BMD constructions

Winnovators
Developing skills, ideas, futures

WATER SOLVE CHALLENGE 2024

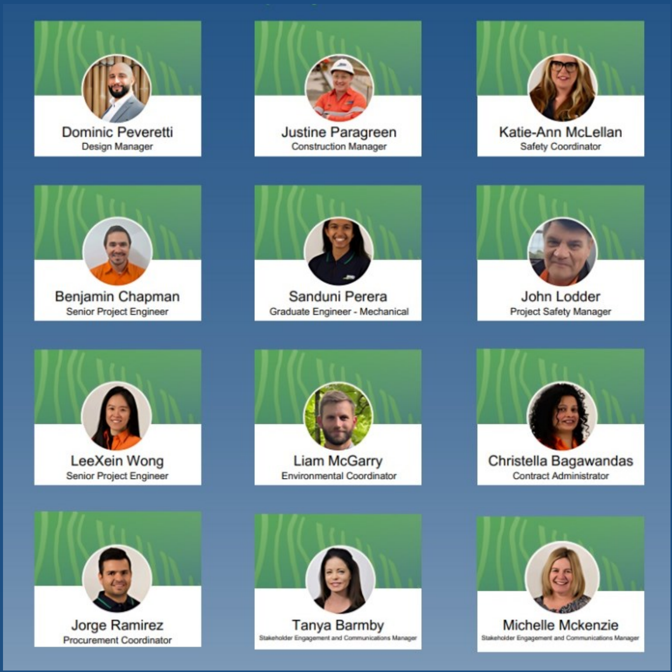
BMD Constructions has chosen the **Water Solve Challenge** as their focus among the three options provided by WaterAid.

Summary Water Solve Challenge

Coastal communities in Tarawai Island in Papua New Guinea are grappling with the dual challenge of accessing clean water and coping with the escalating impacts of climate change, such as rising sea levels and unpredictable weather patterns.

Our challenge is to devise innovative and sustainable solutions to address these pressing issues, with a focus on integrating climate resilience into the water supply systems of these vulnerable communities.

*Introducing BMD's Winnovators — **Squeaky Clean Team***



BACKGROUND

Tarawai Island	
Coordinates	Latitude: -3.20613349 Longitude: 143.25761226
Location	East Sepik province, located 60 km northwest of the capital Wewak
Size	4.3km^2
No. of households	77
Population	170 people
Climate	Tropical
Topography	Generally flat with highest elevation 12 metres
Rainfall per year	1900 millimetres
Estimated water demand per/person/day	20 litres inclusive washing, drinking and cooking. 5 litres for drinking and cooking.
Existing water infrastructure	• 8 x 9000 litre tanks owned by households. • Existing lake with no hygiene testing, used for drinking when water supply is low. Water from the lake has a sulphur odour. • Secondary sources - hand dug wells.
Community skills	• Carpenters, plumbers will be available on the island. Specialist trades such as mechanics or electricians will need to be sourced from Wewak (over 2.5 hours by boat and over 60 kilometres away).
WASH future plans	• Installation of a deep bore hole to reach aquifer approx. 20 metres deep with a solar pump. This is currently under planning and investigation. This will be a significant investment.

THE CHALLENGE


Household water storage and rainwater harvesting on Tarawai Island, used for household drinking water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Water sources	• Insufficient water supply to make it through an entire year. • Quality of water is contaminated from surface water. • No water treatment on the island or testing. • Existing lake is contaminated by sulphur with unknown source of contamination.
Climate change	• Longer dry seasons resulting insufficient water supply. • King tides and flooding events requiring resilient infrastructure.
Infrastructure	• Limited infrastructure such as tanks, pipelines, pumps, and distribution. • Infrastructure is generally at source per household. • Household pump systems are generally in despair.
Education	• Reluctancy in adapting to new systems and technology.

REVIEW OF POTENTIAL TECHNOLOGIES

Portable Desalination Plant

Small scale portable reverse osmosis unit 500 litres to 2000 litres per day.

Advantages

- Reliable continuous water supply from seawater.

Disadvantages

- Cost: $10,000 AUD for a small unit.
- Power requirements, approximately 2 kW to run, continuous generator and fuel required.
- Requires ongoing maintenance and replacement parts.

Shared community water storage

Given the significant rainfalls that occur throughout the year, a large community reservoir would provide enough storage for all the water needs of the community.

This would involve the construction of a large dug out reservoir located at a low point in the island to enable capture of surface flows.

Advantages

- Having the ability to store large volumes of water from consistent annual rainfall would ensure water availability year-round.

Disadvantages

- Difficulty in transporting construction materials to Tarawai Island.
- Lack of community water distribution infrastructure. Water would need to be transported manually.
- Requires large catchment area to ensure tank used.

Bores and inland lake

Groundwater research on the island indicates that water is accessible at approximately 20 meters below the surface as advised during the mid-year WASH update. By drilling one or two deep wells, this groundwater can be extracted to serve as a primary or secondary water supply for the island's residents.

The central lake, a significant freshwater source, could also provide clean water after appropriate treatment. Onsite investigations are necessary to assess water quality and identify contaminants, which will inform the development of an effective water treatment procedure. Potential treatment options include floating wetlands and chemical dosing.

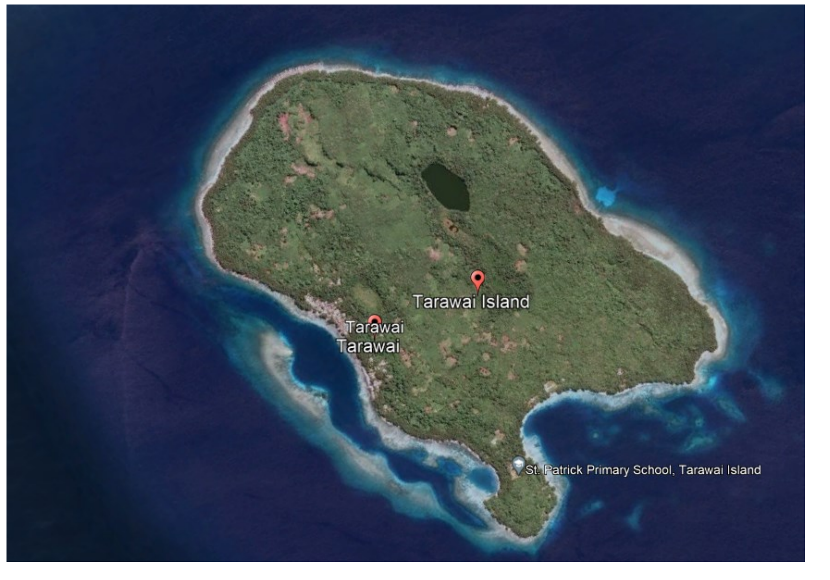
To enhance water distribution on the island, installing a pipeline from the lake to the village could be considered.

Advantages

- Enough supply to provide water for community.
- Bore water potential available year-round (subject to onsite geotechnical investigations).

Disadvantages

- Transporting drilling equipment to the island is difficult and costly.
- WaterAid already has existing plans to construct community bore and pump on Tarawai Island.
- Increasing impact of salinity on water table if the wells are unprotected from sea water.
- Significant piping install would be required to transfer water approximately 1 kilometre to township.
- Water will still require treatment.
- Sulphur odours from inland water body. Onsite investigations required to determine the source of the odour and its effect on the water quality.



OUR SOLUTION - RAINWATER HARVESTING

Selection Overview

As Tarawai is a small community, with around 170 residents, improving rainwater harvesting is the most cost-effective method of providing a consistent water supply year-round. The rainfall across the seasons generally vary between 120 to 180 millimetres a month. Even during the dry season, the island receives 100 millimetres of rainfall per month. A dry year has been considered as 75% of the average.

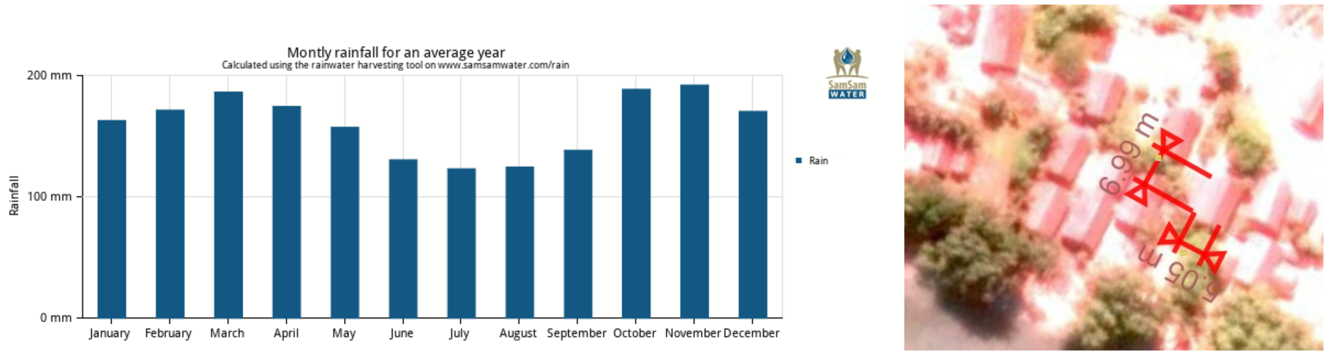


Figure 1: SamSam Water Rainwater Harvesting Tool (Rainfall at Wewak Island)

The minimum monthly water usage for Tarawai can be estimated at 108,000 litres when on water restrictions (20 litres/person/day). This will satisfy basic hydration and cooking requirements. Based on Google Earth imagery, the average building on Tarawai has a roof area of around 35m2. A typical thatched roof has a capture rate of 20%. Assuming the community has a total roof area of 2695m2, rainwater harvesting is not sufficient to meet the demand of the community even in the wetter months on average, with an estimated 103,000 litres captured each month if all available roof area was used for harvesting.

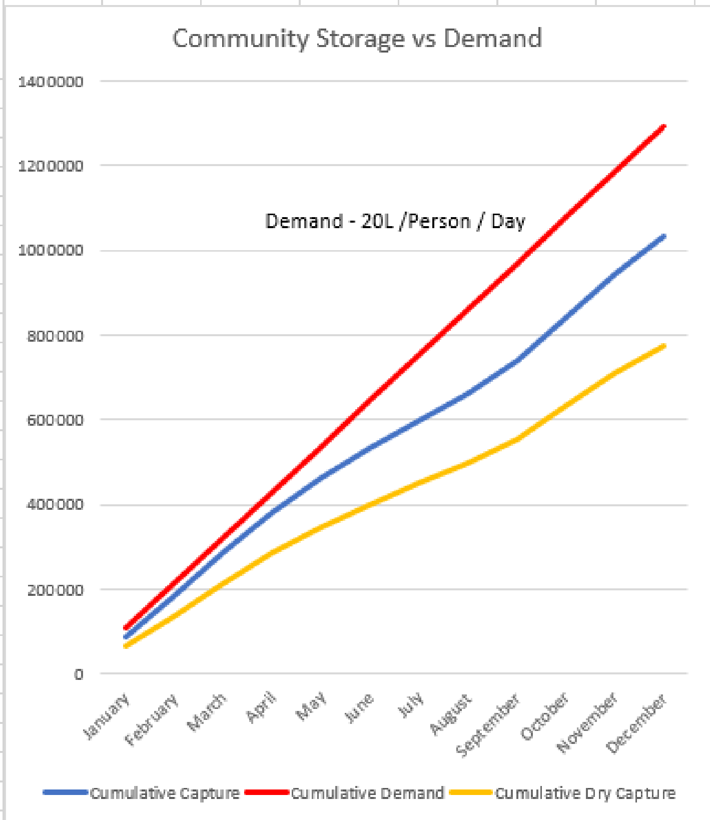


Figure 2: Current Water Demand vs Water Captured

To understand the relationship between the capture, storage, and demand. A sensitivity check has been completed and if the capture rate is increased to 35%, the curve below shows that rainwater harvesting would meet the minimum water demand for the community.

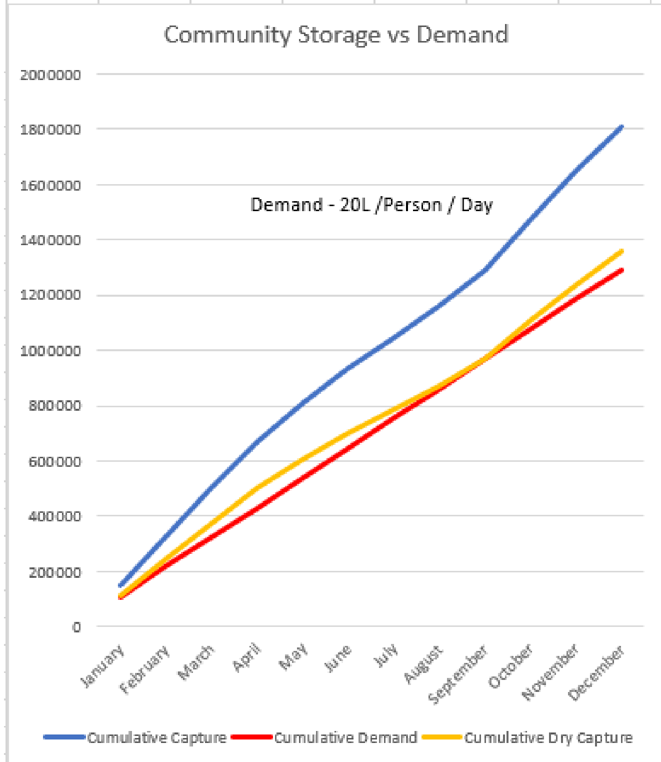


Figure 3: Improved Rainwater Harvesting meeting the Water Demand of Tarawai Island

This level of capture requires a minimum storage capacity in the community of approximately 72,000 litres. This level of storage is already available on the island from the existing 8 x 9000 litre water tanks. However, the issue is interconnectivity between catchment areas.

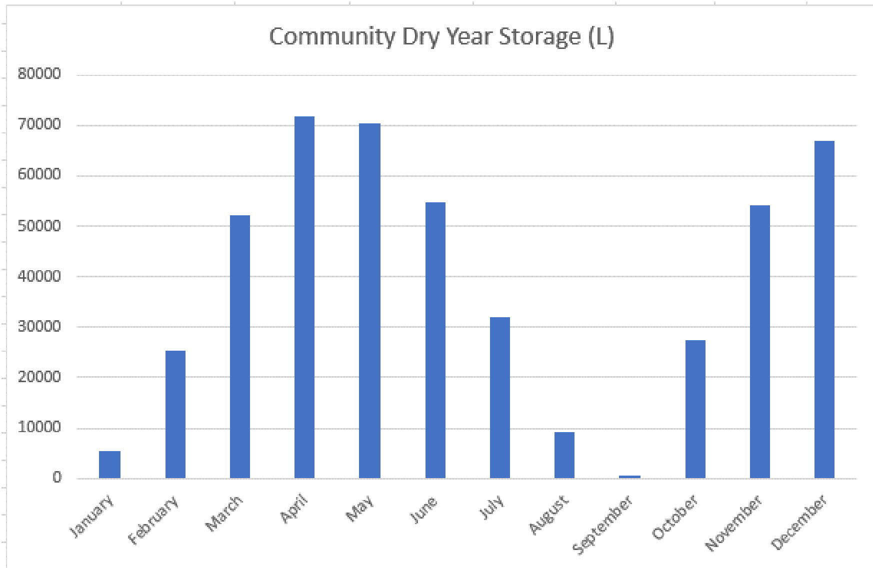


Figure 4: Water Storage Required for Dry Year Monthly

OUR SOLUTION - CAPTURE AND STORAGE

Capture

The primary goal to optimise capture is to include all available roof area in the community and increasing the capture rate. Typically, 'thatch' roofing is not considered for capture due to the poor capture rates and impacts to the water.

Optimising guttering size and arrangement can significantly improve the rate of capture and water quality from rooftops.

- **Position:** positioning of guttering on thatched roofs is critical for increasing capture, due to the much broader discharge profile.
- **Shape:** standard gutter profiles are not wide enough to cover the discharge area. A trapezoidal folded sheet would be most suitable to account for the variability of the roof line. A return section back to the roof would allow the gutter to be tied back to the structure.
- **Angle:** 1° incline toward downpipes to prevent pooling and sagging angle - 1° incline toward downpipes to prevent pooling and sagging.

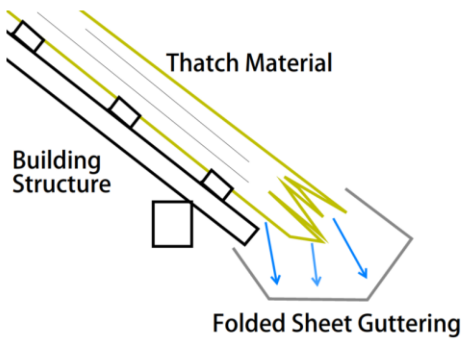


Figure 1: Rainwater Capture Angle and Position

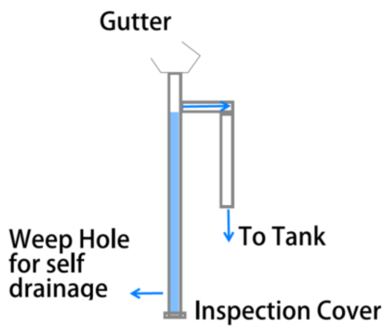


Figure 2: Rainwater Direction and First Flush Diverter Position

- Corrugated sheets or plastic can also be incorporated onto sections of rooftops to increase localised run-off where long sections of guttering are unable to be fixed to the structure.
- First flow diverters will be required to remove any of the additional vegetation and biological material picked up during capture. This will prolong the operational time of any additional filters used in the system.

Storage

Storage systems can vary in size and material significantly. Based on the sensitivity analysis, around 1,000 litres is required for each structure (assumed 35m2 of catchment area and a total of 77 structures).

Where structures are close together, common tanks of around 9,000 litres could be used. Where structures are too far apart, collapsible 1,000 litre tanks would provide a cost-effective storage option and can easily be transported to the island on the regular boats travelling between Wewak and Tarawai as the collapsed size is around 1m x 0.2m x 0.2m, 9 kilograms. The covers have built in cover protecting from leaves and mosquitos and the cover can be unzipped allowing for cleaning and access for buckets to transfer water as pump infrastructure is limited on the island. Multiple tanks be connected where additional storage is required.

Figure 3: Collapsible 1000L Tank

Materials and Investment

Material	Estimated Cost (PGK)
Collapsible water tank (1000 litres)	400.00
Connecting pipework	400.00
First flush diverter	200.00
Guttering	250.00

Table 1: Cost Summary for Capture and Storage per Household

Implementation and maintenance

Education

Primarily the main implementation would be through community education on optimising roof catchment through improved guttering design and roof modifications that community members could fabricate themselves. The education would also extend to optimal maintenance on cleaning guttering to ensure that piping is not blocked, preventing capture and contamination.

Tanks kits

Packaging of rainwater tank 'kits' that include a collapsible tank, first flush diverter and basic connections that could be distributed by local WASH practitioners for purchase by the community to provide easily implementable additional storage.

Future expansion

As capture is improved and there are resources available, storage tank size and volume can be increased to meet the growing population. Suitable tank types would be small to mid-size poly tanks or panel tanks as these are more suitable for transport to the island.

Limitations

The proposed tanks are restricted in size, and although durable, are still a soft material and may be susceptible to damage.

Capture from thatched roof tops can have issues with colour, taste and biological matter. This would require additional treatment as proposed in the following section.

Ultimately changing roofing materials to a corrugate sheet would increase capture efficiency up to 90%, which would allow for households to capture a surplus, increase daily water usage dramatically and allow for much larger storage tanks to be used.

OUR SOLUTION - IMPROVED WATER QUALITY

At source treatment through filtration

Activated bio-sand filter

An activated bio-sand (ABS) filtration system has been widely adopted as a form of water filtration to improve water quality by removing sediments. It incorporates the use of a biomass layer, known as the 'Schmutzdecke' or 'dirty layer', which eliminates harmful microorganisms in contaminated water. The system consists of different sizes of stones and pebbles, crushed coral (optional), coarse sand, fine sand, and activated charcoal arranged in layers inside a plastic container. When contaminated water is added to the filter, a top layer of fully developed biomass consumes the contaminants. As water is filtered down through the sand, any remaining microorganisms are trapped and eventually die off.

The system can be adapted to connect to roof downpipes to provide an integrated system. It has removable sealed lids so can be filled from other sources during the dry season, such as bore water that the WASH program is investigating, or local hand dug wells.

We have proposed a 2-stage filtration process to treat the water.

Stage 1 This stage involves a gravel and coarse gravel filtration system designed to remove larger sediments. This initial filtration step helps prevent blockages in the stage 2 ABS filter by capturing larger particles.

Stage 2 The ABS filter provides the main filtration through sand, enhanced by a biofilm that is crucial for breaking down organic matter and contaminates. The filtered water can then be stored in a storage tank for later use.

It is advised the system is placed in an area under shelter and in shade to prevent any disturbance and prolonged exposure to UV rays can degrade the materials of the filter and plastic parts within the system. Additionally, excessive heat can affect the biofilms efficiency in breaking down the contaminates.

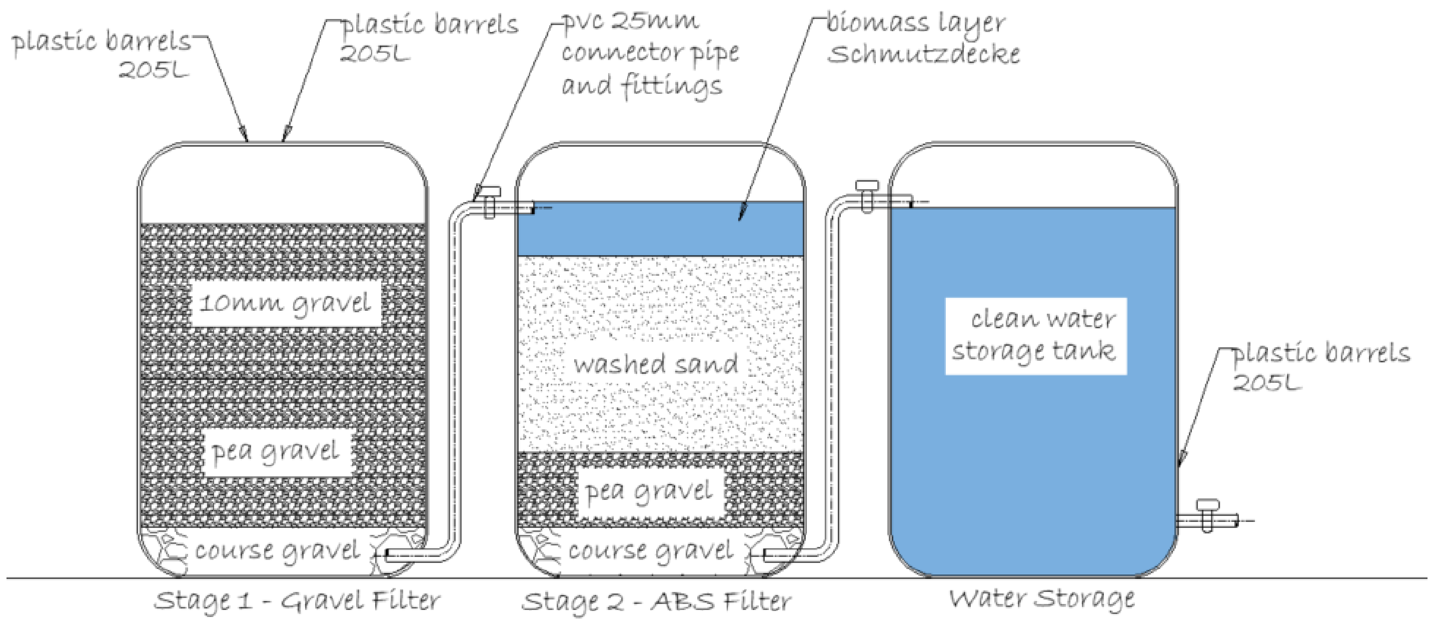


Figure: 4Filtration Process of ABS Filter System

What contaminates and pathogens can be treated?

An ABS system can help in reducing a few contaminates from the water source such as:

- **Pathogens:** The system is effective in removing pathogens such as bacteria, viruses and protozoa
- **Suspended solids:** it can remove suspended solids which are microns found in water
- **Heavy metals:** the system has been shown to remove up to 50% of heavy metals
- **Turbidity:** it can remove up to 99% of turbidity which will provide clear water

Materials and investment required

Due to the remote location of Tarawai Island, it is proposed to use lightweight materials such as plastic water containers and pipework that the residents will be familiar with and can be sourced from Wewak hardware stores. The sand and gravel materials can also be sourced from the island and manually filtered to meet the grading requirements of the various layers.

Material	Cost Prices
Polyethylene Tanks	80
Poly Pipe 25mm	8 - 20 PGK for 3m
Sand	120 PGK /m3
Gravel	105 PGK /m3
Carbon (optional)	Free

Table 2: Material Unit Rate for ABS Filter System

Estimated cost of materials for 1 unit is approx. 120 PGK

(excluding transit and logistic cost)

Implementation and maintenance

The system will be able to treat approximately 200 litres per day which will be more than sufficient for cooking and drinking. Based on the current population of 170 people and 77 households. Approximately 8 to 10 systems could be set up across the community as a shared facility to service multiple households. It is estimated that 100 litres per day could be used with a reserve of 100 litres to be stored for a backup supply within the 200 litre barrel.

The system will need to be cleaned once every 6 months to keep the system running correctly. The typical maintenance would involve:

Clogging: the sand filter can become clogged over time with sediments and debris. The top layer of the sand can be taken out.

Biolayer disruption: the Schmutzdecke layer is crucial for the effective treatment and elimination of some bacteria and pathogens. Regular gentle cleaning helps maintain this layer.

Sand compaction: if the sand compaction becomes too compact it may reduce the effective flow rate. This can be maintained by stirring the sand or replacing it.

Outlet blockage: the outlet pipes may become blocked with debris or biofilm, this can be easily cleaned with a pipe cleaner.

The maintenance of this system is relatively straight forward and should be able to be completed by a nominated community member that has basic plumbing skills.

Limitations

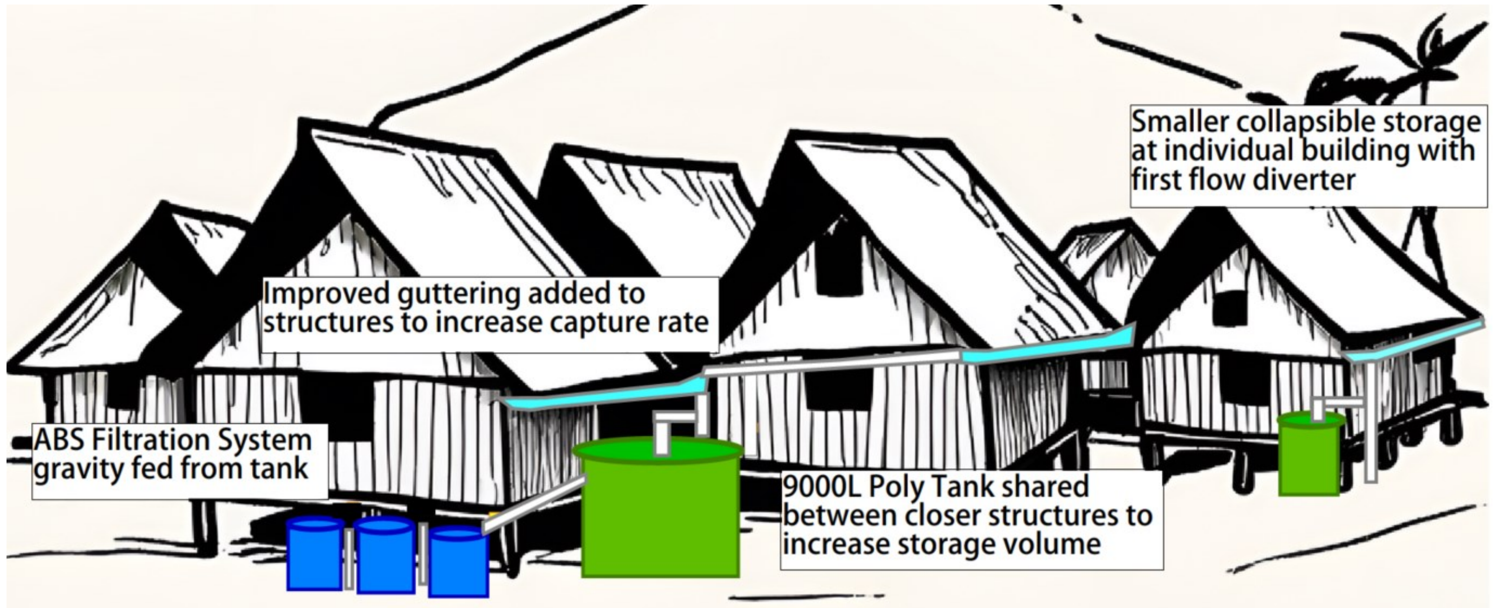
The system will require on-going maintenance and training for residents to enable the system to work effectively. This system can also be accompanied with boiling of the treated water for additional purification.

Alternate available proprietary systems

- Life saver bottle - Our Journey - LifeSaver (iconlifesaver.com) (expensive - could be used in emergencies)
- The safe water sticker - https://thewatergift.org/ (approx. $50/year per family)
- CAWST - centre for affordable water and sanitation technology. Biosand Filter Material - Design, Construction, Installation, Operation and Maintenance - https://sswm.info
- SkyhydrantMAX - 1000 litre / hour UF Membrane https://www.disasteraidaustralia.org.au/our-aid/skyhydrant/amp/

OUR SOLUTION - INTEGRATED SYSTEM SUMMARY

Integrated water system



The proposed integrated system involves installing improved guttering on each structure. An interconnected first flush diverter will enhance the quality of collected rainwater before storage. 1000 litre tank kits will be provided for each structure to provide a storage buffer for dry months.

For households which have better catchment of rainwater through either better-quality roof materials or larger surface area, larger storage of a 9000 litre tank or similar will provide additional volume of storage for dry periods.

The ABS filter system will be service approximately 8 households for drinking and cooking water supply. These filters can be interconnected to the larger tanks to provide gravity fed water to the filtration. The filter system will need to be installed lower than the tank to facilitate this. Where the filters cannot be directly connected to the tank, they can also be manually filled by bucket.

It is recommended that Tarawai further upgrade this system with a shelter to provide UV or/and weather protection for longer user life.

Benefits

Easy solution using natural resources (rainfall harvesting)

From brainstorming to finalising the solution, the BMD Squeaky Clean Team has focused on creating a sustainable and low-maintenance solution for the locals. Calculations from the study (refer to Figure 2 and 3) show that by enhancing and increasing the rainwater capture system, we can secure a reliable water source for filtration. The ABS filtering system will then ensure basic water treatment for drinking purposes.

Integrated with future projects

The BMD Squeaky Clean Team believes that the proposed integrated water system will address the fundamental challenge of providing clean water. To further improve the living quality of Tarawai Island residents and ensure a consistent water supply, WaterAid could consider implementing 'bores' as suggested in the potential technologies section, instead of relying on hand-dug wells.

Climate resilience

Based on the analysis of rainfall patterns throughout the year, covering both wet and dry seasons, the suggested additional storage will be sufficient to provide water resilience through the year.

Total investment

Estimated total investment is calculated based on assumption of every (77) household to have at least one (1) set of rainwater catchment / storage and 8 to 10 ABS filter systems to serve whole community.

Description	Unit Rate (PGK)	QTY	Sub-Total (PGK)
Rain catching and primary filter system	PGK 1,250.00	77	PGK 96,250.00
Activated biosand (ABS) filter system	PGK 120.00	10	PGK 1,200.00
Additional 9,000 litre tank	PGK 6,000.00	2	PGK 12,000.00
Transportation and labour	PGK 18,000.00	1	PGK 18,000.00
			PGK 127,450.00

Note: transportation and labour cost are assumption. May vary based on local resourcing.

PGK 127,450 is approximately equivalent to AUD $48,000 to improve the basic daily drinking water quality of Tarawai Island community without considering the future projects. This high-level proposal is worth considered by WaterAid given that target fundraising for 2024 is AUD $120,000.

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Watermate 1000L Collapsible Rainwater Tank - Pestrol Australia

Muncie & East IN's Best Gutter Guard | Clemens Home Solutions

First Flush Water Diverters - Rain Harvesting Water Diverters - Tank Shop

https://sswm.info Home | SSWM - Find tools for sustainable sanitation and water management!

The Water Gift - Giving the gift of safe drinking water

SamSamWater - Rainwater Harvesting Tool

Roofwater Harvesting - a Handbook for Practitioner - TH THomas and DB Martinson.pdf (samsamwater.com)

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