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Water sources, consumption, and water-related sanitation on Pari Island, Indonesia: a mixed-focus group discussion and survey study

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ABSTRACT

Pari Island has 1,441 inhabitants who are facing major environmental challenges related to water consumption and availability. These challenges may impact water quality and availability in the future. Previous research examining water usage and sanitation behavior on Pari Island remains limited. Since domestic activities dominate in Pari Island, this study evaluated water sources for domestic usage, estimated water consumption, and evaluated sanitation behavior, as well as community behavior and awareness. This study was based on a field survey using a questionnaire involving 317 heads of household, and had focus group discussions. The results revealed that reverse osmosis (RO) water and branded bottled water were the dominant water sources for drinking and food preparation, and RO water had become an important alternative water source for its affordable price. An individual's well water was mostly used for bathing and toilets. Annual water consumption on Pari Island for drinking, food preparation, and water-related sanitation is 24,930.74–29,401.44 m^3/year, which still fell within the estimated water capacity of 290,000.48 m^3/year, yet problems related to sanitation need special attention with respect to the increasing population. The awareness of the Pari Island community on technological interventions should be an advantage to maintain water sustainability.

Key words: domestic usage, Pari Island, sanitation behavior, water consumption, water source

HIGHLIGHTS

- Study of water consumption, domestic usage, and sanitation behavior on small island of Pari remains limited.
- Annual water consumption on Pari Island for drinking, food preparation, and water-related sanitation still fell within the estimated water capacity.
- RO water and branded bottled water were the dominant water sources for drinking and food preparation.
- Individual well water was utilized only for bathing and toilet purposes.

INTRODUCTION

In recent years, Pari Island, a very small island with 1,441 inhabitants, has evolved from a residential island and marine research unit of Indonesian Institute of Sciences (LIPI) into a marine tourism destination due to its natural habitats and proximity to the capital city of Indonesia (Sinulingga *et al.* 2016; Kinseng *et al.* 2018; Utomo *et al.* 2018). As a result of these changes, water consumption and waste generation will both be impacted. In the future, without proper countermeasures on water resources, it is expected that water quality and availability on Pari Island will be affected as similar problems have been observed on other small islands (Cheer 2020; Alamanos 2021). Pari Island can be categorized as a small island that has the same vulnerability as other small islands, such as the Caribbean due to its size, topography, limited natural resources, water sources, population growth, and is directly affected by climate change (Winters *et al.* 2022).

Some studies examining water availability have been conducted on Pari Island, which have found that the ratio of water availability to water demand decreased from 6.25 in 2013 (Sinulingga *et al.* 2016) to 2.05 in 2018 (Marganingrum & Sudrajat 2018). The ratio in 2018 was just slightly above the safe criteria for the water resource supply-demand ratio (Prastowo 2010). Other studies examining the Pari Island groundwater quality were conducted by Marganingrum & Sudrajat (2018) and Cahyadi *et al.* (2019), which found some groundwater samples exceeded standards for coliform bacteria, conductivity, and chemical oxygen demand (COD). Meanwhile, the biochemical oxygen demand (BOD) was investigated by Cahyadi *et al.* (2019) and was found still below the standard, so the resulting COD to BOD ratio was more than 1.5. This indicated that the organic matter in the study site was not fully biodegradable by naturally occurring microorganisms.

Water sources on small islands usually depend on shallow groundwater and rainwater (Hophmayer-Tokich & Kadiman, 2006; UNEP 2014). Increases in tourism and local activities could negatively affect groundwater quality as indicated by the aforementioned studies. Environmental degradation associated with water sanitation behavior would also be affected. A better understanding of the existing water consumption in Pari Island is needed to estimate future water resource availability. In previous studies, the prediction of water consumption was calculated based on the population amount being multiplied by the standard water requirement per capita of 60 L/c/day (Sinulingga *et al.* 2016; Marganingrum & Sudrajat 2018).

While shallow groundwater remains an important water source on Pari Island (Utomo *et al.* 2018), its quality is decreasing as mentioned in previous studies. So, whether other water sources should be introduced and how inhabitants might adapt to the threat of a clean water deficit remains to be explored. Also, a previous study has not examined in depth with regard to the water consumption and sanitation behavior of households and individuals, which are key factors that affect water availability and quality. Therefore, this study determines domestic water consumption and sanitation behavior on Pari Island which is urgently needed for basic data support.

In this study, we discuss (a) the domestic water sources; (b) the estimation of water consumption, including water purchase, water usage, and sanitation behaviors; and also (c) community behavior and awareness related to water and sanitation. Focus group discussions (FGD) were conducted to determine the community's perception of water availability and daily water consumption, the perceived changes in their environment related to water, and their sanitation condition. We also introduced a composting toilet, in order to determine the public acceptance of new sanitation technology. The results of this study contribute toward developing an action plan to ensure water quality and availability on Pari Island.

METHODOLOGY

Study area

This study was conducted in Pari Island, Indonesia, one of the very small islands in Kepulauan Seribu, which is classified as a very small or tiny island by Indonesian Law no.1/2014 (Figure 1). Pari Island has an area of 41.32 ha (Utomo *et al.* 2018; Pari Island Ward Office 2021). Despite its small size, 1,441 inhabitants reside there, with 412 (male 88.6%, female 11.4%) heads of household. Most of the residents' income comes from the fishing sector (Pari Island Ward Office 2021). Administratively, Pari Island is part of the Jakarta Province – Indonesia, belongs to the Kepulauan Seribu regency, and is located in the northern part of the province. It has four groups of Neighborhood Unit (called as RT), and each RT consists of 90–117 heads of household (Pari Island Ward Office 2021).

Data collection

This study used primary and secondary data collected during a field survey conducted in 2021 (Figure 2). Primary data were obtained from questionnaires which were then confirmed through FGD. The sample in this study was selected using a non-probability sample (or convenience sample) technique, where respondents were selected based on convenience and availability (Creswell & Creswell 2018). We considered that when this research was conducted, it was still in the Covid-19 pandemic condition. A total of 317 heads of household or their representatives were successfully interviewed by trained enumerators using a questionnaire instrument. This number represents 76.94% of the heads of household or 21.99% of the total population of Pari Island. In this study, one enumerator was in charge of conducting a survey for all households in the same RT.

The questionnaire in this study was a questionnaire developed by the research team according to this research objective. The questionnaire consists of five parts, namely Part A contains the survey staff's information, Parts B and C contain the identity of the respondent, Parts D and E contain questions related to domestic water sources, estimation of water consumption,

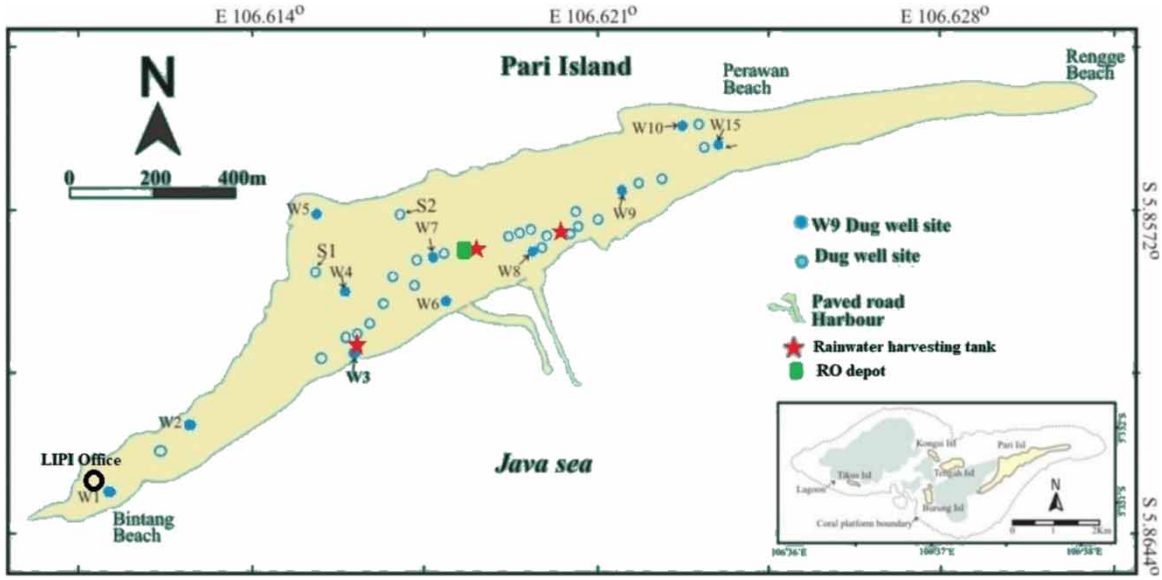

Figure 1 | Map of study location.

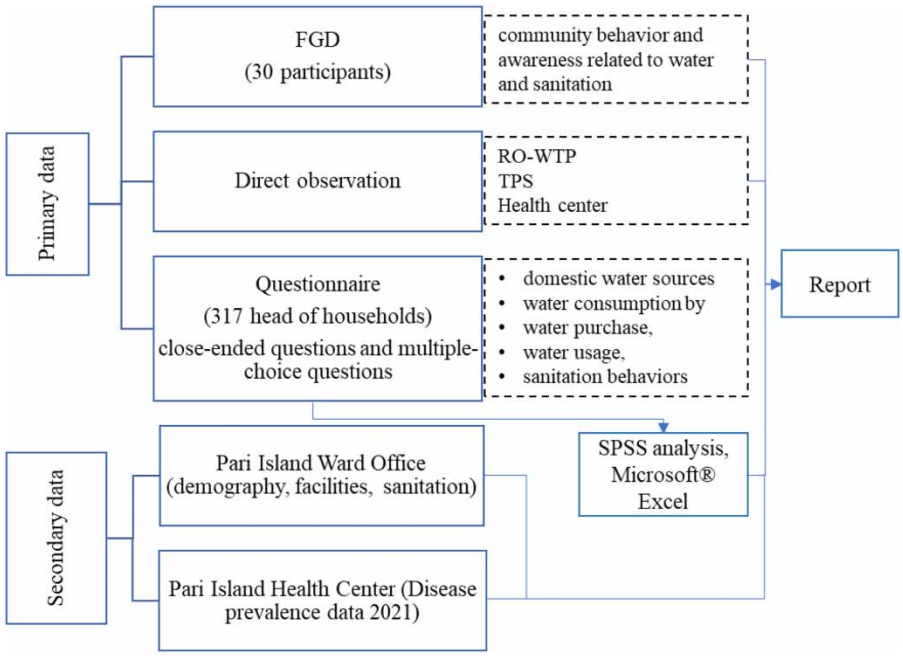

Figure 2 | Flow of study.

including water purchase, water usage and sanitation behaviors and also examine community behavior and awareness related to water and sanitation. The questions in the questionnaire are closed questions using continuous scales (e.g., strongly agree to strongly disagree) and categorical scales (e.g., yes/no, rank from highest to lowest importance). The validity and reliability tests of the questionnaires were carried out on the questionnaire data collected by the Cronbach Alpha test and were declared valid and reliable. Tourism activities were excluded from the questionnaire to obtain basic information from domestic usage.

The participants in the FGD were selected by Rukun Warga (RW) management recommendation. Around 30 participants attended as the representative of each community, group leader, and government representative in the study location. There

were two people each from public bodies, Public Facilities Service Center, Environmental Agency, elementary school teachers, homestay owners, catering owners, ship owners, tour guides, religious leaders, representatives of women's groups for family welfare education, four persons from the head of neighborhood unit (RT 01–RT 04), one person each from the head of citizens' association (the lead person of RW), representative of Village Consultative Council, representative of Marine Protection Council, and representative of the Pari Island Tourism Association. All FGD participants were then divided into four groups to obtain more intensive and interactive discussion.

FGD was conducted in 2 days with the same participants. On the first day, there were discussions to cross-check the questionnaire results regarding perceptions of water, hygiene, and sanitation, especially regarding the option of using composting toilet technology which requires less water consumption for flushing. At the end of the session, a visit to see an uninstalled composting toilet was done. On the second day, there was an open discussion about their impressions of composting toilets. The introduction of the composting toilets in the FGD session was used to determine the potential for public acceptance of new sanitation technology. This toilet can reduce water-flushing requirements and omit the septic tank for treating the feces and is recommended for pollution prevention strategy in Small Island Developing States (South Pacific Regional Environment Programme 2004).

Direct observation was carried out to observe local activities and also visit an RO water treatment plant (WTP), the temporary waste collection facility (TPS), and the health center (Pos Kesehatan).

Secondary data about Pari Island's demography, facilities, and sanitation were obtained from the Pari Island Ward Office monthly report. Disease prevalence data for 2021 were obtained from the local health center (unpublished).

This study complied with the ethical clearance from the Indonesian Institute of Sciences/LIPI Social and Humanities Committee (no. 67/Klirens/VII/2021).

Analysis

The water consumption volumes for drinking, food preparation, and water-related sanitation were calculated by multiplying the frequency by the volume of water usage per unit of each activity. Water-related sanitation only included bathing and toilet usage for defecation and urination.

The questionnaire data were analyzed using SPSS where the validity and reliability were calculated beforehand, which resulted in the frequency and data distribution, and then graphically visualized using Microsoft Excel (Microsoft Corp., Redmond, WA, USA) for each variable. Meanwhile, FGD data were classified based on the issues discussed and then analyzed descriptively.

RESULTS AND DISCUSSION

Water source

Based on the findings from the field survey, there were several Pari Island water sources used for domestic purposes:

- Shallow groundwater well
  On Pari Island, the community typically has shallow groundwater wells near their homes. These are approximately 0.5–4 m in depth from the surface. For sampling, a well was selected which had relatively tasteless water. It was observed that water was pumped and delivered to a certain house. Some of the community uses communal wells which are shared between two or three families in a neighborhood. The water from these wells is utilized for bathing, toilets, washing, and gardening.
- Branded bottled water
  Commercially bottled water usually comes from outside Pari Island through trade activities. The bottle sizes vary and include 240 mL, 600 mL, 1.5 L, and 19 L. The largest size is usually referred to as 1 gallon. The price for each bottle size is 1,000 IDR (0.07 USD), 5,000 IDR (0.33 USD), 10,000 IDR (0.67 USD), and 25,000 IDR (1.66 USD), respectively (1 USD $\approx$ 15,000 IDR). The community uses bottled water primarily for drinking.
- Reverse osmosis water
  This water comes from a WTP that utilizes a multi-stage filtration and reverse osmosis (RO) water treatment process. The RO installation has been supported by the government in the program of Energy and Mineral Resources Services since 1995. Initially, the process was based on seawater filtration (SWF) or seawater RO (SWRO). Later, the process changed to groundwater filtration (GWF) and groundwater RO (GWRO), utilizing water sourced from groundwater located at 80 m below surface level. This process potentially increases the total dissolved solids of wells nearby due to the wastewater

produced by the system. The RO system begins its process from storage tanks, and then proceeds with silica filtration and nanofiltration, before using the RO membrane. The membranes and filters are cleaned once a week by backwashing. The backwash effluent flows into the sea through a domestic greywater closed-pipe system. Since 2019, the GWRO depot has been managed by the Water Resources Sub Services (Sudin SDA), DKI Jakarta Government. Due to increasing demand, Sudin SDA DKI Jakarta plans to build an additional installation.

To obtain RO water, the community brings their own 19 L (gallon) or 20 L jerry cans to the RO depot (Figure 1) to be refilled by depot staff. The community purchases RO water for 25 IDR (0.002 USD) for 1 L or 500 IDR (0.03 USD) for 1 gallon. Based on RO depot data, the average RO water consumption is approximately 3,000 L/day. During the holiday season, food preparation increases, which directly affects water consumption, reaching 5,000 L/day. The RO water is generally used for drinking and food preparation, including food washing and cooking.

- Harvested rainwater

  Rainwater is collected from the roofs of buildings and stored in storage tanks ranging from 500 to 800 L. These tanks are provided to store the collected water, and include a drain pipe at the top so that excess water can flow to the ground when it is full. Rainwater storage tanks on Pari Island have been installed in public facilities, e.g., prayer rooms, mosques, and the RO depot by Sudin SDA DKI Jakarta (Figure 1). At this time, rainwater is utilized as a backup water source during the dry season.

Based on the results from the questionnaire, domestic water sources were divided into three categories, i.e., drinking, food preparation, and bathing/toilet use. These sources and usages are illustrated in Figure 3. Figure 3(a) shows that residents primarily use RO water (74%) and bottled water (56%) as their drinking water sources. Less than 2% of respondents utilized water from their wells or communal wells as drinking water. As shown in Figure 3(b), RO water is primarily used in food preparation. Meanwhile, for bathing, 88% of residents used their well water and only 12% used communal well water Figure 3(c).

Previous study in 2005 (BPS 2006) mentioned that the well was the water source for bathing, meanwhile, there was no piped water provided by national WTP (namely PAM) available. A study in 2009 (BPS 2010) mentioned that rainwater

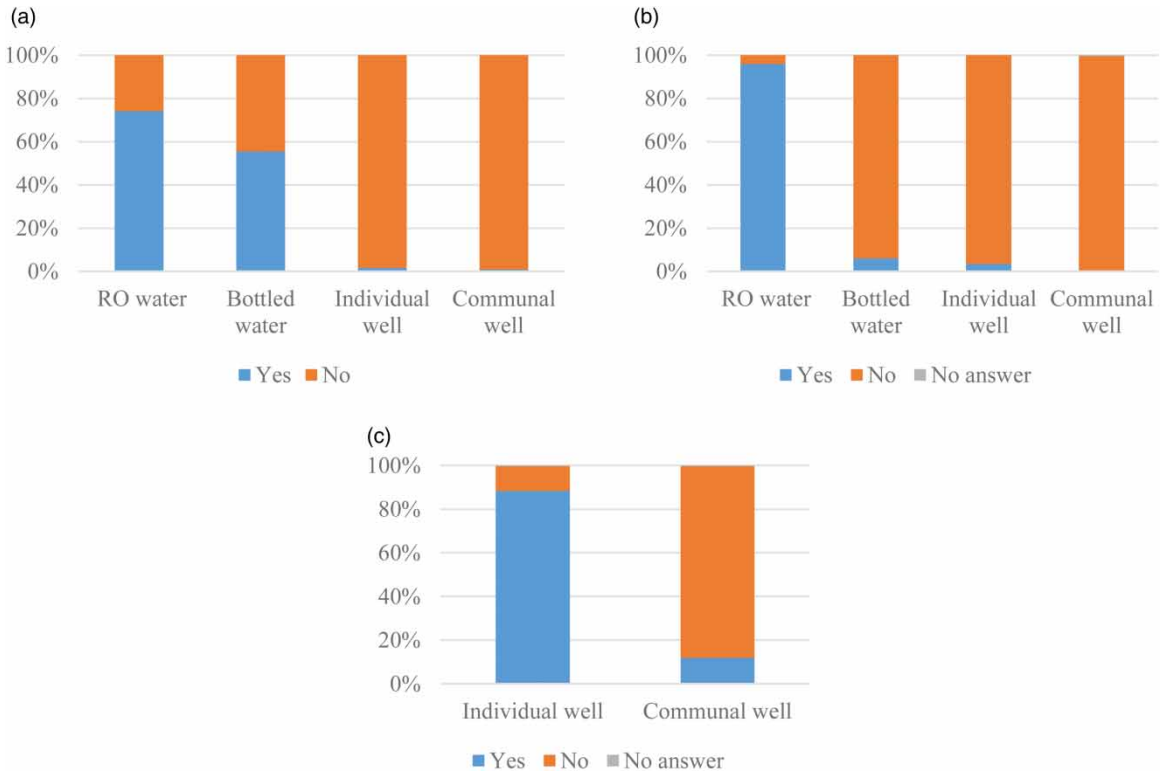

Figure 3 | Percentage of respondents which use water sources for (a) drinking, (b) food preparation, and (c) bathing.

(35.93%), bottled water (26.83%), retail water seller (10.91%), protected well (8.47%), refilled water (6.28%), and others (11.27%) were used as drinking water sources. This study reveals that recently there is a shift in the water sources, especially for the drinking water sources, where 74% of respondents used RO water as their main drinking water besides bottled water (56%), and rainwater is no longer used for the main drinking water source. Meanwhile for bathing, even though there is no quantitative amount stated in the previous study, well water is still used as the main source.

Water consumption

Water consumption behavior was described for each activity. Figure 4 shows water consumption for food preparation and drinking, indicated by RO water and bottled water purchase frequency. Most respondents made one purchase weekly, with 70% purchasing RO water once and 47% purchasing bottled water once, respectively. Based on that and direct observation where one purchase of RO water using a 20 L jerry can and one purchase of branded bottled water using a 19 L bottle per household, where each household consists of three to four individuals (Pari Island Ward Office 2021), water consumption per capita was 39 L/week. This is equal to 1.4–1.9 L/c/day.

Water consumption for toilets, including toilet flushing and body washing after urinating or defecating activity, was more than 4 L/c/day, as shown in Figure 5. Meanwhile, for bathing, 86% of respondents mentioned using more than 6 L/c/day every time they bathed.

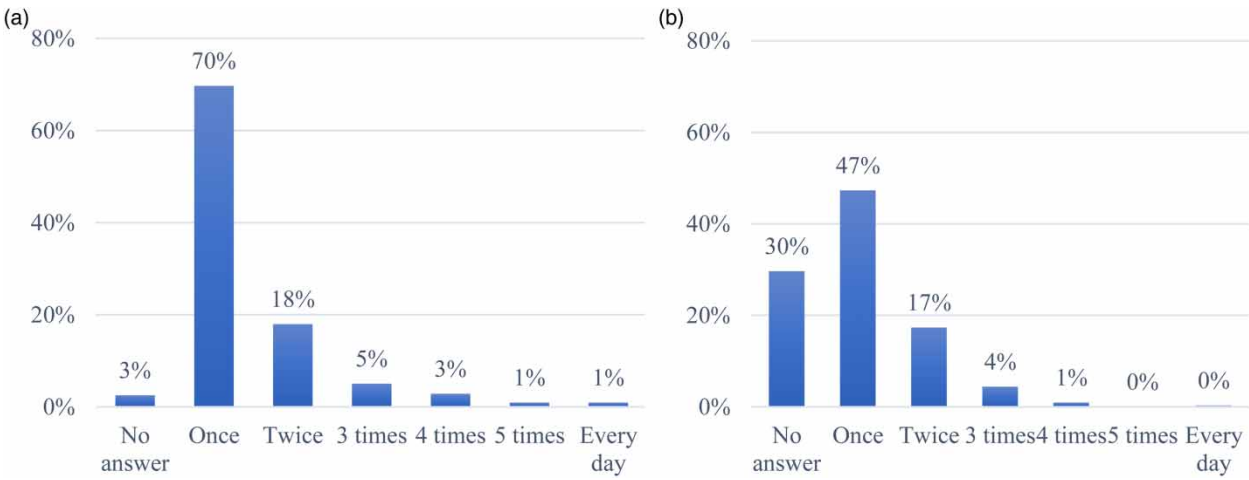

Figure 4 | Percentage of respondent on (a) RO water and (b) bottled water purchase frequency per week.

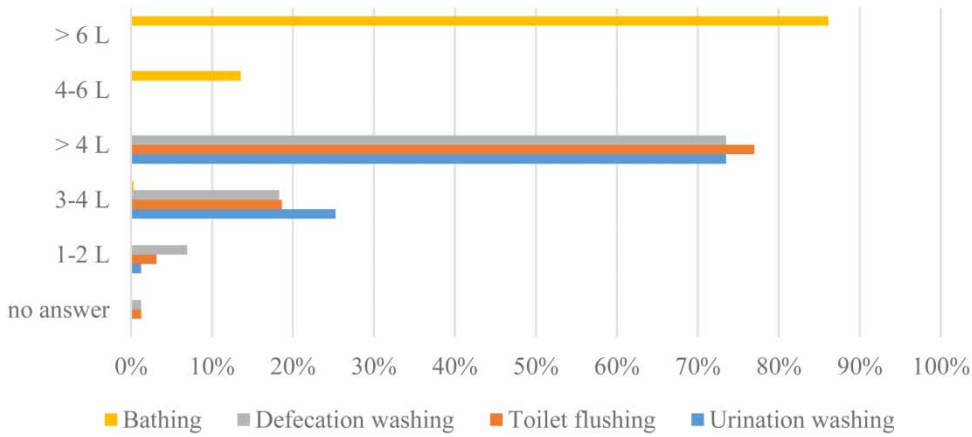

Figure 5 | Percentage of respondent on daily bathing and toilet water consumption per capita.

The bathing activity mainly was twice a day, while most defecation frequency was once and urination three to five times daily (Figure 6). This urinating behavior finding is still reasonable in numbers, between 4 and 6 times daily (Wrenn 1990).

Based on Figures 4–6, the minimum daily water requirement was calculated to be 8 L for bathing and toilet use. Therefore, the total basic water requirement for drinking, food preparation, bathing, toilet, and urination was between 37.4 and 45.9 L/c/day (Table 1).

Water-related sanitation

According to water-related sanitation behavior on Pari Island, the toilet location behavior reported by 92% of the respondents used individual toilets (i.e., privately owned) and 8% used a public toilet, with no respondents admitted open defecation in yards or along the coast/shoreline, as shown in Figure 7(a). For toilet type, 88% of respondents reported using squat toilets with goosenecks. Among the remainder, 6% used squat toilets and 4% used sitting toilets as shown in Figure 7(b).

From a previous study in 2009 (BPS 2010), 47.83% of households used private toilets, 8.16% used public/joint toilets whereas 44.02% still had no toilet facility. This study reveals that there is a significant shift in defecation behavior in individual toilet usage and preventing open defecation. Toilet ownership might become one reason for this shifting defecation behavior, besides local norms or hygiene issues (Bhatt *et al.* 2019).

Wastewater discharge

Meanwhile, for the toilets described in Figure 7, blackwater was primarily discharged into septic tanks, with 93% having their own septic tanks, 5% using communal septic tanks, and only 2% not discharging into septic tanks, as shown in Figure 8(a). This confirms the statement that 92% of respondents use their own toilet and emphasizes the statement that every toilet is always equipped with a septic tank.

The distances between septic tanks and wells varied Figure 8(b), with the majority having distances between 4 and 8 m (55%). Only 36% had distances of more than 8 m. There were 2% that responded no distance separating their septic tank

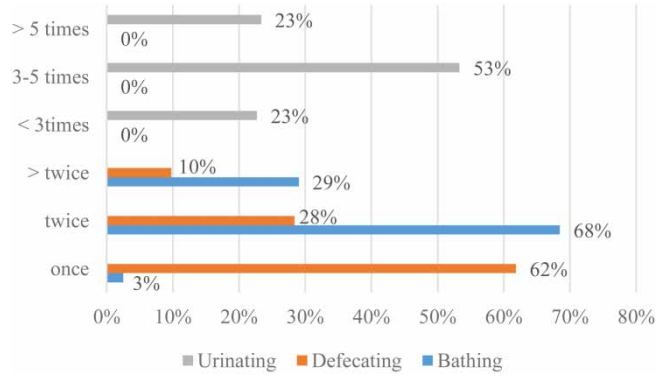

Figure 6 | Percentage of respondent on daily frequency of bathing, defecating, and urinating.

Table 1 | Basic water consumption calculation per capita for related activities

		Minimum water consumption		Calculation	
Activities	**Frequency, daily**	**Amount**	**Unit/capita**	**Amount**	**Unit**
Drinking and food preparation	1	39	L/house/week	1.4–1.9	L/c/day
Bathing	2	8	L/times	16	L/c/day
Defecating	1	8[a]	L/times	8	L/c/day
Urinating	3–5	4	L/times	12–20	L/c/day
Total				**37.4–45.9**	L/c/day

[a]Sum of minimum water required for body washing and toilet flushing.

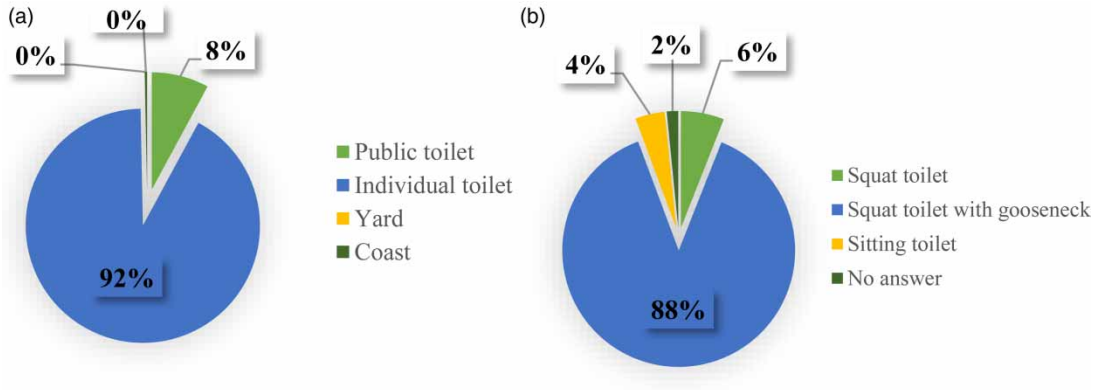

Figure 7 | Response to toilet location (a) behavior and (b) type.

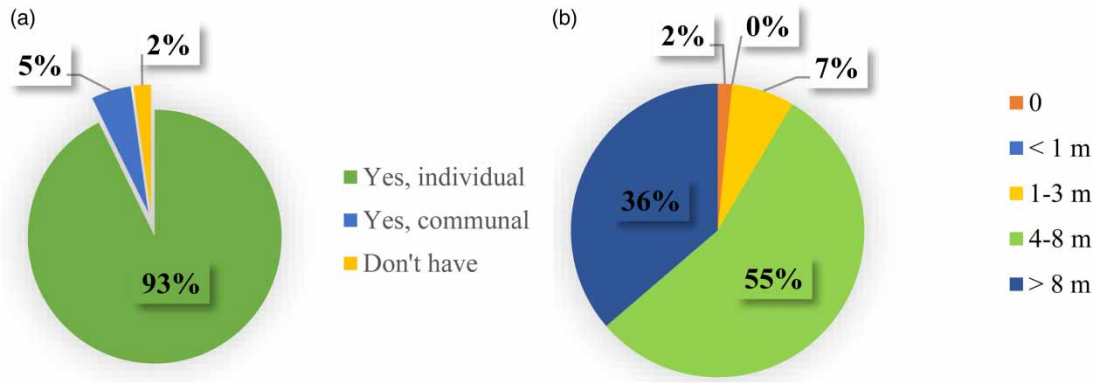

Figure 8 | (a) Septic tank ownership and (b) distance between the septic tank and water well.

and well, but this was related to Figure 7(b) where 2% did not answer their toilet type. It could be assumed that they did not discharge their blackwater into septic tanks.

Based on field survey data, all households had access to communal bathing-washing-toilet facilities (called 'MCK' in Indonesia). In tourist areas, such as Bintang Beach on the west side of Pari Island and Perawan Beach on the east side, there are public toilets that are managed by the community.

Figure 9 shows that 80% of domestic wastewater from bathing and washing, called greywater (Ghaitidak & Yadav 2013), was discharged through drainage channels, 14% into yards, and only 6% discharged directly into the sea. For those discharged into their yards, they used the infiltration principle applying either 'cubluk' (without gooseneck) or 2-chamber septic tanks. Greywater was also infiltrated into the ground around their houses.

Focus group discussion

The FGD was conducted to obtain additional responses to similar questions as presented in the questionnaire. The focus was on water sources and usage, cleanliness issues, and an introduction to new technologies in sanitation. The new technology consisted of a composting toilet that would minimize the water usage required for toilet flushing. The FGD results are shown in Table 2.

DISCUSSION

Water consumption and availability

Regarding the result, RO water (74%) is dominantly used for drinking water compared to branded bottled water (56%). Less than 2% of respondents utilized their wells and communal wells for drinking water. The trend is quite similar in DKI Jakarta

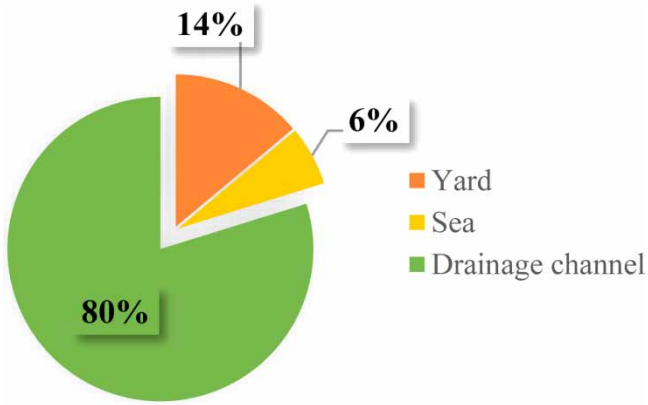

Figure 9 | Wastewater drainage from bathing and washing.

Table 2 | FGD findings for each issue examined

Water source and usage	Cleanliness issue	Introduction to composting toilet
• Water consumption increased, especially RO water and branded bottled water, because of food preparation for the tourists. • Rainwater harvesting became unpopular because it required preparation, such as boiling and incurred additional costs for purchased gas. • Before the RO WTP was built, the community managed traditional wells for drinking water supply, i.e., two wells at RT, three for RT 3 and RT 4, one well at RT 1, and one well at RT 2. Recently these wells have not been utilized as drinking water sources.	• Seasonal solid waste in the sea during certain months is caused by rob tides coming from the southeast, e.g., wood cutting, plastic waste, and bulk waste which contributed to reduced cleanliness of coastal areas. • Waste from tourism activities was also becoming a concern. • The influence of tourism on the amount of waste can increase significantly, especially during special events • To address greywater and blackwater from domestic and tourist activities, the community has constructed infiltration septic tanks in their houses, with concrete sidewalls with a sand layer at the bottom. • Septic tank cleaning is not urged yet because it still meets capacity requirements. • Inhabitants are aware that the sea was not a final disposal area (TPA), and the community is trying to keep their environment clean. • The climate change issue also emerges in FGD discussion especially in raising public awareness towards natural conditions and properly maintain it.	Composting toilet factors: • Situation dependent: whether technology increased the quality of groundwater and whether the community was ready to accept. • Socialization on how the composting toilet works is required. • Composting toilet management team became a limiting factor, unsatisfactory for women because of limited water usage. • The participants lacked knowledge about composting toilets, even after reading the flyer. • A belief that composting toilet use to conserve water is still unnecessary because water is still available. • Low-water toilet is perceived as less hygienic. This belief may reduce if composting toilets are more frequently used. • Cost is a potential factor that limits the acceptance of composting toilets. • People are willing to conduct a trial of composting toilets in the public area. • If residents see and feel the benefits, and if the composting toilet is practical and inexpensive, then acceptance and adoption of the composting toilet will occur. • Alternative locations for composting toilets: o Tourism areas o Communal facilities o Qur'an learning centers for children (TPQ)

Province, where 79.78% of households use bottled water (both branded and refillable) as a source of drinking water, in contrast to 11.98 and 8.11% of households that use pumped well water and piped water, respectively (BPS-Statistics Indonesia 2022). The refillable bottled water depot has emerged in recent decades in Indonesia and has been seen to have poor quality control and been known to generate hygiene problems (Komarulzaman *et al.* 2017; Kooy & Walter 2019). Nevertheless, on Pari Island, refillable bottled water depots do not exist. The likely factor is the higher cost associated with using seawater. This is because the salinity of raw water is associated with higher energy requirements for RO systems to produce potable water (Kim *et al.* 2019). When this capital cost was covered by the government, it became reliable and the price of RO water became much cheaper than branded bottled water products. Despite this, branded bottled water became the second drinking water source on Pari Island, possibly because of security and quality concerns. Figure 3(b) shows that RO water was primarily used in food preparation. On a national scale, 35.04% of households in Indonesia use pumped well water as their food preparation and washing water source (MoH Indonesia 2020). Overall, the inhabitants of Pari Island use several water sources for household use, a very common phenomenon seen in developing countries (Komarulzaman *et al.* 2017).

Based on Table 1, the water consumption rates of 37.4–45.9 L per capita per day are relatively similar to the World Health Organization (WHO) hierarchy of water requirements, i.e., 30 L/c/day (Reed no date) or between 20 and 50 L/c/day (Crouch *et al.* 2021). If washing requirements are included, an additional 10 L/c/day are needed, thus increasing total basic water consumption on Pari Island to 47.4–55.9 L/c/day. This value is between the range 34 and 194 L/c/day of domestic water consumption in rural areas previously reported by Widyarani *et al.* 2022 and between the range 50 ± 5 L/c/day of predicted water use for absolute basic consumption (ABC) four to five people per household reported by Crouch *et al.* (2021), so this finding is reasonable. This water consumption was limited to situations where each household consists of three to four members.

To calculate the total annual water consumption, the total basic consumption of 47.4–55.9 L/c/day and the population of 1,441 inhabitants (2021) were used to result in 24,930.74–29,401.44 m^3/year. This result was lower than the findings of previous studies which used the WHO standard 60 L/c/day. Sinulingga *et al.* (2016) mentioned in 2018 that the water demand had increased to 54,443.953 m^3/year and predicted that it would increase to 63,548.472 m^3/year in 2023. While Marganingrum & Sudrajat (2018) found that Pari Island had a higher water demand of 109,741 m^3/year in 2018. In other small islands in the Pacific, similar to atoll islands like Pari Island, a study by White *et al.* (2004) mentioned that the water consumption per capita is estimated at 50 L/c/day. The larger village suggested a higher estimation.

Based on this study, the rural inhabitants' water demand for basic drinking, food preparation, and water-related sanitation is still underestimated by other studies. When considering the water availability on Pari Island as 290,000.48 m^3/year (Sinulingga *et al.* 2016), and with natural recharge as the main source, it is seen that the water capacity still meets the water consumption requirement. But anthropogenic activity which decreases the quality of groundwater should be a warning against groundwater usage. Government management action to add water sources other than groundwater, e.g., installation of the RO WTP and rain harvesting tanks, aid in groundwater conservation. A previous study also examined the construction of artificial storage recharge and recovery for groundwater (namely SIMBAT, Indonesian acronym for Simpanan dan Imbuhan Buatan Air Tanah) and found positive effects on reducing the salinity of groundwater (Utomo *et al.* 2018).

Water-related sanitation and wastewater discharge

The water-related sanitation behavior findings revealed that the inhabitants and local government already showed awareness by having individual toilets (92%), and there were no respondents who openly defecated in yards or along coastlines. For toilet types, squat toilets with goosenecks were found to be the most common toilet type and were more economical for users. A study by Niedfeldt *et al.* (2021) revealed that squat gooseneck were common in three rural districts of their study area in Indonesia.

This study also reveals that blackwater was primarily discharged into septic tanks, with 93% having their own septic tanks, and only 2% not discharging into septic tanks (Figure 8(a)). This condition is better than the national proportion of blackwater discharge into the closed discharged system, around 18.8% (MoH Indonesia 2020).

The study found that 93% of respondents have their own septic tanks which are positioned no more than 10 m from each house as regulated by the Indonesian government (Indonesia National Standard Agency 1992). Only 36% had a distance of more than 8 m. This was caused by space limitations by land acquisition issues which limited septic tank placement to very close to their own house (Kinseng *et al.* 2018), sometimes even under their main building. The relatively close distance between the water source, septic tank and infiltration system of the septic tank increases the possibility of contamination

of the water source. The increasing number of visitors on weekends or public holidays will also contribute to reducing the groundwater and environmental quality. This situation could be overcome by the design of a septic tank, which would benefit from an infiltration system at the bottom of the septic tank which would allow blackwater to pass into the sand first. The construction of existing septic tanks in Pari Island is very simple with only cemented walls that are partially embedded into the ground without any bottom layer. So, all the liquid from the blackwater is allowed to seep into the soil or sand. The characteristics of sand support the filtration of suspended solids (Spychala *et al.* 2019) and reduce periodic puddling of water. In 2020, Sudin SDA (local government in charge of Resource Management) constructed a 70 m discharge channel with 20 connected borewells to improve the situation.

Related to sanitation, health levels become another indicator. According to unpublished disease prevalence data from the Health Center on Pari Island, stomach disease, diarrhea, dysentery, typhoid fever, and dermal disease caused by contaminated water were not predominant diseases in 2021.

FGD result

Cleanliness issue

The cleanliness issue in Pari Island indirectly relates to tourism activities. The influence of tourism on the amount of waste can increase significantly, especially during special events such as the Reggae festival and the new year's commemoration. The previous study stated that garbage production by tourists was double that of waste produced by local residents of Pari Island (Assa & Wibisono 2020). To maintain cleanliness, the local community controls the garbage around Perawan Beach and Bintang Beach through the involvement of tourism awareness group (KOPDARWIS) which constantly monitors the cleanliness of this island. The community also announced a warning to prevent littering habits around Bintang Beach and Perawan Beach.

The climate change issue during FGD may emerge from the interaction between tourists and the local community. Pari Island is facing the water vulnerability induced by anthropogenic causes, as well as other small islands (Thomas *et al.* 2020). The Indonesian Forum for the Environment (WALHI) at the end of November 2020 reported an the tidal flood that occurred on Pari Island. The Pari Island community was still not prepared to face this flood disaster which occurred twice, in July and November 2020, and lasted several days (WALHI 2020). But the indication of climate change impact should be studied further. The limited study about climate change phenomena in Pari Island becomes a challenge because similar conditions had occurred in another island of Kepulauan Seribu. The study by Zulriskan *et al.* (2018) on Kelapa and Harapan Island where the land requirement is increasing as an implication of population growth suggested the restriction on the additional area in there in order to reduce the risk of disaster. In Pari Island, this action has already been adapted several years ago because of space acquisition issues (Kinseng *et al.* 2018) that push the community to keep their houses increasing in numbers. Other studies in small Bintan Island, Indonesia also concerned about water availability, so reliable water monitoring should be conducted (Narulita *et al.* 2021). Improvement in water management has become one solution to deal with the climate change caused (Azhoni *et al.* 2018).

Composting toilet acceptance

Various considerations stating the reluctance of the FGD's participants to use reduced-water toilets for flushing/composting (USEPA 1999) were caught on the first day of the FGD. After seeing the composting unit themselves, there was a significant shift in perception. On the second day, they stated that the composting toilet looked more hygienic, clean, and modern. Their concern was more about the price and also the safety of the children who would use it.

A comparison between first- and second-day FGD results found a slight change based on the location of the composting toilet. Regarding composting toilet usage, greater accessibility to the public and maintenance issues became concerns. A composting toilet will be located at Perawan Beach, in a closed room and constructed at a specific elevation to prevent flooding during the tidal season. The following section will include a urine collector which will enable utilization as liquid fertilizer.

FGD impressions of the composting toilet were as follows:

- Modern, good, practical.
- The high price of material could be reduced by replacement with other cheaper materials with similar functions.
- Child-safety factors should be considered, e.g., short circuit electrical prevention, non-conductive material, and location of the electricity panel.

- The best location for a composting toilet was Bintang Beach because the electricity could be supplied from the LIPI office, as the composting toilet has a limited capacity, and the LIPI office has human resources to manage the composting toilet.

The FGD identified a psychological obstacle based on the perception that using composting toilets would make a user feel less clean after use and will also provide an unsatisfying feeling due to limited water use. One alternative solution is socialization on how to use the composting toilets or a trial period for the community to develop its use as a new habit. A gender aspect was identified regarding perceived cleanliness, with most women using more water than men to achieve a satisfying level of cleanliness. However, they were willing to try the composting toilet in public areas for residents and tourists. If the benefits can be clearly felt and it is seen that they are easy to use, and have a cheap price, the acceptance of less-water toilets will increase. This relates to the previous study by Birawida *et al.* (2021) where community behavior in saving water and sanitation practices was a significant factor in preventing water vulnerability in small islands. So, this study also reveals that the Pari Island community already has an awareness of their limited water availability.

Meanwhile, community behavior in saving water, especially in small islands, is still facing challenges. A previous study in the Haitian community had a good response to using rainwater as their water source, on condition that the government support the investment cost (François *et al.* 2021). Actually, on Pari Island the government already facilitates the rainwater harvesting storage tank in several public areas. So, it only needs further effort on community willingness to adopt this alternative water source.

When discussing the water quality of well water, most FGD participants were not informed yet about the key factors, including knowing *Escherichia coli* (*E. coli*), one of the key parameters of water quality. So far, there have been no disease cases on the island related to *E. coli*, e.g., diarrhea or skin disease. Regarding interview results from June and November 2021, the community has not yet encountered water scarcity.

CONCLUSIONS

This study examined the domestic water sources, water consumption, and water-related sanitation behavior on Pari Island. The RO water and branded bottled water were the dominant sources for drinking and food preparation, and RO water has become the most important alternative water source because of its affordable price. Meanwhile, individual well water was mostly utilized for bathing and toilet usage. Regarding basic drinking, food preparation, and water-related sanitation requirements, water consumption on Pari Island was estimated to be approximately 47.4–55.9 L/c/day, resulting in an annual water consumption level still lower than the estimated water capacity. Even though the available quantity of water still meets water demand, the decreasing quality of groundwater should be an alert to residents and government agencies about allowable water-intensive activities on Pari Island. Additionally, introducing good sanitation practices and safe septic tank positioning are important steps to prevent environmental degradation and health problems. Several policies related to groundwater conservation have already been introduced, e.g., building water drainage channels in the central area, installing a WTP, and harvesting rainwater as an additional source of water. The acceptance by residents of such technologies might provide additional insights besides good water management, into the introduced policies and allow their efficacy and sustainability to be further measured. This study only focused on the domestic aspect. Considering the shifting of Pari Island into a tourism destination, the study on tourism's influence on water quality could be indispensable to conduct. Regarding the economic level mostly related to water consumption and sanitation behavior, its relationship also needs to explore further.

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AUTHOR CONTRIBUTION

All authors have read and contributed to this paper. D.R.W. developed the main concept, data analysis, and interpretation; N. S. contributed to data design and water-related sanitation; D. M. on water availability; T. T. and V. B. on data design and collection; E. Y. and H. S. on technology acceptance and environment changes.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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