# Bukti Korespondensi Local Environment - The International Journal of Justice and Sustainability

Author : Santy Paulla Dewi (First and Corresponding Author)

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**Judul :** "Revealing Community Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas"

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1	Submission Created	9 Desember 2021						
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Reviewer 1,

Prof. Dr. -Ing Wiwandari Handadyani, ST, MT, MPS NIP. 197605252000122001 Departemen PWK, FT. UNDIP Semarang, 26 Juni 2023 Reviewer 2,

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Prof. Dr.sc.agr. Iwan Rudiarto, S.T., M.Sc. NIP. 197403271999031002 Departemen PWK FT.Undip

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# Submission Created (09-12-2021)



## Submission Incomplete (13-12-2021)

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		Dear Santy Paulla Dewi,					
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		Submission ID Manuscript Title	213401138 Revealing The Community's Capacity for Applying Rain Water Harvesting In Semarang Coastal Areas				
		You can check the progra Thank you for submitting If you have any queries, Kind Regards, Local Environment Edito	ses of your submission, and make any requested revisions, on the <u>Author Portal</u> . your work to our journal. please get in touch with journatsheipdesk@taylorandfrancis.com.				

Submission Received (17-12-2021)



## **Revision Required (15-08-2022)**



Comments from the Editors and Reviewers:

Reviewer: 1

Comments to the Author

In abstract the sentence "Rainwater harvesting is an alternative water supply method to the community, mainly in areas that include drought-prone areas and did not cover by the Local Water Company" needs clarification, the wording is awkward.

The paper should be proof-read by a fluent English speaker enabling wording of sentences and grammar to be corrected.

There is some good background information in the introduction. However, the paper needs to clarify what the study is aiming to do through using a research question and discussing what the aims of the study are. This could be done in the introduction and also needs to be mentioned in the abstract so that readers know exactly what the paper is about. Currently, it is not clear what the author is trying to achieve through this research.

The methods of the study appear to be sound, however a research question and a clearer direction to the paper is needed to identify what is relevant for this article and what is not relevant, and whether these methods appropriately address the question.

The "Results and discussion" are put into the same section. In doing this, it is really important to have a very clear delivery of findings, interpretation, analysis and implications. All these elements should be visible to the reader.

The section under "Results and discussion" named "Physical Characteristics of Study Areas" does not appear to be relevant to the research that is being conducted. The need for this subsection should be clarified, and potentially moved to a different part of the paper where it would fit better as it does not seem relevant to this section.

There is also little to no sources in the results and discussion, or any mention of where this information has been obtained from, whether it was from the research or from other authors work, etc.

Furthermore, throughout the results and discussion section there is very little evidence presented, or if there is it is not made clear what is evidence gained from the research. More evidence from the research conducted should be added and it needs to be made clear where this evidence is from, for example stating "from the questionnaire it was found that...".

In the second to last sentence on page 15 "appropriately" is repeated twice at the end of the sentence.

The conclusion is very short, should be expanded. Also, once a research question is created this will allow the author to explain more clearly what the research set out to do. A research question will also allow the author to have a clearer direction for the research and the way the paper is written.

#### Reviewer: 2

Comments to the Author Dear authors.

This is an article on an important topic and both provides some useful data on community views about RWH, as well as extensively describes the context of RWH in Semarang.

The paper is however, poorly written, poorly structured, and it is unclear whether sufficient rigor was used when analysing the data.

Also, I think the paper makes two important contributions: 1) reports on the survey data, although currently not in a sufficiently rigorous manner, and 2) describes the context of RWH in Semarang and this is useful in itself.

#### Specific comments are:

- · Language editing is required preferably by someone proficient in English.
- Only 96 responses constitute a rather small sample.
- · Line 41, water is an issue both globally as well as locally.
- If you are referring to the UN, why not mention their water-related SDGs?

End of page 2, what is the point of the historical perspective of rainwater harvesting? Anyway, it seems tentative that there is evidence about exactly where the rainwater harvesting first appeared. We know it's an

- ancient practice all around the world in many places that are not culturally or socially connected, and isn't that the point? It's an ancient human technology applied in pretty much all cultures.
- . Why do you not mention the importance of rainwater harvesting for the urban water cycle?
- · There is plenty of literature from Australian on RWH that you are not referring to here. Especially in relation to the community involvement in the practices.
- · Page 4 line "means to self-sanctification, including from wickedness and glorified as a blessing" what does this mean?
- Why is the regulation and legislation about rainwater harvesting in the introduction? This would make more sense to be part of a context section.
- Page 5, line 28, poor English "Some communities consumed water rivers and wells with poor water quality.' What are 'water rivers'? Do you mean river water? Or another
- · Page 15, line 15, clarify what you mean by 'several exposures'?
- Page 5, line 19-27: 59% and 9.4% doesn't add up to 100%. What do the other households use for water supply? Maybe a table would be useful to describe the breakdown?
- · Overall, in the introduction especially around page 5, this describes the context in a fairly unstructured manner and I think it would be useful to be more structured about it.
- Only use abbreviations that you require several times, i.e. BPDP is unnecessary.
- Page 6, line 49 "sea-water intrusion significantly affects water quality". I think this refers to either groundwater or surface water. Please specify.
- · Page 6, line 56 "The three sub-districtss" one too many ss.
- · Can you please provide a copy of the (translated) questions that you used?
- · What was the demographic statistics in your respondents? Gender balance? Socio-economic sample? Etc? You will need to provide a description of the statistical distribution of attributes of your sample.
- · What was the air quality and potential for contamination into RWH systems?
- Districtss consistently written with two s!
- · Page 8 'Physical Characteristics of Study Areas' why is this in the results section? Why don't you have a context description section?
- · Discussions generally seem anecdotal rather than representing the total sample. I find the descriptions of results very disorganised.
- Page 11-12, the analysis of RWH potential seems optimistic. Why are you aggregating, why not looking at individual households? It is easy that this becomes over-optimistic. The analysis also does not consider how

large the storage capacities are required to ensure 31 days of water supply etc. Again if you do this analysis on a per households basis, it may be more useful.

- I like the factor analysis being done but would prefer it described a bit better. Specifically also Table 6 needs much more explanation and why %-values > 100%?
- The results are mixed with interpretation which would normally go into the discussion.
- Also context is brought in, which can be included in introduction/context or in the discussion. For example, "Even though the government and private sectors provided all the RWH installations, the community did not use them and abandoned them."
- The anxiety about mosquitos should be taken seriously. Even in more well-resourced areas this is a problem, i.e. https://www.sciencedirect.com/science/article/abs/pii/S0022169416306527
- · Is the issue about getting porous teeth associated with fluoride? If so, can fluoride supplements be given to households using RWH?
- For me to consider reviewing this article again, I would expect:
- 1. Significant rewriting of the article to a more traditional structure, which includes:
- a) an introduction which is shorter than the current one
- b) a description of the context for which you have plenty of material

c) rigorous description of your methodology, why you have chosen your analysis method, how exactly you collected the data, etc etc.

- d) reporting on the data and the analysis of it including a set of overview tables
- e) a disussion that incorporates your understanding of the context

You may also consider that another contribution would be your qualitative description of the context, but I am not entirely sure how you write this into your article.

But I do like the paper, and I think it has potential to provide genuine knowledge contributions.

# **Revision Incomplete (17-08-2022)**



# **Revised Manuscript Submitted (14-09-2022)**

Revised submission received	for Local Environment (Submission ID: 213401138.R1) (Eksternal) 🗩 Kotak Masuk 🛪		¢	Ø
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	Dear S.P Dewi, Thank you for submitting your revised manuscript.			
	Submission ID     213401138       Manuscript Title     Revealing The Community's Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas       Journal     Local Environment			
	You can check the progress of your submission, and make any requested revisions, on the <u>Author Portal</u> . Thank you for submitting your work to our journal. If you have any queries, please get in touch with journalshelpdesk@taylorandfrancis.com. Kind Regards, <u>Local</u> Environment Editorial Office			

# Revision Required (11-12-2022)

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Dear Dr Dewi:		
Your manuscript entitled "Revealing The Community's Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas" which you submitted to Local Environment, has been reviewed. The reviewer con are included at the bottom of this letter.	mment	5
The reviewer would like to see major revisions made to your manuscript before we consider it for publication. Therefore, I invite you to respond to the reviewer comments and revise your manuscript.		
When you revise your manuscript please highlight the changes you make in the manuscript by using the track changes mode in MS Word or by using bold or coloured text.		
To submit a revision, go to https://rp.tandfonline.com/submission/flow?submissionId=213401138.R1&step=1. If you decide to revise the work, please submit a list of changes or a rebuttal against each point whic raised when you submit the revised manuscript.	:h is be	ing
If you have any questions or technical issues, please contact the journal's editorial office at LocalEnvironment@tufts.edu.		
Because we are trying to facilitate timely publication of manuscripts submitted to Local Environment, your revised manuscript should be uploaded as soon as possible. If it is not possible for you to submit your revised manuscript should be uploaded as soon as possible. If it is not possible for you to submit your revised manuscript should be uploaded as soon as possible. If it is not possible for you to submit your revised manuscript should be uploaded as soon as possible.	revisior	ı by
Once again, thank you for submitting your manuscript to Local Environment and I look forward to receiving your revision.		
Sincerely, Professor Michelle Thompson-Fawcett Editor, Local Environment mtf@geography.otago.ac.nz		

#### Reviewer: 1

#### Comments to the Author Dear authors,

Thanks for addressing an important topic and collecting some seemingly useful data. However, unfortunately, as it stands, the paper is very difficult to read (as an academic article) and there must be some significant improvements in the structure, and writing before I can go into the details. Specifically, I can't quite tell where the evidence comes from as you draw on expert interviews, survey and (largely) grey literature and case study observation, and the way that the article is structured, it is all mixed up with no clear indication of why I should trust the evidence.

Saying that, the conclusions seem appropriate, the data seems appropriate, the method is roughly appropriate, and the case study description (which is scattered throughout) is very interesting.

However, to be able to judge the validity of the manuscript, it needs more discipline and structure.

#### Specific comments.

#### Format

- · Firstly, I can't find a "response to the reviewers comments" anywhere. This is something that I would expect!
- · The article still requires major editing as it is full of spelling errors and poor grammar.
- · The results section currently starts with a long description of the case study area this is very odd!
- · The survey results are provided in the discussion section rather than in the results section
- · Unusual units are being used? I.e. dm2 etc. This is not standard in an academic journal on this topic, as far as I know.
- Most of the discussion seems to be based on interviews rather than the survey but it's hard to tell what comes from the interviews, what comes from the survey, and what comes from reports etc. This needs to be much clearer. Also, how many people were interviewed, how were they chosen, etc?
- · The results are described in the discussion section, and it is hard to judge where the evidence comes from and what is authors' interpretations and what is from literature.

#### Baseline information about the case study

- · What is the incidence of waterborne disease in the area? This is an important baseline piece of information in the context.
- · It would be useful to include a picture of the study area, i.e. what are the types of homes that people use to collect the water from?

#### Survey

- There is a strong bias towards male respondents in the survey. Water collection and use is a strongly gendered activity in many locations, yet you are almost entirely missing the female perspective. This needs to be discussed in the article.
- · Ideally, you should provide the questionnaire as supplementary material.
- Also, it appears a lot of information was gauged from expert interviews, yet there is almost no information about this provided.

I will review this more thoroughly when/if the article is better written and structured.

#### Results and analysis

The main contribution is the survey and the associated statistical analysis, yet this is rushed in the section "Analysis of Community Capacity on RWH". More detail is required to explain the analysis that was undertaken and what the results mean.

### **Revised Manuscript Submitted (10-02-2023)**



### Revised Unsubmitted (14-02-2023)

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Dear Dr Dewi:		
Your above referenced manuscript, entitled "Revealing The Community's Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas" has been unsubmitted to Local Environment.		
Please completely blind author names in the anonymous version. Thank you. You. may visit the instructions to authors to complete your submission and re-submit the manuscript f consideration of publication.	or	
To re-submit your manuscript, please go to your author dashboard at https://rp.tandfonline.com/dashboard/, locate the manuscript and click 'Resume'.		
Sincerely, Local Environment Editorial Office		

# Submission Received (18-02-2023)



## Decision on Manuscript - Accepted (27-05-2023)

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Dear Dr Dewt			
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We are pleased to accept your paper in its current form which will now be forwarded to the publisher for copy editing and typesetting.			
You will receive proofs for checking, and instructions for transfer of copyright in due course.			
The publisher also requests that proofs are checked and returned within 48 hours of receipt.			
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# Author Agreement (02-06-2023)



# Author Corrections (09-06-2023)



# **Manuscript Submission Author Portal**

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# Published (14-06-2023)





# Revealing The Community's Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas

S. P. Dewi, Rina Kurniati, Novia Sari Ristianti

Department of Urban and Regional Planning, Faculty of Engineering, Universitas Diponegoro, Semarang, Indonesia

Address: Jl. Prof. Soedarto, SH, Tembalang, Semarang, Central Java, Indonesia Email : santy.paulla.dewi@pwk.undip.ac.id

# Revealing The Community's Capacity for Applying Rain Water Harvesting in Semarang Coastal Areas

Public participation is essential in integrated water management, including the implementation of rainwater harvesting (RWH). Rainwater harvesting is an alternative water supply method that can be implemented at the household level. The community in drought-prone areas that do not cover by the water system and have to buy water from the private water seller may utilize this method. However, it was difficult to encourage the community to apply RWH because of socio-economic constraints. Therefore, this study aims to analyze the potential of water that can be harvested and the economic benefit for the community that applies RWH. Besides, it also analyzes the determining factors that need to be considered, so the community agrees to apply RWH. The research used the quantitative method by distributing questionnaires to 96 respondents to determine their knowledge, ability, and willingness to implement RWH. Besides, the potential of rainwater analysis revealed the calculation of the rainwater volume captured compared to the community's demand. Afterward, the potential rainwater analysis was confirmed to the community to comprehend the possibility and advantages of applying RWH. Besides, the factors that influence the community's capacity were also analyzed through factor analysis. The community emphasized the cost of adopting RWH as the main reason for objecting to it. Besides, there are also health issues that make the community refuse to use RWH. Therefore, implementing RWH requires both government support and the collective participation of community leaders as role models.

Keywords: rainwater harvesting, community's capacity, coastal areas

# Introduction

Water is an essential issue globally and locally; it relates to the community's access to clean water, sanitation, water-related problems, food security, and sustainable development. Ensuring the sustainability of water access and sanitation for all of the community is one of the SDGs' targets. However, it deals with several challenges, such as sustainable water sources and water quality (<u>https://sdgs.un.org/goals/goal6</u>). Indeed, climate change makes water provision more challenging and requires good planning and

integrated governance. The United Nations World Water Development Report 2020 stated that water has two opposite sides, a problem and a solution; it requires a comprehensive approach to formulate water-related strategies. Hence, water management must be well-delivered, especially at the community or local level. One of the water-related strategies implemented at the local level is rainwater harvesting (RWH). According to Yannopaulos et al. (2019), rainwater harvesting practices have been conducted since 6000 years ago in China and spread over the world; 4500 years ago in Iraq, 4000 years ago in Thailand, and others. RWH is one of the rainfall-collection methods for specific storage for direct or future purposes (Yannopoulos, Giannopoulou, & Kaiafa-saropoulou, 2019). Regarding the urban water cycle, RWH is useful for reducing runoff before discharge to the sea. RWH utilizes the housing rooftop to collect the water, channelling it into the tanks. The temporary rainwater storage process encourages the evapotranspiration process in which the rainwater can be reused (Lamera, Becciu, Rulli, & Rosso, 2014).

Previous studies on RWH have been carried out both technically (Ammar *et al.*, 2016; Terêncio *et al.*, 2017; Norman *et al.*, 2019; Alim *et al.*, 2019) and socially, such as community involvement in water management (Park & Kim, 2014), community perceptions about RWH activities (Bunclark et al., 2018), and also the capacity of communities and stakeholders in a water safety plan (Ferrero et al., 2019). However, RWH is a household scale (domestic) strategy that relies on the community's role and capacity to succeed the rainwater management. The community capacity initially also starts from the water management context, which reveals how people can manage their environment (Craig, 2007). This water management covers community understanding and institutional aspects, which are realized by community participation (Craig, 2007; Landström *et al.*, 2019).

Regarding capacity building, it is necessary to recognize the characteristics of the community (Craig, 2007). McGinty (2003: 71-72) and Jones et al. (2018) stated that capacity building consists of five main elements such as building knowledge, leadership, building a network, respecting the community, inviting the community to achieve goals together, and information support. The community's perception influences the readiness to implement RWH and determines the program's success or failure (Demeke, Andualem, & Kassa, 2021). Comprehending the community's willingness and ability is essential because it will determine the sustainability of the RWH praxis. Gao et al. (2018) mentioned that the community's impression of water management becomes an opportunity to overcome water-related problems and gain economic benefits.

Water usage for the community is expansive, not only for daily needs but also as a means for purification. The use of rainwater in Indonesia also started centuries ago; water is a means of self-purification, including from evil, and glorified as a blessing. Water is a means to cleanse oneself from the lust for bad qualities in humans. Water is also a medium for purifying weapons that are considered to have supernatural powers (Fadli, Hamidi, & Harianto, 2014). The water referred to is the source of springs and other water sources, including rainwater, a gift from God whose existence needs to be acknowledged. For instance, the traditional performance in Java, called "*wayang jantur*," raises stories about rainwater as sky (heaven) water that is valuable and must be glorified (Kompas, 3 December 2020). However, rainwater's traditional and local spirit is fading gradually; people are reluctant to use it because it is considered dirty and unfit for consumption, especially for food and drink needs. They prefer to use surface water from wells, so rainwater utilization in the community is becoming uncommon. A similar condition also occurs in Greater Sydney, where people are unwilling to install the RWH system due to the high cost. Therefore, the local government provides incentives and assistance with installation costs to people willing to adopt this system at home (Rahman, Keane, & Imteaz, 2012). Likewise, in Indonesia, the government attempts to encourage the community to use rainwater as one of the water sources, especially in drought-prone areas. Rainwater is an alternative water source that is easy to get and cheaper than people having to buy water for their daily needs.

This study emphasizes Semarang City as the first city in Indonesia that engages in The 100 Resilient Cities (Semarang Resilience Strategy Document, 2020). This engagement shows the commitment of the Semarang government to be more sustainable and resilient from several exposures to water-related problems, such as flood, tidal flood, abrasion, water pollution, sea-water intrusion, land subsidence, and drought (Buchori et al., 2018). Regarding water supply, the State-Water Company (PDAM) covers 59% of the Semarang area, whereas other water sources (community-based water supply, private) serve 9,4% of the total area (see Table 1). Some communities consumed river water and wells with poor water quality.

Based on The Semarang Resilience Strategy Document (2020), one of the initiatives is to realize sustainable water and energy, such as providing alternative water sources through RWH. As previously mentioned, our ancestors practiced traditional rainwater harvesting. However, the practice was not institutionalized and discontinued. Therefore, the city government's initiation of RWH in Semarang is top-down. The first RWH pilot project began in 2011 with the initiation and funding from the Asian Cities Climate Change Resilience Network (ACCCRN) by carrying out a domestic RWH installation in three houses and a school. The same year, through The Revenue and Expenditure Budget (APBD), the Semarang City Environment Agency developed RWH

installation in ten sub-districts. In 2012, APBD and the Tobacco Excise Revenue Sharing Fund (DBHCHT) also funded RWH installation in 16 sub-district offices and 23 educational facilities (elementary and high school). As of November 19, 2020, The Environment Agency listed the RWH installation in 8 urban sub-district offices and 18 schools on its website. These data pointed out that the Semarang City Government is committed to applying the RWH to meet water demand overcome drought, floods, and land subsidence, mainly in the areas that experience drought, flood, and discharge.

In Indonesia, a study of RWH concerns the concept level by identifying whether RWH can be adapted in response to water-related problems or not (Prihanto, Koestoer, Sutjiningsih, & Darmajanti, 2018). Meanwhile, the research on community capacity regarding knowledge and readiness for rainwater-harvesting implementation was limited (Riba, Rtkl, Kiviet, & Edgar, 2016). It is necessary to comprehend the community's knowledge of rainwater benefits as an alternative water source (Demeke et al., 2021). A good understanding of rainwater management will motivate the community to participate in the implementation. Hence, this study emphasizes the community's willingness and ability to apply RWH daily.

#### **Research Method**

The research was conducted in Semarang, mainly in the coastal area considered vulnerable to water-related problems. This area covers 20 sub-districts spread over from Tugu to Genuk District. Nevertheless, this study emphasized the Mangkang Wetan, Mangkang Kulon, and Mangunharjo sub-districts (see Figure 1). As the Regional Disaster Management Agency (BPBD) of Semarang city stated on the website, the three sub-districts included the most vulnerable sub-districts facing several problems, such as flood, rob, and land subsidence. These sub-districts have not served the water supply

piping network from the State-Water Company (PDAM). Likewise, the water provision strategies such as ponds or RWH have not been implemented yet. Meanwhile, the seawater intrusion contaminates underground water, and domestic and non-domestic waste disposal pollutes rivers and degrades surface water quality.

The three sub-districts include the Beringin River Watershed and categorize as one of the critical watersheds because of land conversion in the upstream area, sedimentation, and riverbank landslides. Hence, these sub-districts flood yearly, and drinking water provisions are harder to obtain. The community that resides along the Beringin River is the respondent in this study.

The data collection through distributing questionnaires used simple random sampling (Alvi, 2016; Bacon-Shone, 2015), and the sample size was determined based on Slovin's calculation (error of 10%). According to the Semarang Central Bureau of Statistics (BPS) data, the population in the research area was 2,510 households. Based on the Slovin formula, the sample was 96, consisting of the community living in the coastal area in the three districts. Questionnaires used closed questions distributed equally among the three sub-districts to obtain the community's preferences in implementing RWH. Following are the questions that were asked:

- Community's social-economic characteristics such as livelihood, financial, educational background
- Physical characteristics, such as the quality of housing, infrastructures, especially clean water provision
- Flood characteristics, such as flood frequency, the flood level, and the community's losses because of flood

Besides the questionnaire, it was conducted interview to the Planning and Development Agency and Housing and Settlement Agency of Semarang City to obtain information on the government regulation and programs regarding RWH.

This study used a quantitative method to analyze factors influencing the community's willingness to implement RWH. There were two objectives; first, analyze the potential benefits for the community when implementing RWH. It quantified the financial benefit for the community that was determined by the amount of rainwater harvested in a year. Meanwhile, the second step is identifying the primary factors influencing the community's capacity to implement it. This analysis applied statistics and factor analysis to determine critical factors that encourage the community in RWH praxis. Variables processed in the statistics were the community's characteristics (age, education, income, and ability to pay), the community's economic affordability, the community's knowledge, physical characteristics (land area, rainwater usage), and water demand.

# Results

# **Regulation and Initiative of RWH**

The government's commitment to the RWH implementation can be seen in the Minister of Environment Republic of Indonesia Regulation No. 12 of 2009 about rainwater utilization in the community. Article 1, Section 1 asserts that rainwater utilization is an activity to collect, use, and absorb rainwater into the ground. In addition, Article 3 states that rainwater collection ponds are storage used to collect rainwater that falls on the roof of a building (house, office, or industry) channeled through gutters. RWH aims to reuse rainwater daily to reduce the water surface runoff. Besides, it is also considered a water storage alternative and useful during the dry season, particularly for household activities, agriculture, and other activities in drought-prone areas (Bunclark et al., 2018; Tu, Wang, Zhang, & Wang, 2018).

Realizing the government regulation above, The Environment Agency of Semarang City leads RWH implementation by consistently conducting socialization and facilitating the community. Afterward, other agencies, including the private sector, contributed to RWH practices by granting the installment to the community and spreading its implementation. Most RWH rooftop installations are located in public facilities such as schools, village offices, and public facilities that require large amounts of water.

## **Respondent Characteristics**

80% of respondents who answered the questionnaire were male as the head of the family. While the rest are women who represent their husbands who are working. Regarding occupation, 100% of the respondents work in the informal sector as fishermen, construction workers, farm laborers, or small traders.

All respondents live in privately owned houses, where 70% of the people live in permanent houses (tile roofs and walls). While 25% of respondents live in semipermanent houses (some of the walls and some use boards), and 5% of respondents live in non-permanent houses (using wood materials and limited facilities). The average house area is below 100 m<sup>2</sup> and is inhabited by five family members.

# **Physical Characteristics of Study Areas**

The three sub-districts include flood-prone areas based on the Regional Disaster Management Agency because of the yearly experience of both pluvial and fluvial floods. The Beringin River that flows into the research area experiences sedimentation, causing the river width to narrow downstream. Fluvial flood occurs when the highintensity rain prevents the river from collecting the water and flowing into the surrounding. Likewise, flash floods are caused by landslides from critical embankments and water flow to the settlement. Meanwhile, the pluvial flood happens when the extreme rain in the upstream area increases the runoff, and the river capacity downstream cannot accommodate it.

Several flood mitigation efforts from the government, private institutions, and community organizations (NGOs) have not overcome the floods significantly. The river normalization program planned by the Semarang government in 2020 is still dealing with the land acquisition problem. This program aims to rehabilitate the river and reduce the occurrence of flooding. Based on the Regulation of the Minister of Environment and Forestry, the rehabilitation of the Beringin River border is at least 50 meters from the right and left of the riverbed along the river channel (see Figure 5). Indeed, some residential areas and public facilities are less than three meters from the river. The inhabitants refused to be displaced, so the river normalization hampered.

Floods decrease the environmental quality of the coastal area. Likewise, this area lacks adequate infrastructures, such as drainage, water, and sanitation networks. The settlement quality has also included poor, represented by semi-permanent houses. The community's self-improvement was difficult because of their economic limitations. Hence, the Semarang City government improved environmental quality through the Neighborhood Upgrading and Shelter Project Phase 2 (NUSP-2) of the Semarang City Non-Slum City program. In addition, these three sub-districts were also included in the

Resilient Coastal Sub-district program by the Ministry of Maritime Affairs and Fisheries, which emphasized community empowering programs and poverty alleviation.

Comparing the three sub-districts, Mangunharjo was the priority village for improving environmental quality programs because this village faced regular flooding and high abrasion risk. Moreover, some community settlements reside adjacent to the coast, which is susceptible to abrasion significantly when the sea levels rise. Hence, the government and the private sector (through the Community Social Responsibility program) also emphasized procurement of barriers through mangrove planting and conservation to reduce abrasion levels. Previously, the mangrove conservation conducted in this sub-district was unsuccessful because of the lack of community participation in maintaining mangroves. Moreover, sedimentation has also influenced the failure of mangrove conservation.

## Discussion

#### Socio-Economic Characteristics of Community

The socio-economic characteristic is the primary factor that influenced the community's capacity to implement RWH, such as the community's educational background (Bunclark et al., 2018; Gao, Church, Peel, & Prokopy, 2018; Park & Kim, 2014). Statistics data and questionnaires, showed that more than 50% of the community (both men and women) have a low level of education that graduated from elementary school (see Figure 2). The questionnaire found that most of the male population graduated from elementary school and worked as fishermen and industrial laborers in port-industrial areas. Residents who work as fishers follow their parents' jobs, where since childhood, they have been taught fishing techniques so that they have a lot of experience and skills. In carrying out their work, fishers and their parents use the same boat, which the fisher will inherit in the future. Meanwhile, residents who worked as

industrial laborers were immigrants who had lived in the area for more than ten years and did not come from fisherman family. They worked as industrial laborers because it did not require specific skills or experience. Likewise, industrial locations are relatively close to their homes, so there is no need to incur high transportation costs.

However, having similar characteristics in educational background, communities of the three sub-districts had different occupations (see Figure 3). 61% of the Mangunharjo community worked in the informal sector, such as street vendors and odd jobs. The informal sector workerincome is uncertain; they do not get a fixed monthly income and are primarily under the Semarang City minimum wage standard (see Figure 4); two million rupiahs compared to two and a half million rupiahs. Meanwhile, some communities had income more than the minimum wage standard (three million rupiahs per month), a joint income between the husband and wife, who both worked in the informal sector. However, the number of working women in these sub-districts was few. Another joint income is between the father and the children, mainly those who reside in the same house. The children also have a low educational background, those that graduated from the senior-high-school then worked with their parents. Even though the children had been married and had kids, they still supported the parents in fulfilling daily needs. The children lived in their parent's house because they could not afford their own house.

In Mangkang Wetan and Mangkang Kulon sub-district, 27% of the communities worked as agricultural laborers. The farm (agricultural) laborers did not have their paddy fields or ponds; they cultivated agricultural land and paid based on the crop yield (three times a year) or laborers working in fish farming ponds.

# Analysis of Economic Benefit from RWH Initiative

The State-Water Company's service coverage area has not reached out to all research areas. Hence, 55.03% of the total coastal area population uses groundwater through deep wells to fulfill their water needs. While the use of surface water and rainwater to meet daily water needs was still 0%. Dissimilar with some communities (2.33%) upstream (hilly area) that started to utilize rainwater for daily needs through modest water treatment. Another water provision method in the coastal area relied on the community-based water drinking program (Pamsimas), especially for those who do not have individual wells. However, the water quality from deep wells and Pamsimas was poor due to sea-water intrusion, so it was unsuitable for consumption. The community must buy bottled water for their daily needs. On average, people buy bottled water 60-80 liters of bottled water weekly, equivalent to 80,000 rupiahs per week. This expenditure was only for drinking water needs, whereas for Pamsimas, they still had to pay around 50,000 rupiahs per month or depend on the water consumption per household. In total, the community's expenditure on clean water for drinking, cooking, bathing, and other needs was around 130,000 rupiahs per month. The water-related expenditure did not include electricity costs for the community that utilizes deep wells. Therefore, the expenditure to provide water reaches 20% of the total income of the community.

The government encourages the community to exploit alternative water sources, such as RWH. Although this method has been known for centuries, socialization about the RWH benefit is a principal activity to prioritize. Some favorable aspects of this method are contributing to water-saving (for daily community water needs as well as the agricultural sector), minimizing greenhouse gasses emissions and pollution, and reducing extra-expenditures on water.

The sustainability of RWH implementation relies on the rainwater amount. Semarang has low to moderate rainfall levels, about 5.64 mm in 2018, whereas, during the rainy season (from November to April), the average rainfall rises to a high level or > 300 mm (Semarang in Numbers, 2019). The potential for high amounts of rainwater during the rainy season is the basis of this RWH to be used during the dry season. For instance, during the long dry season in 2019, which extended until November, the community had to seek an alternatively clean water supply.

Therefore the following will illustrate the potential for water efficiency when applying RWH. This estimation refers to the domestic RWH that utilized the roof of the building (house, office, or industry) as a catchment area. Then rainwater that falls on the roof is channeled through the gutter for further collection into a tank. The water storage can be in a tank or a tub, water barrels, a pond, or a garden inside the house.

• The research area is fully covered by a roof with an area of about 569,652 m<sup>2</sup> (=56,965,200 dm<sup>2</sup>) and an amount of rainfall of about 5.64 mm/year (=0.0564 dm/year) in 2018. Therefore, the volume of rainwater falling on one roof of a house with a roof area of 56,965,200 dm<sup>2</sup> in one year is:

 $= 56,965,200 \text{ dm}^2 \text{ x } 0.0564 \text{ dm}$ 

= 3,076,120.8 dm<sup>3</sup>/year

= 3,076,121 liters/year

• With the assumption that only 80% of the total rainfall can be harvested (the remaining 20% is lost due to evaporation or pipe leakage), then the volume of water that can be harvested:

= 80% x 3,076,121 liters/year

- = 2,460,896.8 liters/year
- = 2,460,897 liters/year

- From the volume of water that can be harvested as much as 2,460,897 liters/year or equivalent to 649,677 gallons of water (1 liter = 0.264 gallons), if gallons is assumed to cost Rp 5,000,- per gallon, then households in the study area have been saving as much as IDR 3,248,385,000,/year.
- If it is assumed that all households in the study area implement RWH, then the volume of stored water will be able to meet the water needs of one family during:

= 2,460,897 / (3 x 4 x 2,510)

= 2,460,897 / 30,120

= 82 days (more than two months)

The estimation above points out that the water produced from RWH can meet the community's water needs for 82 days. If these days are compared to the number of dry months in Semarang, from April to September (six months), the potential for clean water is still not comparable yet, particularly when the community has to deal with the long dry season; the duration of the long dry season extended by 30 days or even more (eight months).

Afterward, this estimation result was confirmed to the prioritized community to find out the community's perception. The community considered that the potential economy of RWH was not significant because it could not be sufficient until the end of the dry season. Moreover, compared to RWH installment costs, such as engineered roofs, tanks, and pipes, the potential for clean water is not comparable. The community objected to providing all the RWH installation equipment because of the high cost.

The communities refuse to apply RWH because the installation cost that is expensive, and they do not convince of the rainwater quality. There was a common

perception that rainwater contains many harmful chemicals to the body and other living things, including plants. In the rainwater harvesting process, microbiological contamination, such as pathogenic bacteria is found when rainwater flows through the roof (Sánchez, Cohim, & Kalid, 2015; Zdeb, Zamorska, Papciak, & Skwarczyńska-Wojsa, 2021). In addition, regional air quality also affects the quality of rainwater. The research location adjacent to an industrial area where air pollution occurs contributes to the pollution of rainwater quality.

However, the community has traditionally made efforts to purify water through settling, filtering, and boiling water. People still use these three techniques in their daily life, intending to kill pathogenic bacteria so that the water becomes fit for consumption. However, this water purification method is usually for well water or water from pipelines and has not been found in rainwater. It shows that the community has an understanding of conventional water purification. Generally, people let the water settle for one night, then the next day it is filtered using a filter or a clean cloth, then the water is boiled. In addition, there was no best practice (success story) toward RWH practices, so the community did not convince of utilize the rainwater.

Meanwhile, if the government or other parties are willing to provide equipment assistance, 100% of the community is willing to apply for RWH. They considered this method an alternative and prioritized water supply from Pamsimas and deep wells. They will implement RWH when the primary water source cannot be used.

Afterward, it is essential to reveal what factors influence the community to implement RWH. Is the cost the primary factor, or are there other factors influencing the community options? The following analysis explains the factor affecting the community capacity for RWH.

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### Analysis of Community Capacity on RWH

The community's capacity and willingness to adopt RWH will determine the sustainability of water management. Hence, it is necessary to specify the principal factors synthesized from the physical and socio-economic variables (see Table 2). The factor analysis method used to define the key factors in RWH consists of several steps. They first determine the appropriateness of the data from KMO and Bartlett's Test (see Table 3). The Values Expected above 0.5 means all data can proceed further. Second, measuring the sampling (data) adequacy for each variable and correlation between independent variables from the MSA (Measure of Sampling Adequacy) value (see Table 4). Therefore, Table 5 shows that all independent variables have a value >0.5, which implies that all variables have adequate data to analyze in the next step. The third, grouping the variables into three main factors according to similar characteristics (see Table 6). Fourth, assessing the grouping variables to find out the principal variables from the Total Variance Explained analysis (see Table 7).

According to the percentage of variance, the most representative component was the Socio-Economic Factor, such as age, education, and income. The community emphasizes the socio-economic benefit that they may get from RWH. Indeed, the community in the three sub-districts includes low-income communities with limited financial ability. The primary consideration for the community is more on how to provide RWH installation because it is considered relatively expensive (9 million rupiahs with a 1,000-liter capacity). Meanwhile, the community's perception of RWH urgency was less important. In addition, they prioritize fulfilling their daily needs rather than spending money on something considered less crucial and with uncertain benefits.

Hence, it implies that the community emphasizes the short-term output, particularly on the money they have to spend to provide the installation, whereas the outcome or long-term benefit, fulfilling the water demand during the dry season, was not considered. Indeed, the community has economized the expenditure previously spent on buying water from water sales points. However, some RWH pilots in Semarang failed due to a lack of public understanding. Even though the government and private sectors provided all the RWH installations, the community did not use them and abandoned them. It relates more to how the community reviewed the urgency of RWH; they did not feel the benefits of implementing RWH, and they find the practice of RWH difficult because they do not understand the technique. Therefore, the following recommendations enhance the community's understanding and participation in RWH implementation.

## Building Knowledge

Reviewing the community's knowledge about RWH, 90% of respondents did not yet understand what RWH is, its purpose, or mechanism. Respondents with an education level neither graduated from elementary school nor who graduated from the elementary school stated that they believed that the utilization of rainwater for daily life was not good because it caused the teeth to become porous rapidly. The concentration of chloride (Cl) has been increasing steadily for the past 20 years. The chloride content in clean water must not exceed 250 mg/L; levels higher than that indicate poor water quality. The underground water in Semarang's coastal area exceeds the maximum chloride level found in clean water (Semarang City Government, 2016). Actually, porous teeth are more due to a lack of fluoride, whereas rainwater does not contain fluoride and tends to contain high acid, so that it can damage the teeth.

In addition, there is anxiety that storing water in the tank will become a mosquito growth media that will eventually cause dengue fever. Generally, this disease

is still a significant problemand the number of cases increases every year. Dengue fever is included in the ten priority diseases that are of concern to the government. Semarang City is one of the endemic areas for Dengue Fever (Semarang City Health Office, 2021). Therefore, water storage and water storage operations in RWH need attention. As a result, the community preferred to use existing water sources through deep wells and Pamsimas. After the RWH was installed, there was once socialization in the community, but it is more technical, such as using RWH and its benefits. The community did not get further assistance and education on the RWH. Consequently, the community will go back to their understanding and perspective on the best way to water consumption. Building community understanding of RWH is crucial because it is essential to program success. A good understanding allows the community to operate the RWH installation and carry out maintenance appropriately (Bouabid and Louis, 2015). However, developing community comprehension takes time and is not easy, requiring assistance from the related stakeholder.

# Leadership and Network Building

The initiation of RWH in Semarang City was encouraged by many parties, starting from the Environment Agency, Development Planning Agency (Bappeda), Public Works Agency (DPU), universities researchers, and international institutions such as ACCCRN. Moreover, as part of the 100 Resilient Cities network, Semarang has opportunities to get support from national and international parties regarding the community's vulnerability to clean water fulfillment.

The challenge is operationalizing the concept and method of water management at the local level so that the community can contribute actively. Indeed, the community's leader's involvement in these water management programs is essential because they are the community's role models and representatives. The several existing water management pilot projects, including RWH, had always involved the community's leader, such as the head of RT (the lowest division of government administration), RW (a government agency consisting of several RT in a village), and a village community empowerment institutions (LPMK). For instance, the RWH pilot project starts with the head of RT or RW house as a role model to ensure and encourage the community to participate in RWH. Likewise, good communication and active involvement from the community's leader are essential parts of RWH implementation.

Meanwhile, there are two strategies to support RWH; establishing regulations about applying this method and facilitating subsidies and incentives to the community (de Sá Silva, Bimbato, Balestieri, & Vilanova, 2022; Yusop & Syafiuddin, 2018). The top-down regulation allows the RWH implementation faster because the government's financial support and the parties involved have been determined. The second method relies on RWH's progress in the community. The subsidies are expected to motivate the community to implement and develop RWH.

# Respect and comprehend the local value of the community

RWH considers the appropriate method in water management at the community level because it enables all communities to get the same opportunity to involve. Especially with the rooftop RWH model carried out individually in each home, community involvement is a significant factor (Jones, Edwards, Bocarro, Bunds, & Smith, 2018). Developing community involvement needs a simultaneous approach, such as having monthly meetings that sustain communication among communities, including discussions on RWH. Informal discussion allows the communication process smoothly. Differences in socio-economic characteristics reflect the high heterogeneity in society, so it requires the proper approach to ensure good communication.

Furthermore, RWH can enhance the community's economic capacity by reducing the community's spending. Increasing community capacity is coherent with poverty alleviation because of community empowerment and better quality of life (Imbaya, Nthiga, Sitati, & Lenaiyasa, 2019; Wignaraja & Yocarini, 2008).

#### Information support

Generally, the implementation of RWH in Indonesia refers to a top-down approach, from initiation to implementation. The community tends to be the object of the project, wherein their house was installed RWH. However, the socialization, assistance, and monitoring process were less highlighted. The government, as the initiator, expects the active role of community leaders who have obtained information from initial socialization activities. However, this did not run smoothly because the project emphasizes the physical output (installment). This situation occurs in several locations of RWH pilots, including in Semarang. As a result, the installation of RWH became useless, and the community left it. Hence, it is essential to build a network with similar communities that practice RWH to transfer information and knowledge.

## Conclusion

The implementation of RWH in Semarang intends to address the shortage of clean water and reduce surface run-off. Furthermore, it is expected to minimize groundwater exploration and restrain land subsidence levels. Initiation at the stakeholder level has been around since 2011, but the implementation is still a pilot project. The community emphasized that the installment cost did not compare with the benefit. Some pilot

projects of RWH were failed because the community refused to use it. Indeed, the community was less captured on the paramount urgency of RWH. The community's knowledge and government assistance are the main factors in RWH. Government or other parties' assistance is temporary because the most important thing is the community's willingness and commitment to the implementation of RWH. The government and private sector support emphasized more on the technical aspect; of installing the RWH in some houses. Meanwhile, there was no community assistance that revealed the short and long term socio-economic and environment benefit. As a result, it can bring up a sense of belongingness so that the community will maintain the facility. In the first step, the economic benefit as the community's reason to participate in RWH is acceptable. Involving the community follows the leader. A community leader has a strategic role expected to encourage the community and enhance community awareness of environmental issues, including adopting RWH to extend the city's scale.

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