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CRANK: CLIMATE RESILIENCE WATER TANK WITH RAINWATER HARVESTING AND FILTRATION TECHNOLOGY AS HOUSEHOLD WATER SAFE STORAGE TO TACKLE CLIMATE CHANGE

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ABSTRACT

Indonesia, a country highly susceptible to climate change, faces severe water scarcity due to unpredictable rainfall patterns and intensified extreme weather events. This paper presents an innovative solution, the Climate Resilience Water Tank with Rainwater Harvesting and Filtration Technology (CRANK), to address the deepening water scarcity crisis amplified by climate change. CRANK is a sustainable water storage system that integrates rainwater harvesting technology with infiltration wells. The system collects rainwater from rooftops, filters it, and stores it in a tank. When the tank reaches its maximum capacity, the excess rainwater is channeled into infiltration wells where it is filtered and replenishes the groundwater table. This dynamic strategy ensures the optimization of rainwater resources based on local weather dynamics. CRANK is a dependable, sustainable water source for various purposes, including drinking, cooking, and agriculture, and can alleviate the burden on pre-existing water supplies. It also mitigates urban flooding risks by efficiently managing surface water runoff. The feasibility of CRANK is meticulously assessed, including cost of production, profit margin, and operational expenditures, making it an affordable and lucrative solution. The system's target implementation sites are remote villages grappling with severe water scarcity. CRANK represents a significant step towards climate change adaptation and resilience by providing a sustainable, climate-resilient remedy for the water scarcity problem in Indonesia.

Keywords : Water Crisis, Absorption Wells, Water Resources, Floods**.**

ABSTRAK

Indonesia, negara yang sangat rentan terhadap perubahan iklim, menghadapi kelangkaan air yang parah akibat pola curah hujan yang tidak dapat diprediksi dan meningkatnya kejadian cuaca ekstrem. Makalah ini menyajikan solusi inovatif, Tangki Air Ketahanan Iklim dengan Teknologi Pemanenan dan Filtrasi Air Hujan (CRANK), untuk mengatasi krisis kelangkaan air yang semakin parah yang diperburuk oleh perubahan iklim. CRANK adalah sistem penyimpanan air berkelanjutan yang mengintegrasikan teknologi pemanenan air hujan dengan sumur resapan. Sistem ini mengumpulkan air hujan dari atap rumah, menyaringnya, dan menyimpannya di dalam tangki. Ketika tangki mencapai kapasitas maksimumnya, kelebihan air hujan dialirkan ke sumur resapan untuk disaring dan mengisi kembali permukaan air tanah. Strategi dinamis ini memastikan optimalisasi sumber daya air hujan berdasarkan dinamika cuaca lokal. CRANK adalah sumber air yang dapat diandalkan dan berkelanjutan untuk berbagai keperluan, termasuk minum, memasak, dan pertanian, serta dapat meringankan beban pasokan air yang sudah ada sebelumnya. Hal ini juga mengurangi risiko banjir perkotaan dengan mengelola limpasan air *permukaan secara efisien. Kelayakan CRANK dinilai dengan cermat, termasuk biaya produksi, margin keuntungan, dan pengeluaran operasional, menjadikannya solusi yang terjangkau dan menguntungkan. Sasaran penerapan sistem ini adalah desa-desa terpencil yang mengalami kelangkaan air parah. CRANK mewakili langkah signifikan menuju adaptasi dan ketahanan terhadap perubahan iklim dengan memberikan solusi yang berkelanjutan dan berketahanan iklim untuk mengatasi masalah kelangkaan air di Indonesia.*

Kata kunci : *Krisis Air, Sumur Serapan, Sumber Daya Air, Banjir.*

Introduction

Climate change, marked by rising temperatures, acceleration of ice-melting, rising sea level, and increasing precipitation, is fueling disasters such as floods, droughts, heatwaves, wildfires, leading to pressing issues including destruction of infrastructures, rising risk of human health, endangered agriculture, water scarcity, and overall food security. Anticipated consequences of climate change encompass a rise in average global temperatures, projected to increase up to 5,8°C and alterations in precipitation patterns (DeNicola et al, 2015). Over the past 7000 years, average temperature has been rising at a baseline rate of 0.01 per century, but since 1970, the global average temperature has surged to a staggering 1.7 per century (Intergovernmental Panel on Climate Change, 2018). This abrupt acceleration in temperature serves as compelling evidence that climate change is becoming more concerning and shows that a rising projection of 5.8 in temperature would pose as a threat for the Earth. Temperature shifts are poised to have a significant effect on the quality and availability of water, including variations in the quantity and seasonal distribution of precipitation and increasingly frequent and severe temperature fluctuations and weather events, causing droughts and floods (McMichael et al,, 2006). But one thing to know and note about climate change is that even though it is a global phenomenon, the impacts are local.

According to the physical climate risk analysis conducted by the Cross Dependency Initiative (XDI), Indonesia is on the list of the five countries most vulnerable to climate change with erratic rainfall trends and increasing intensity of extreme rain throughout Indonesia (Amani, 2023); (World Bank, 2010). Climate hazards have already impacted cities in Indonesia with dry spells and flooding as the most prominent climate-related challenges. These climate hazards have high impacts on sanitation access for locals, interfering with household's sanitation use and functionality. Based on the study done in four cities with high sensitivity of climate change in Indonesia, 29% residents experiences water shortages and have quantity issues for using the toilet and have basic sanitation needs multiple times per week (UTS-ISF, UI, and UNICEF, 2021). During the rainy season, flood disasters hit Indonesia, making it difficult to get clean water from existing clean water sources because access is difficult (Kami, 2021). Meanwhile, during the long dry season, access to clean water is also affected by the community because water sources are drying up (Prasetyo, 2023). The problem identification of this paper came from Indonesia's climate situation, where regardless of the season, water scarcity remains a persistent issue, affecting residents' access to basic sanitation and this issue is made even more challengeing by the worsening effects of climate change, which magnify the scale of the problem.

In the face of these challenges, it becomes imperative to explore innovative and adaptive strategies that not only mitigate the impact of climate change on water resources but also empower communities to proactively address water scarcity and quality issues. Indonesia mainly relies on groundwater and surface water as water sources, with 46% of Indonesia's population utilize groundwater as a source of clean water (Permana, 2020). The utilization of rainwater in Indonesia is still quite minimal, with approximately 75% of the rainfall going to waste into the sea (The Ministry of Public Works and Housing, 2012). The regions in Indonesia with relatively high annual rainfall, ranging from 2,000 to 4,000 mm per year, have the potential to serve as an alternative source of clean water but also encourages reducing reliance on traditional water sources such as groundwater usage (Rofil & Maryono, 2017).

Therefore, this paper focuses on one innovation and solution, namely CRANK, short for Climate Resilience Water Tank with Rainwater Harvesting and Filtration Technology, as a strategic adaptation to water scarcity intensified by climate change, in a form of water storage tank with structural steel tower with integrated rainwater harvesting technology and infiltration wells. What differs this innovation with a regular water storage system is its sustainability and resistance to climate hazards, including securing water from floodwater to contaminate and provide residents with an alternative water source when flood or droughts kick in. The objective of this study is to select the materials for the rainwater harvesting structure, choosing the rainwater treatment method to obtain clean water that is safe to use by residents, and creating a design using SketchUp. By combining sustainable rainwater harvesting techniques with cutting-edge water storage solutions, this system offers households a safe, reliable, and climate-resilient source of water.

Methods

Rainwater harvesting is an approach used to address climate change by ensuring water availability at the household level. By capturing and storing rainwater, this method makes a significant contribution to water conservation efforts and provides an alternative source of clean water for domestic use (Elliot, Anstrong, Lobugilo, & Bartram, 2011). Through a deep, literature studies are sourced from various reports, international academic journals, and news sources, this research can present in-depth and relevant information on how climate-resilient water tank technology with rainwater harvesting capabilities can be utilized as a secure water storage solution for households, thereby aiding in mitigating the effects of climate change. Based on this approach, it provides an explanation of the capabilities of rainwater harvesting systems.

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aiding in mitigating the effects of climate change. Based on this approach, it provides an explanation of the capabilities of rainwater harvesting systems. In the implementation of CRANK innovation, several tools and methods involve designing using software such as SketchUp and conducting in-depth literature studies. The use of SketchUp enables researchers and technology designers to create rainwater storage systems with precision and high efficiency. The use of SketchUp in this research is because SketchUp allows creating 3D models of products or spaces, enabling researchers to test designs and visualize their projects before constructing them physically Utilizing the 3D designs generated by SketchUp, technological innovations can be visually represented, displaying the structure and capacity of rainwater tanks clearly. This approach considers various technical and design aspects, size, shape, and optimal installation locations. By harnessing the capabilities of SketchUp, the innovation process becomes more streamlined, allowing for detailed planning and visualization of rainwater harvesting systems.

The techniques involved in implementing CRANK encompass various crucial aspects. From a technical standpoint, the rainwater collection and filtration system play a pivotal role, enabling the accumulation of rainwater into storage tanks as precious reserves when water supplies are disrupted due to climate change and rainwater harvesting practiced by direct digging of potholes and by installing overhead tanks (Pala & Pathivada, 2021). The efficiency in rainwater filtration and management ensures the availability of clean and sustainable water, addressing the challenges posed by climate change. Rainwater, which is naturally clean, can become contaminated when it falls onto surfaces exposed to air and environmental pollution. Therefore, it is important to use water filters that can address various contaminants, including chloride, heavy metals, and pathogens such as bacteria and microorganisms. Modern filtration systems are specifically designed to remove chloride, which can contaminate rainwater through various pathways such as air pollution or the use of chemicals in urban areas. Moreover, heavy metals such as lead, zinc, and copper, which can pose health risks to humans, can also be effectively eliminated using appropriate filtration technologies. Pathogens such as bacteria and microorganisms, although small, can pose a serious threat to human health. On the environmental front, the implementation of rainwater harvesting technology at the household level yields dual benefits. Besides reducing pressure on natural resources by diminishing reliance on groundwater and surface water, the utilization of storage tanks also aids in curbing excessive groundwater exploitation, thus supporting ecosystem preservation and maintaining environmental balance.

Results and Discussion

Our solution and innovation for water scarcity in Indonesia, CRANK, can be suitable in both rural and urban areas, but its suitability may vary depending on specific circumstances and needs in each area. In rural regions, where access to a dependable and safe water supply can be a challenge, this technology proves invaluable. It offers a consistent source of water for various purposes, such as drinking, irrigation, and livestock, making it particularly valuable in areas with irregular water supply. Rainwater harvesting helps rural communities become more

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self-sufficient, reducing their reliance on distant water source and enhancing their ability to withstand the impacts of climate change, such as droughts and changing precipitation patterns. In urban areas, the suitability of water storage is influenced by a range of factors. Space constraints are a notable challenge in urban settings, as available room for additional infrastructure like water storage tanks is limited. Nevertheless, rooftop rainwater harvesting is a common practice in urban areas, where rainwater is collected from building roofs and stored in smaller tanks or cisterns. While rainwater harvesting can also be beneficial in urban areas, its advantages are often more pronounced and critical in rural settings where alternative water sources are less readily available (Atik, 2019).

Material sensitivity in the context of water supply systems is a crucial consideration when designing climate-resilient infrastructure. It refers to the degree to which the materials used in these systems are affected by or responsive to changes in climate conditions and their related impacts. Understanding how different materials respond to climate drivers, such as extreme weather events and geological factors like landslides, is vital for constructing systems that can withstand and adapt to changing environmental conditions. In rural areas, prioritizing cost-effective solutions in the design and construction of water supply systems is often a prudent approach. Rural communities frequently face budget constraints, and it is crucial to strike a balance between ensuring climate resilience and managing project costs efficiently. This involves selecting materials and technologies that are both affordable and suitable for the area's specific needs, taking into account local climate and environmental conditions.

For the water tower, structural steel is selected due to its low sensitivity to climate change phenomena, including flooding and windy seasons. Another option considered is reinforced concrete, which has similar sensitivity characteristics but is less cost-effective than structural steel. Hence, CRANK utilizes structural steel for the water tower to ensure climate resilience while managing costs. Regarding the roof of the water tower, two options are presented, corrugated metal roofing and concrete roofing. Both options have low sensitivity to flooding, high resistance to landslides, low sensitivity to wind, and low sensitivity to storm surges. However, corrugated metal roofing is more cost-effective than concrete roofing. As a result, CRANK chooses corrugated metal roofing for the water tower, aligning with its goal of achieving a climate-resilient and cost-effective water supply system (AECOM International Development, 2017).

The originality of our innovation is evident in the design, particularly the system responsible for channeling harvested rainwater directly into the water tank. This system efficiently collects rainwater, removes impurities through effective filtration, and securely stores it in the tank. Identifying and planning the water management, including rainwater treatment, is a crucial step in building an effective rainwater harvesting system. A well-thought-out rainwater treatment flow diagram ensures that the collected rainwater is safe and suitable for its intended uses. Here is the planned rainwater treatment flow diagram to be implemented in CRANK as seen in **Figure 1.**

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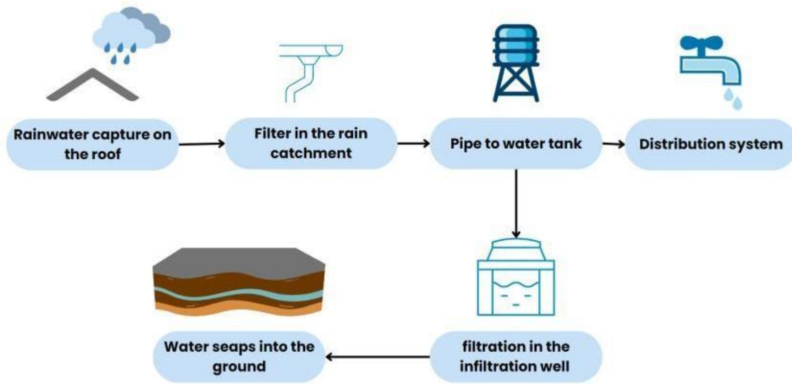

Figure 1. CRANK Flow Diagram

From the illustration, the system begins with rainwater captured from the roof, which then flows into a rain catchment as a place for water collection before being directed to a water tank. In the rain catchment, there is a filter that functions to remove contaminants from the water equipped in the rain catchment pipe. The filter is made using a polypropylene woven filter fabric with 75 µm pore size and 1.07 mm thickness, targeted to have 65% treatment efficiency (Vieira, Weeber, & Ghisi, 2013). After filtration, the water is stored in the water tank until it reaches the maximum limit. Once the water reaches the maximum limit, to prevent overflow and to still make the rainwater can be used, it will be directed to a infiltration well, or locally called by "*sumur resapan*", as a way to implement managed (artificial) aquifer rechange (MAR). Infiltration wells are a fairly common construction in Indonesia and has been proven to contribute to groundwater recharge with high effectiveness (Alviansyah & Har, 2021). In the infiltration well, the water will undergo natural filtration using materials like coconut fiber, gravel, and others. After filtration, the water will directly seep into the ground to become groundwater, which will be used by the residents through their own dug well systems. However, if the water in the water tank has not reached the maximum level, residents can access the water through an effluent pipe that will flow directly from the water tank for use.

In addition, it should be noted that there is a valve installed to control the flow of the pipe leading to the infiltration well. During periods of drought, the valve will be closed to prevent water from flowing into the infiltration well. This is done to maximize the quantity of water stored in the water tank and ensure a stable water supply during dry periods. However, when there is rainy weather and the water tank reaches its maximum capacity, the valve can be opened. This allows excess water to flow into the infiltration well, preventing the water tank from overflowing and ensuring that rainwater is efficiently directed into the ground for recharge. This dynamic valve control mechanism helps to optimize the use of rainwater resources based on the prevailing weather conditions. After considering the materials and treatment flow, it is necessary to measure the dimensions to create a design for the system. Once the dimensions are known, a model can be created to illustrate the system that will be built as seen in **Figure 2** and **Figure 3**.

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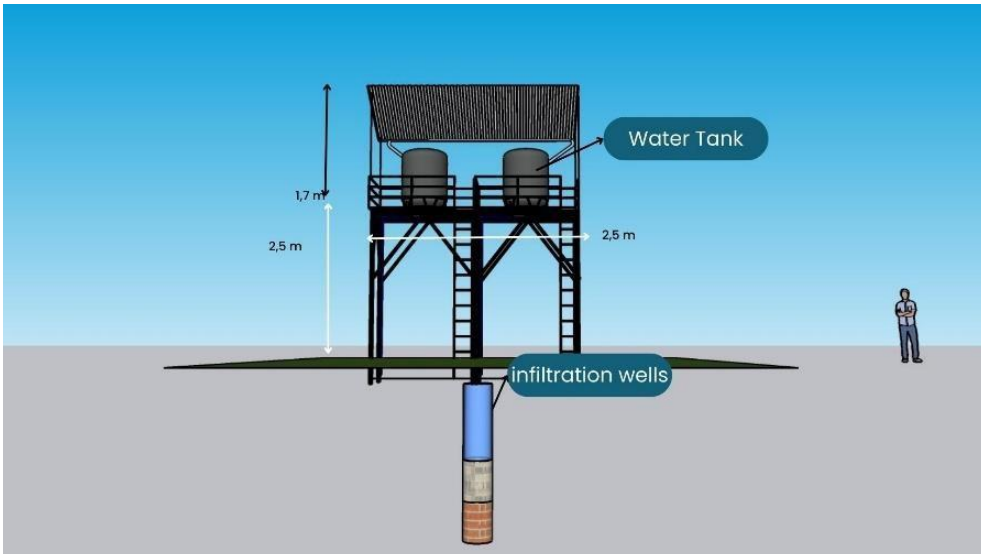

Figure 2. Front View

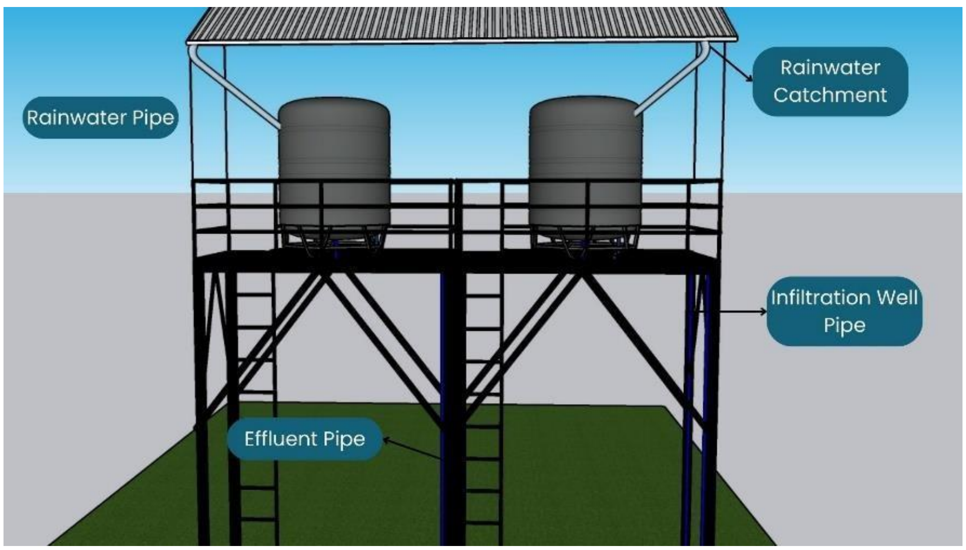

Figure 3. Back View

During the dry season, when traditional water sources often run dry due to the effects of climate change-induced extreme weather conditions, CRANK can serve as a valuable solution by providing a backup water supply. This backup water supply is derived from the rainwater collected during the rainy season, stored in water tanks, and directed into infiltration wells to recharge groundwater. By utilizing this stored rainwater during the dry season, CRANK ensures a stable and reliable water source, meeting the needs for washing, cooking, and various household requirements. In addition to addressing water scarcity, CRANK plays a significant role in reducing flood risks in urban areas by efficiently managing excessive surface water runoff, thus decreasing the likelihood of floods caused by heavy rainfall. This multi-faceted approach enhances the quality of life for people in regions facing water challenges exacerbated by climate change.

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Rainwater harvesting and infiltration wells each have their own advantages and disadvantages. One significant advantage of rainwater harvesting is its ability to provide a local and sustainable water supply, reducing dependency on centralized water systems. This encourages water conservation by capturing rainwater that would otherwise go to waste, providing a resource for various non-drinking purposes and thus conserving valuable drinking water resources. The average annual rainfall in Indonesia in 2022 was approximately 3,495 mm/year (BPS, 2022). With the CRANK system's roof area as a rain catchment measuring 6.25 m^2, the volume of catchment water can be calculated as follows (Kariyana, 2022).

$$Volume = Average\ rainfall\ in\ Indonesia\ per\ year\ x\ CRANK\ roof\ area$$

$$\begin{aligned} Volume &= 3{,}495\ m/year\ \times 6.25\ m^2 \\ &= 21.85\ m^3/year \end{aligned}$$

This demonstrates the substantial potential for collecting rainwater with the CRANK system, making efficient use of abundant rainfall in the region. Rainwater harvesting systems are relatively easy to install and can be adapted to both residential and commercial buildings, making them a versatile solution for water scarcity issues. On the other hand, one of the drawbacks of rainwater harvesting is its reliance on sufficient rainfall. In areas with irregular or minimal rainfall, the system might not generate an adequate water supply, posing limitations to its effectiveness.

As for infiltration wells, their advantage lies in managing rainwater runoff, reducing the risk of urban flooding. Infiltration wells allow rainwater to seep into the ground, replenishing groundwater levels and preventing surface runoff. This process helps maintain soil structure, supports plant growth, and reduces erosion and water pollution. However, one limitation of infiltration wells is their effectiveness is influenced by soil composition. In areas with dense or clayey soils, water infiltration might be slow, reducing the efficiency of the well.

We believe CRANK is a feasible and an optimal choice from both technical, practically, and non-technical standpoints. In terms of non-technical aspects, particularly in the realms of business and cost, the production cost of CRANK is Rp13.645.200 (detailed budget plan can be seen on **Table 1**). From an entrepreneurial perspective, CRANK can be sold at a profitable margin by increasing the selling price by 5% from the manufacturing cost, which remains affordable for local governments to invest in, aligning with the village budget of 75 million per month (Sumarto, 2018). Operating costs are also manageable, and the involvement of the local community is feasible to collectively maintain the functionality of CRANK. The target implementation for CRANK is in remote villages far from urban area, which are most impacted by water scarcity, such as Bojongbarat Village, Bojong Subdistrict, Purwakarta District, West Java, which has been recently affected by a water crisis due to prolonged drought (Kompas TV, 2023).

Conclusion

In conclusion, the pressing issue of water scarcity, exacerbated by climate change, affects a significant portion of the population in high sensitivity of climate change. This problem is primarily driven by the heavy reliance on groundwater and

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surface water sources, with only a small percentage of people harnessing the immense potential of rainwater in Indonesia, estimated at 2000-4000 m3/year. In response to this challenge, the introduction of CRANK, designed for communal use rather than individual households, offers a promising solution. CRANK can store up to 21,85 m^3/year and can facilitate residents communally for alternative water sources, up to 15 households. CRANK has the potential to not only address water scarcity but also significantly increase water infiltration into the ground, enhancing sustainability.

Table 1. CRANK Cost Construction Budget Plan

No	Output	Unit	Volume	Price (Rp)	Total
1	Water Storage Tank				
1.1	Tools and Materials				
a	Water Reservoir D 0.7 m	300 L	2	Rp1.000.000	Rp2.000.000
b	Water tank holder	Pre-cast 2m	2	Rp2.000.000	Rp4.000.000
c	Pipe PVC AW (D 6.5 cm)	5.8 m	1	Rp237.800	Rp237.800
d	Elbow Pipe (D 7.5 cm)		2	Rp44.400	Rp88.800
e	Faucet Tee Pipe (D 7.5 cm)		2	Rp54.800	Rp109.600
f	roof (300x80)		4	Rp120.500	Rp482.000
g	Valve		5	Rp32.500	Rp162.500
h	Roof holder	6 meters	2	Rp75.000	Rp150.000
i	Rain gutter	4 meters	3	Rp68.000	Rp204.000
j	Water filter		2	Rp77.000	Rp154.000
1.2	Hire Workers				
a	Worker	2 days	2	Rp200.000	Rp800.000
2	Infiltration Wells				
2.1	Hire Workers				
a	Worker	7 days	2	Rp200.000	Rp2.800.000
2.2	Tools and Materials				
a	Concrete		1	Rp500.000	Rp500.000
b	Iron well cover D10	kg	45	Rp11.900	Rp535.500
c	Well Cover	kg	1	Rp840.000	Rp840.000
d	Brick	units	70	Rp700	Rp49.000
e	Palm Fiber	kg	6	Rp15.000	Rp90.000
f	Sand	m3	1,5	Rp90.000	Rp135.000
g	Coral	m3	0,5	Rp104.000	Rp52.000
h	Stone	m3	1,5	Rp170.000	Rp255.000
	Sub-Total				**Rp2.456.500**

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No	Output	Unit	Volume	Price (Rp)	Total
		Total			**Rp13.645.200**

References

AECOM International Development. (2017). *Climate-Resilient Water Infrastructure: Guidelines and Lessons From the USAID Be Secure Project.* USAID Philippines.

Air Kami. (2021). *Walau Musim Hujan, Wilayah Tuban Masih Krisis Air Bersih*.

Alviansyah, & Har, R. (2021). Efektifitas Pemanfaatan Sumur Resapan dan Biopori sebagai Artificial Recharge untuk Meresapkan Iar HUjan ke dalam Lapisan Akuifer Dangkal pada DAS Batang Kuranji Kota Padang. *Jurnal Bina Tambang*.

Amani, N. K. (2023). *Indonesia Masuk Daftar Negara Paling Rentan Perubahan Iklim*.

Atik, D. (2019). Areas, Rainwater Harvesting in Urban and Rural Areas. *Research Gate*.

BPS. (2022). *Curah Hujan dan Banyaknya Hari Hujan di BMKG 2020-2022.*

DeNicola, E., Aburizaiza, O. S., Siddique, A., Khwaja, H., & Carpenter, D. O. (2015). Climate Change and Water Scarcity: The Case of Saudi Arabia. *Annals of Global Health*, 342- 353.

Elliot, M., Anstrong, A., Lobugilo, J., & Bartram, J. (2011). *Technologies for Climate Change Adaptation.* Roskilde: UNEP Risoe Centre.

I Made Kariyana, T. H. (2022). Rainwater Harvesting-Based Water Resources Conservation. *Jurnal Presipitasi*, 532-541.

Intergovernmental Panel on Climate Change. (2018). *Framing and Context: Global Warming of 1.5 Degrees Celcius.* Cambridge: Cambridge University Press.

Kompas TV. (2023). Terdampak Kekeringan, Begini Kondisi Warga di Sejumlah Daerah saat Antre Bantuan Air Bersih.

McMichael, A. J., Woodruff, R. E., & Hales, S. (2006). Climate change and human health: present and future risks. *The Lancet*, 859-869.

Pala, G. K., & Pathivada, A. P. (2021). Rainwater harvesting - A review on conservation, creation & cost-effectiveness. *Materials Today: Proceedings*, 1-5.

Permana. (2020). *Urgensi Menjaga Ketersediaan Air Bersih yang Aman di Indonesia*.

Prasetyo, A. Y. (2023). *Bencana Kekeringan yang Makin Meluas di Indonesia*.

DOI: 10.22373/ijes.v1i2.3973
ISSN 3046-885X

Rofil, & Maryono. (2017). Potensi dan Multifungsi Rainwater Harvesting (Pemanenan Air Hujan) di Sekolah bagi Infrastruktur Perkotaan. *Proceeding Biology Education Conference, 14*(1), 274-251.

Sumarto, S. W. (2018). *Akuntabilitas Dana Desa*. Retrieved from Badan Pengawasan Keuangan dan Pembangunan (KPPN).

The Ministry of Public Works and Housing. (2012). *Pemanfaatan Air Secara Optimal*. Retrieved from Kementrian Pekerjaan Umum dan Perumahan Rakyat.

UTS-ISF, UI, and UNICEF. (2021). *Climate resilient urban sanitation in Indonesia: Hazards, impacts and responses in Four Cities.*

Vieira, A. S., Weeber, M., & Ghisi, E. (2013). Self-cleaning filtration: A novel concept for rainwater harvesting. *Resources, Conservation and Recycling*, 67-73.

World Bank. (2010). *Jakarta: Tantangan Perkotaan Seiring Perubahan Iklim.* World Bank.