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## **Amazing to escape the cold Dutch winter!**

Aruba.

An island that I had never heard of before (please don't be mad) until the opportunity of coming here showed up. I love to travel and have been fortunate enough to visit a few places. Sadly, the time was always only very limited and max 3 weeks. This time, it was 2,5 months, WHAT A DREAM. The words that I am writing down do not even get close to all the pictures and memories I got to experience here. People always say one picture says more than a thousand words, well one memory is indescribable, let alone 2,5 months full of memories.

I was blessed to be able to come with a very good friend of mine (Marta) to this island. This made the anticipation very exciting and this whole trip already a success for me. But what came up during this time was not something I was expecting. Yes, Aruba is a beautiful island with incredible

nature and great weather (amazing to escape the cold Dutch winter!), but my personal highlight was to meet new people, experience Aruban culture and have the time to understand and live the Aruban island life.

When we arrived here, we got the chance to experience Carnival which was a lot of fun! Then, I got to meet and have class with amazing people who inspire me a lot. I also began to learn the language, Papiamentu, and it was a fun challenge that I shared with my peer friends. Another highlight of mine was swimming with the turtles. I did not think I would be able to experience this so soon! I was always amazed by tropical ecosystems, especially coral reefs, and I got to see them and share the experience with my new friends here which made it very special. When meeting new people, I love to play sports as it is an easy way to involve more people. As I play volleyball in the Netherlands, I wanted to continue playing in Aruba and I met a very nice

group here that plays regularly on the weekends. They even introduced me to a new sport: beach tennis. I enjoyed it a lot and even participated in tournaments which I did not expect. I was just a beginner, but it was a lot of fun! Seeing the support that we gave one another even though we barely knew each other was truly surprising in a positive way, making me feel less like I was living 8000km away from my family and friends.

The people I met and Aruba itself already have a special place in my heart that I will never forget. I am forever grateful to have had this experience and share the memories with my friends. Exchanges are said to be great but there is no way I can put my feelings into these few words.

Masha danki Aruba!

# **An exploratory paper: Societal gaps for a transformation towards sustainable rainwater harvesting in Aruba.**

Yanina Diaz-Maroto Knöfler

Aruba is a small island state in the Caribbean with unique climatic conditions and landscapes. It is part of the Kingdom of the Netherlands but since the 1980s it has been an autonomous state within the Kingdom (Derix, 2016). Being a small island, it has unique characteristics where water has consistently been a limited resource.

Water has always been present on the island, with rainwater harvesting used as an ancient method to collect fresh water. The early inhabitants, mainly the Arawak natives, gathered their water supply through surface water and groundwater wells (Marchena & Halman, 2018). Later, cisterns were incorporated into the houses to harvest rainwater from roofs. In the 20th century, the desalination plant was introduced with thermal desalination technology and, later, the reverse osmosis membrane technology. This occurred due to the transition of the national economy from gold and aloe to oil refining (Derix, 2016). With the oil refinery industry expanding, the water demand increased, and a new, additional, freshwater source was needed leading to the desalination plant. This led to a boost of economic and societal development of the island. Several industries, among others the tourism sector, were able to grow and expand due to a reliable (freshwater) drinking supply (Marchena & Halman, 2018). In the 1960s, a law was passed that forbade the construction of rainwater harvesting tanks in new buildings. During this time, many new houses were built due to population growth, but without the tanks

(Interview results I1, explanation in methods). In 2008, the law was changed again, allowing the addition of rainwater harvesting (RWH) tanks to buildings. Nevertheless, the news of implementing these laws has not yet reached the entire Aruban community. This represents the Precontemplation stage of the Stages of Behaviour change model by Prochaska et al. (1992). The Precontemplation stage represents the human unawareness of a problem. The following stages Contemplation, Preparation, Action, and Maintenance illustrate a person's phase of a desired behaviour towards acting and continuing to act on the problem.

This is one example that brings the RWH implementations in Aruba into context. Today, several challenges require us to rethink practices and approaches. The desalination plant contributed to boosting Aruba's economy and society by providing water supply to the entire island, but it also caused some environmental challenges (Marchena & Halman, 2018). The process of removing the salt from the seawater to gain drinking water is very energy-intensive. Furthermore, in Aruba, the energy source is mainly HFO (heavy fuel oil), more concretely, fossil fuels that have negative environmental consequences through their extraction and use, like habitat destruction and high greenhouse gas emissions. Moreover, the production of drinking water generates wastewater (brine) that is released back into the seawater unfiltered and impacts the nearby ecosystems, e.g. coral reefs (Marchena & Halman, 2018).

The brine contains substances that could potentially be removed for different uses and circular purposes that can help mitigate environmental effects, also called resource recovery (Acevedo et al., 2023).

Thus, there is potential for improvement towards a sustainable water supply. The addition of rainwater harvesting could increase Aruba's water security and -resilience. The high dependency of the island on the desalination plant could be catastrophic in the case of e.g. an accident or a natural disaster. The island has an emergency supply of (drinking) water for the population but a more diverse, second supply source could prolong the number of days of water security. Regarding sustainability, the trend is expanding as more and more nations, companies and individuals want to contribute to sustainability. Aruba has committed to, nationally, implementing the Sustainable Development Goals (SDGs) in the next decade (Overheid van Aruba, 2024). Therefore, how can a small island state contribute globally and locally to society and become more sustainable?

Due to the small size of the island, the achievement of a global change is not realistic. However, since islands have hard boundaries, small size, isolation, recent human settlement and many similar features, they are often described as models that show exemplary development or characters (Warren et al., 2015). They can serve as an example to follow or replicate in other places around the globe. Local-scale actions in island contexts can have large impacts that appear quicker as a result of the small, isolated ecosystems in which they exist. In the context of water and the sustainability of an island, it is important to not only look at the direct issues but at the system as a whole. One should approach these issues as so-called wicked problems, problems that don't have one single solution as the system is very complex, having different interconnections. Islands have strong interlinkages (Warren et al., 2015), as a result, it is required to look at island challenges from multiple

perspectives and disciplines. So, interdisciplinary and transdisciplinary perspectives need to be included for a complete transition towards sustainability, including rainwater harvesting in Aruba. For the development of understanding sustainable water supply, the following perspectives will be included in this study: environment, socio-economic, politics and interdisciplinarity.

Hence, the question arises what gaps there are in the societal system of Aruba that need to be addressed to solve the issue at hand. The question that this paper focuses on is **“What societal gaps can be identified in Aruba for a transformation toward sustainable rainwater harvesting?”**

For a deeper understanding, several key concepts need to be clarified: First, rainwater harvesting in this paper is used as the practice of collecting rainwater with e.g. rainwater tanks or rain gutters. This water is then re-used for non-potable purposes, for instance, irrigation in agriculture. Second, a gap is defined as a “lack that means something is not complete” (Cambridge Business English Dictionary). Societal gaps can be knowledge gaps, communication gaps or others that are primarily connected to society but also influence other environmental fields or individual action. This paper will explore the societal gaps in Aruba that might hinder the implementation of RWH systems.

## Methods

I conducted a literature review and linked the outcomes of this review with the findings of an ongoing research and consultancy project on the feasibility of rainwater harvesting in Aruba. A literature search demonstrated a limited availability of academic publications on rainwater harvesting and related issues. Yet, the articles that were found have been integrated into this paper. Simultaneously, data was collected through interviews and surveys on RWH knowledge, practices and opinions among stakeholders in

the Aruban community. Seven interviews were conducted with people from different fields. In this paper the interviews will be cited with numbers one to seven (i.e. “I1”, “I2”, “I3”, “I4”, “I5”, “I6”, “I7”). These include a consultant, a representative of DOW (Department of Public Works), a citizen, a representative from the farmer community, two hotels in Aruba, and a representative of DNM (Directorate of Nature & Environment). The limited time in which the project was executed did not allow for more interviews with stakeholders from different backgrounds. Still, through the semi-structured interviews that were conducted, a deeper understanding of the environmental, socio-economic, and political factors that influence RWH implementation was gained. Next to the interviews, a survey was sent out to reach a general public, i.e. a broad audience. It gave a general idea about the knowledge the people have about RWH and whether they practice it. This survey received 102 answers and will be cited with “survey” in this paper.

## Societal gaps

### Environmental gaps

One of the benefits of rainwater harvesting includes the reduction of erosion and flooding through decreasing surface runoff (van Houselt, 2021). In Aruba, there are no flood mitigation plans (I2). Hence, in the event of rain, the streets get flooded and transport large amounts of sediment that damage other ecosystems on and around the island. Next to the sediments that flow into the sea, pollution reaches the sea as well, which leads to negative impacts on marine life (Lyubimova et al., 2016). As rainwater harvesting lowers these impacts, it could be a solution that contributes to flood prevention. 98% of the respondents to the survey believe that flood management should be improved (survey, 2024). Yet, there is no data on the awareness of citizens about rainwater harvesting preventing floods. Another observation made during the consultancy project is that the community partly uses rainwater for irrigation purposes. This is considered to be better as it leads to a stronger growth of the plants (I1, I3).

Rainwater contains diverse minerals while the water from the desalination process is pure and only gets enriched with a few selected minerals. However, this knowledge is not widespread (survey, 2024). In addition to these results, one main reason why the community in Aruba does not implement RWH is that they believe it does not rain enough, especially in the dry season. 13% say the lack of rain is a barrier to the application (survey, 2024). However, in Aruba more than 7 times of the drinking water production falls in the form of rainwater per year (on average it rains 450-480mm/yr on the island and the island is 175km<sup>2</sup>, leading to 85-90 million m<sup>3</sup>/yr rainfall on the island while the water production of WEB is 12 million m<sup>3</sup>/yr leading to around 7x more rainwater than drinking water production; Eric Mijts, personal communication, 2024). This is not widely known though either. As Aruba has a wet and dry season it is believed that the dry season interferes with the abundance of rainwater falling during the year (survey, 2024). Interviewee 1 shared that, from personal experience, it is possible to water all their plants with an adequate rainwater collection system. Thus, with the right infrastructure, materials and funds, this could be a feasible practice. Finally, looking at the current water production in Aruba, most of it is produced with the use of HFO (heavy fuel oil). Next to the negative environmental impacts that importing and burning HFO has, the process of extracting it leads to, among others, land change, waste and noise on-site (Ngene et al., 2016). The reverse osmosis technology emits around 0.08–4.3 kgCO<sub>2</sub>/m<sup>3</sup> and uses 4.0–4.5 kWh/m<sup>3</sup> of energy during water production (Cornejo et al., 2014). In addition, the production process also produces wastewater, called brine water, that is often released unfiltered into the environment which damages surrounding ecosystems. Nevertheless, 52.5% of the Aruban population believe that the desalination plant is environmentally friendly (survey, 2024).

### Socio-economic gaps

The main societal gap that was identified is the need for more awareness and the availability of accurate

information. The Aruban population is not informed enough about the possibilities and technical ways to implement rainwater harvesting systems. As Mukarram et al. (2023) describe, financial insolvency, lack of technical skills, and insufficient education are the main reasons for the unsuccessful implementation of rainwater collection. 51% of the respondents to the survey (2024) indicated that they cannot afford to install RWH systems in their household. Other sources, like Peters (2016), confirm that the absence of socio-economic factors in RWH projects was the most significant motive to why it was not successful. Van Househelt (2021) describes that in Curacao the application of rainwater collection was not economically feasible. In addition, several people expressed that they do not have the knowledge and skills to build and maintain the systems (survey, 2024) which is in line with the statements of the above-mentioned sources. Still, a benefit that many Arubans discovered is that rainwater harvesting reduces their water bills. 71.6% say that their water bill is too high (survey, 2024). The water production involves many different stages and, therefore, is expensive. RWH could contribute to supporting the community financially. Moreover, there are many large buildings where the roofs could be used to collect rainwater but the lack of initiative by private owners and the government makes the practice currently uncommon for the island population (I2, I6).

#### Political

Rainwater harvesting currently takes place in Aruba but not on a large scale. Only a small number of individual households are implementing it. As mentioned before, a law was introduced in the 1960s prohibiting new rainwater harvesting infrastructure; and then changed again towards allowing new RWH systems some 50 years later (I1). The interviews demonstrated that there is unclarity in the Aruban population about whether it is allowed to harvest rainwater or not (I2, I3, I7). While interviewee 2 shared the certainty that rainwater harvesting is allowed, interviewee 7 claimed that it was not allowed. In addition, the ambiguous

information that is shared on this topic creates distrust in the government (I1, I3, I4). Distrust can also appear when a citizen's evaluation of a political situation, and the competencies of the actors in a government, do not align with the expected results (Bertsou, 2019). As a result, the citizens do not rely on the government to act, or to support them. Moreover, the data from the consultancy project indicated that according to most interviewees, there is no water quality measurement, e.g. mineral, toxicity, pH, or conductivity, and management for the (collected) rainwater (I1, I2, I3, I4). Nevertheless, the interview with DNM demonstrated that there are measurements taken at several dams, the natural rainwater harvesting systems in Aruba, but these are neither complete nor timely accessible (I7). Thus, citizens of Aruba are not sure what they can use the water for, which makes them hesitant about the purpose and safety of collecting rainwater. Finally, the diverse interests of different stakeholders like the government, desalination plant or the tourism industry could affect the contribution and action to and process of the implementation of rainwater harvesting (I1, I2, I3, I4). Depending on the distribution of power between these interests, it could benefit or hinder the process of implementing rainwater harvesting systems. From the survey, 86% of the participants wish the government to initiate support for RWH in households. This could be in the form of policies, financial support, or other forms of incentives.

#### Interdisciplinarity

The data of the consultancy project revealed that communication between governmental departments is not high (I2). As a result, the cooperation and efficiency for interdisciplinary projects like rainwater harvesting are low. A different approach, that is applied in different places around the world like Asia and Africa, is community-based rainwater harvesting (CBRWH). According to Kim et al. (2016), the community-based approach can significantly improve the water supply system. This would require cooperation between several stakeholders but could

have a great impact on the Aruban community. CBRWH could be implemented by using several larger locations for rainwater harvesting that then would be distributed to the individual households close by. This source also states that there is a need for local pilot projects for more research and successful models. This would shed light on the significant technical and societal success factors for CBRWH. Aruba, being an isolated island, could become an exemplary model on how RWH could be implemented and benefit the whole community, as mentioned by Warren et al. (2016).

## Conclusion

Coming back to the guiding question **“What societal gaps can be identified in Aruba for a transformation toward sustainable rainwater harvesting?”**, this paper examined the gaps from different dimensions, including the environmental, socio-economic, political and interdisciplinary. The first gap that was identified is the knowledge and educational gap. The Aruban population is not aware of the possibilities, opportunities and barriers that come along with rainwater harvesting. There is a lack of easy access to information about the types of RWH, the costs and maintenance. The results indicate that the Aruban community wants to get involved and wants to act environmentally friendly but that missing and incomplete information on these topics is one of the main barriers to act. Data about the quality of the collected rainwater is either non-existent or difficult to access. Thus, citizens are not sure what they can use it for and if it is clean or not. In addition, one of the largest, unexpected findings is the misconception of the existing and past laws. Different beliefs regarding the authorization of rainwater harvesting systems have been found during the data collection. There are also no noticeable governmental or other efforts to inform the community on this. Another gap that has been observed is the financial gap. Even though many citizens are interested in implementing rainwater harvesting systems, according to the survey, they are not able to afford it. Currently, there

is no active financial support from the government for the development of RWH infrastructures at a household level. Hence, the infrastructure for rainwater harvesting is limited. The final gap that has been classified in this paper is the communication gap. The communication between the governmental departments, the government and citizens as well as between citizens is limited and can be related to the distrust of the government and an unwillingness of the citizens to help each other out.

These gaps overlap in different disciplines and need to be addressed. The implementation of rainwater harvesting depends on the tackling of these barriers. This could be started by looking at possible ways to increase awareness, leading to guiding the citizens from the Precontemplation stage to the Contemplation stage, which represents the phase of unawareness to awareness of a problem (Prochaska et al., 1992). It is then recommended to research specific intervention techniques, for this case study, to direct citizens towards a more active behaviour that implements rainwater harvesting. Furthermore, it is advised to investigate the most optimal ways of RWH on the island, not to promote rainwater harvesting as the only and needed solution, but rather as a complementary way to achieve a more sustainable water supply.

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