the depth of the communal rainwater catchment is 2 meters, then in each RW needed as much as 3000 meters$^2$ of land.

**Figure 2.** (1) Examples of communal rainfall harvesting water distribution systems at open space, (2) Underground, and (3) Under the shops, parking lot.

4. Conclusion

In terms of quantity and quality, the current drinking water supply system in Cimahi City is still very limited. The three operators that distribute piped drinking water system, Bandung District’s Tirta Rahaja PDAM, Bandung City’s Tirta Wening PDAM, Cimahi City’s BLUD only serve a small portion of the Cimahi City community. As for the quality and continuity of the non-piping system in the form of individual wells and communal wells are found to be problematic.

Cimahi City can develop a drinking water supply system through rainwater harvesting. A high annual rainfall is a potential that should not be overlooked. The quality of rainwater in Cimahi City is better than the existing groundwater, which can also be a potential that can be developed. Permanent buildings with roof tiles can be used as rainwater tanks before it is processed and used. In accordance with the potential and existing problems, the technical direction of rainwater harvesting for drinking water that can be applied in Cimahi City is using a combination of individual and communal systems. Individual systems are used during the rainy season. Excess water that is not utilized in the rainy season will be collected in the communal system which will then be used in the dry season.

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