

Review of water safety planning processes and options for improved climate resilient infrastructure in Vanuatu

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ABSTRACT

Vanuatu is a small island state ranked the most at-risk for natural hazards globally. Access to safe and secure water is limited, particularly for poor and rural residents. It is projected that climate change will increase temperatures, sea level, cyclone intensity, and extreme rainfall events in Vanuatu. As the impacts of climate change become clearer, it is becoming easier to predict the consequences of those changes on water infrastructure. The Government of Vanuatu, Department of Water Resources (DoWR) wants to support communities to enhance the resilience of community water supply infrastructure, despite the additional challenge of climate change. Since 2013, DoWR has adapted Water Safety Plans to the local context with Drinking Water Safety and Security Plans (DWSSPs). An analysis of actions taken after 199 DWSSPs, site visits and interviews, revealed an opportunity to integrate climate change more into existing community risk planning processes. The analysis also identified many potential problems with existing water infrastructure that increase their exposure to climate risks as well as possible improvements to decrease those risks. As a result, adjustments were made to the current water safety planning approach, so that communities review hazards associated with climate change and identify resilient infrastructure improvements.

Key words: climate change, Pacific Islands, Small Island States, water safety planning

HIGHLIGHTS

- As the impacts of climate change become clearer, it is easier to predict the consequences of those changes on water infrastructure.
- In Vanuatu, water safety plans are an appropriate tool for communities to assess climate risk and identify appropriate infrastructure improvements.
- Minor adjustments can be made to current government approaches to limit damage to water infrastructure during extreme climate events.

INTRODUCTION

Vanuatu is a small island developing nation in the Pacific, which is ranked the most at-risk for natural hazards globally (Garschagen *et al.* 2016). Vanuatu is exposed to many natural hazards: tropical cyclones, flooding, El Niño-induced drought, volcanic eruptions, earthquakes and tsunamis. As a consequence, natural hazards cost Vanuatu's economy tens of millions of dollars a year (PCRAFI 2001). In addition to recovering from disasters, communities are increasingly forced to cope with and adapt to the impacts of climate change. It is predicted, Vanuatu will experience less frequent but more intense tropical cyclones, receive more frequent extreme rainfall events, increased temperatures, and sea level rise (PACCSAPP 2014).

In 2015, the Government of Vanuatu met the Millennium Development Goal target to halve the percentage of people without access to an improved drinking water source. The Vanuatu Government is now aiming to achieve universal access to safe water and sanitation in line with the Sustainable Development Goals (SDG) targets by 2030. However, simply keeping up with the annual population growth rate of 2.3% (VNSO 2017) and maintaining aging infrastructure in the disaster prone country will take considerable effort. Access to safely managed water is limited in Vanuatu due to island geography and rainwater dependence, especially among poor and

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rural residents. The UNICEF/World Health Organization (WHO) Joint Monitoring Programme (JMP) results indicate that 91% of households in Vanuatu had access to at least a 'basic' water supply in 2017 (UNICEF/WHO 2017). However, the definition of 'basic' does not actually include a measure of how much water is available or the equity with which the quantity is distributed (UNICEF/WHO 2019). In addition, the JMP reports that only 44% of the population has access to a safely managed drinking water service. This service is predominately provided by a private utility that pipes chlorinated water to residents in the urban capital. The utility reports the service is provided to approximately 50,000 (18% of the population) and is regulated by the Utilities Regulatory Authority. Unfortunately, 8% of the rural and 1% of the urban population are still dependent on surface water. The JMP also reports that only 34% of *ni-Vanuatu* households have access to basic sanitation with the majority using unimproved or limited sanitation service, less than 1% of individuals defecating in the open, and just 25% of *ni-Vanuatu* households have a basic handwashing facility at home. The poor water, sanitation, and hygiene (WASH) situation is impacting children. Global evidence shows that poor child health indicators such as diarrhea and stunting are a result of many factors, including poor water, sanitation, and handwashing (Checkly *et al.* 2008). The 2013 Demographic Health Survey (DHS) found that 29% of *ni-Vanuatu* children under the age of five years are stunted and that 12 percent of children under the age of 5 years had diarrhea within the two weeks prior to the survey (VNSO 2014).

To address the water and sanitation concerns, the Government of Vanuatu has adapted the SDGs to the local context. They have created the National Sustainable Development Plan, also called the, 'People's Plan' (Vanuatu 2016). The national targets include: 'ensuring all people have reliable access to safe drinking water and sanitation infrastructure' and protecting 'watersheds, catchments and freshwater resources, including community water sources'. To achieve the People's Plan targets for water, the Government of Vanuatu created a National Water Policy for 2017 to 2030 (DoWR 2017). The policy outlines how Vanuatu will secure a safe and sufficient, accessible, affordable, reliable, and sustainable source of water for all by 2030. Along with the policy, the Government of Vanuatu created a corresponding National Water Strategy (DoWR 2018c) to strengthen and implement key priority areas. One of the priority areas in the strategy is, 'water safety and security'. The National Implementation Plan for Safe and Secure Water (NIP) lays out how the national government will achieve safe and secure water in rural areas (DoWR 2018c). The NIP supports communities to identify risks and create 'Drinking Water Safety and Security Plans (DWSSPs)'. The NIP also sets a target for all 2,000 *ni-Vanuatu* communities to develop a DWSSP for their water supply systems by 2030. After communities and schools have created a DWSSP, they should complete no/low-cost improvements that they identified during the planning process on their own. Meanwhile, DoWR staff read the DWSSPs and rank those communities with the greatest residual needs according to risk. Those communities with the greatest need of safe and secure water improvements are then prioritized for financial support by Provincial authorities through a Capital Assistance Program (CAP). A document finalizing the CAP (DoWR 2018b) was approved by the National Water Advisory Council in 2018. As part of this process, sometimes government or civil society partners follow-up with communities after the DWSSP to assess their progress.

The objective of the research discussed in this article was to review existing government processes and determine how climate risks can be integrated into the DWSSP and current infrastructure improvements efforts. This research in Vanuatu supports the country to achieve WASH targets in the country set out in the 'People's Plan'. It also contributes to global efforts to reach WASH SDGs despite the additional pressures of population growth, climate change and disasters.

METHODS

To determine how DoWR can enhance the resilience of community water supply infrastructure in Vanuatu, a thorough understanding of key areas is needed: 1) current efforts to improve water supply infrastructure in rural areas, and 2) the potential failure points in water supply infrastructure as a result of climate impacts in Vanuatu in the future.

Initially to better understand current government water service delivery efforts a desktop review of government policies was conducted and a dataset compiled. The dataset included DWSSPs and complementing actions facilitated by DoWR, NGOs, Ministry of Health (MoH) and contractors from 2013 until the end of 2019. To compile an initial list, DoWR identified all partners and government officers who had conducted drinking water safety plans or DWSSPs and collected all previous reports. In some cases, this took multiple follow-up visits. After

all documents were received and a final list created of DWSSPs, the DWSSP process, follow-up and actions taken reported to date by DoWR staff were compiled and reviewed. The dataset was expanded to include risk ranking, no/low-cost actions by communities and follow-up visits by DoWR. The data was compiled using a shared online Google spreadsheet so DoWR staff could contribute data. However, most of the data collection also required one on one interviews with DoWR Provincial staff to determine the status of each community that had already conducted a DWSSP. Analysis of the compiled dataset was accomplished using Microsoft Excel and focused on risk rankings completed and relevant physical infrastructure improvements that communities identified in their plans. This dataset and analysis did not review village water committee management, maintenance, or finances. The dataset was then turned into an information management system, views of which can be seen on the Ministry of Lands website.

To understand potential infrastructure failure points and climate change impacts, a desktop review of existing research was conducted, current infrastructure status was observed and assessed through site visits. Additionally, lessons learned through previous experience were reviewed through interviews and as part of group discussions organized by the authors. Over 50 communities, on at least 15 islands, covering all of Vanuatu's provinces, were visited by just one of the authors. The lifetime experience of the other authors which contributed to the infrastructure review of this paper is difficult to quantify, but likely almost includes all 65 inhabited islands in the country. Multiple interviews were conducted with each of the DoWR Supervisors for the six provinces. In addition, DoWR Provincial Community Development Officers, MoH Environmental Health officers, DoWR urban staff who have assisted with rural water infrastructure, Engineers without Borders volunteers in country, NGO staff who have conducted DWSSPs, and DoWR contractors were consulted.

RESULTS AND DISCUSSION

The results from the desktop review, site visits, interviews and group discussions are shared below and discussed. This section reviews water safety plans and processes as they are in Vanuatu, moves to discuss climate change, and concludes with changes made to the processes to adapt for climate change.

Water safety planning

The DWSSPs approach is a local adaptation of Water Safety Planning (WSP) introduced in the 3rd edition of the World Health Organization (WHO) Guidelines on Drinking-water Quality. As per the WHO Water Safety online Portal (WHO/IWA 2019), WSP is a risk assessment and management approach that aims to, 'consistently ensure the safety and acceptability of a drinking-water supply'. WSP generally includes six tasks for small water supplies: (i) Engage community and assemble a team (ii) Describe the water supply (iii) Identify and assess hazards (iv) Develop and implement an improvement plan (v) Monitor control measures and (vi) Document, Review and Improve all aspects of Water Safety Planning (WHO 2012). The Water Safety Planning process is not perfect and has not always yielded the desired outcomes (String *et al.* 2017; Kumpel *et al.* 2018). In Vanuatu, the WSP process has been reviewed, improved and adapted to the local context. In Vanuatu, the steps now include: (i) establish the team; (ii) describe the water and waste systems; (iii) assess risk of current system; (iv) create an improvement plan; (v) operate, monitor and maintain the system; and (vi) conduct committee actions. During a period of prolonged El Niño drought in 2015, the Vanuatu government added an additional 'S' to look beyond the safety (quality of the water), to also look at the security (quantity of water available). The amount of water from available sources, including estimated rainfall and yield from tap-stands was tallied, and divided by the total population to determine if additional water sources should be developed to ensure an adequate amount of water was available to the community. Sanitation surveys were also added as it became clear that a lack of toilets could be a risk point in many communities. The sanitation surveys investigated household infrastructure type and status, identifying number of facilities that need to be replaced or upgraded. Thus, each of the DWSSPs include planned actions to improve and upgrade the water and sanitation infrastructure, management, operation and maintenance for individual communities.

Summary of DWSSPs completed

By the end of 2019, 199 water safety plans or DWSSPs were compiled from a variety of sources. The DWSSPs were conducted between 2013 and end of 2019, with the majority being conducted by DoWR contractors or staff, CARE and Oxfam. (Those reports written prior to 2015 were standards water safety plans, before the DWSSP format was created). The villages that participated in the DWSSPs were selected by the organizations facilitating

them. In many cases, the DWSSP process formed an integral part of the response and recovery phase following Tropical Cyclone Pam. As such the locations of DWSSP villages are more often in Cyclone Pam affected areas and are not representative of the country and data could not be extrapolated to draw country-wide conclusions. For the first three years when water safety plans were introduced, only a few were completed each year by government. However, in 2016, 2017 and 2018 the number of DWSSPs increased to more than 40 per year. In 2019, will funding from the New Zealand Ministry of Foreign Affairs and Trade, ten DWSSPs per province were contracted by DoWR and eventually completed. However, not all had been finalized and approved as of January 2020 when this analysis was conducted. As a result, only completed Water Safety Plans or DWSSPs were reviewed during this research. (See [Table 1](#)).

Table 1 | Water safety plans and DWSSPs completed by year in Vanuatu included in this review

Year	Water Safety Plans/DWSSPs
2013	1
2014	5
2015	5
2016	44
2017	83
2018	42
2019	19
Total	199

NIP/CAP review

A review of those DWSSPs received in 2019 or before showed that 82% (163/199) of DWSSPs have been risk ranked by provincial or national DoWR staff or interns. While the responsibility to respond to DWSSPs is on communities, a DoWR staff member, an NGO partner, or area council member had revisited the community after the DWSSP and followed-up on at least 33% (65/199) of DWSSPs in the last year. DoWR might not be aware of all follow-up actions taken since some DWSSPs were followed up on and construction completed by NGOs. However, DoWR staff report that at least 22% (43/199) of communities have completed no/low-cost improvements following the DWSSP. There is not enough evidence to say whether DoWR follow-ups improved community implementation of no/low-cost activities. One DWSSP facilitator reported that she felt additional funding brought via the CAP might help motivate communities to implement their no/low-cost improvements more than follow-up visits.

A smaller analysis was conducted of only those DWSSPs contracted out to NGOs and the private sector by DoWR in 2018, some of which were completed in 2019. That analysis showed that DoWR returned and followed up on 44% (21/48) of DWSSPs and 21% (10/48) of those DWSSPs resulted in communities making no/low-cost improvements on their own within a nine-month period of DWSSP completion. Of the 48 DWSSPs, DoWR staff had created designs and calculated cost estimates for 23% (11/48) and DoWR had procured materials or started construction on 8% (4/48) within 9 months of DWSSP completion. From the data analysis it was revealed that not all communities are motivated by the DWSSP process to implement designed solutions and that DoWR staff have not been able to follow-up on all DWSSPs. However, work continues, and it is expected that within 18 months of DWSSP completion, follow-up visits will have occurred in all communities.

This finding shows some improvements compared to research that was conducted on just DWSSPs before the NIP/CAP processes were created. The research conducted in 2016 of 10 DWSSPs found that while the community was engaged, community water systems were described, and hazards were identified, improvement plans were not actually implemented, monitored, or reviewed ([String et al. 2020](#)). This current analysis found that some DWSSPs were implemented: communities conducted some no/low cost improvement plans and government helped communities upgrade systems. In addition, DoWR staff and partners monitored by following-up on DWSSPs and construction activities. Given DoWRs widespread use of and continual improvement of DWSSPs processes in community water planning, this research determined it would be appropriate and worthwhile to integrate climate resilience into DWSSPs.

Potential impacts of climate change

While the 199 DWSSPs conducted pre 2020 did look at water security risks, they did not look at risks related to climate change. Vanuatu is better off than some of their Pacific neighbors, however, future projections of the impacts of climate change under various emission scenarios predict that:

- Tropical cyclones will be less frequent, but more intense
- Extreme rainfall events will occur more often
- Overall temperatures and extreme elevated temperatures will increase
- Sea levels may rise 3–17 cm by 2030^{3,4} (VMGD 2011; PACCSAPP 2014)

At least one study also shows that the El Nino cycle will also become more variable, increasing drought (McPhaden *et al.* 2020). The leeward side of many of the islands already suffers from drought. A water resources inventory conducted by DoWR across 44 islands between 2014 and 2016 found that already more than half of all rainwater tanks and 16% of spring-sources piped schemes fail to provide a year-round supply of water (Foster *et al.* 2018).

The observations and interviews conducted with this research revealed that climate induced cyclones, extreme rainfall events, increased temperatures and sea level rise is already affecting water infrastructure. Tropical cyclones often bring flying debris that can cause destruction of water supply infrastructure such as tanks, tap stands and pipelines. This was especially evident during the Category 5 tropical cyclone, Pam. However, it was reported that even smaller cyclones and tropical depressions have severely damaged water infrastructure. Extreme rainfall brings flooding and landslides, altering spring source locations, breaking pipelines and contaminating unprotected springs and wells. While not yet measured in Vanuatu some individuals interviewed thought that increased temperatures may cause faster evaporation of open water rainwater collection tanks. Coastal communities report that shallow wells close to shore are becoming more saline. This could be caused by rising sea levels which may ultimately cause some populations to relocate further inland. Table 4 outlines some climate change impacts noted during the literature review and the expected impacts on water infrastructure based on observations, interviews and research by others.

A qualitative analysis of the DWSSPs reports and site visits identified many potential problems with existing water infrastructure that increase their exposure to climate risks. As shown via photographs in the supplementary material, situations exist where pipes are hung over rivers and roads with only bamboo sticks to support them; water sources are unprotected or have incorrectly built spring boxes that turn spring water into surface water before being fed into pipelines; hand-dug shallow wells are at risk of contamination due to a lack raised well rings; covers and deep well aprons are cracked; water tanks are not tied down or protected from movement during large winds; rainwater harvesting roofs, gutters and fascia board are weakly connected; air release valves, clean out valves and tap-stands are unprotected; pipes are unburied; and tanks are placed in precarious locations.

Potential water supply improvements to address climate change

The review of DWSSPs, site visits, and interviews has shown us that in many ways, communities in Vanuatu are already resilient. First, communities draw on multiple improved and unimproved sources used for different potable and non-potable needs (Foster *et al.* 2018). The authors observed many communities that have a gravity fed water system who still collect rainwater for drinking, and/or use surface water for bathing. For example, when the entire island of Ambae evacuated following 2017 volcano eruptions to Maewo island and Santo locations with enough piped ground water fed water supply systems, some communities still collected additional rainwater for drinking. Second, many communities were observed anticipating shortages and rationing water. In December 2019, community members and village leaders on the island of Sola in Torba province reported locking water taps for distribution at appointed times only (See Figure 1).

While communities, across Vanuatu already have implemented some resilient water strategies, more could be done to adapt water infrastructure to reduce disruption and contamination of water supplies for a number of climate threats. For example, to prepare for cyclones of increased intensity, communities can build concrete covers to protect spring sources. Hand-dug wells can be protected from cyclones with sealed aprons and solid covers and tanks protected from cyclone debris and wind with covers and tie downs. Rainwater harvesting roofs, gutters and fascia board connections can be improved for cyclone resistance. Road and river pipe crossings can be strengthened, and housing around air release valves can be built to reduce cyclone damage, and bare pipe standpipes built



Figure 1 | Water locks to ration water during drought on Mota Island in Torba Province.

to government standard with cement and PVC coating. To prepare for the threat of high rainfall, flooding and landslides, communities can repair broken deep well covers, install closed rainwater harvesting tanks to replace rain water collect holes, bury pipelines to reduce flood and cyclone falling tree damage, and relocate rainwater tanks at risk of landslides from flooding. To reduce disruption of water supply and contamination because of rising sea levels and drought, communities can dig hand dug wells further inland to reduce salinity and develop new water sources. (See Supplementary material for photographs of possible improvements).

Integration of climate change in DWSSP

A literature review shows that Water Safety Plans (WSP) play a role as a resilience tool in climate change adaptation in many other countries already (GWP 2014; MWIE 2015; MWSS 2017; WHO 2017; UNICEF 2018). Through this review, DoWR has decided to support communities to cope with current risk and/or adapt to climate change by including resilience as part of the the DWSSPs. Communities now review the climate change risks and plan resilient water infrastructure improvements to directly address climate threats. For example, given the expected increase in cyclone intensity, a specific section on cyclones has been added to the DWSSP. Also, more specific water supply infrastructure upgrade ideas for communities to review were added into the various ‘improvements’ boxes throughout the document. These possible improvements have check boxes next to them in the standards DWSSP format to make it easier for specific upgrades to be included in the final plan (See Figure 2). Additional improvements added throughout the document to reduce the impact of climate change include ideas such as: repairing broken covers, burying pipelines, relocating tanks at risk of landslide, and protecting watersheds.

Cyclone Risk and Preparedness			
Risk Factors	Mitigation Measures	Risk	Improvements
High winds <input type="checkbox"/>	High storage capacity <input type="checkbox"/>	High <input type="checkbox"/> (Action Needed Now) Medium <input type="checkbox"/> (Upgrades Needed) Low <input type="checkbox"/> (No Action Required)	Cover Water Sources <input type="checkbox"/>
Damage to intake, pipes, tanks <input type="checkbox"/>	Multiple water sources <input type="checkbox"/>		Tie Down storage tanks and rainwater collection roofs and gutters <input type="checkbox"/>
Other (Please list)	Good spring or well-head protection <input type="checkbox"/>		Strengthen road/river pipe crossing <input type="checkbox"/>
	Water resource management (WRM) undertaken <input type="checkbox"/>		Construct housing around valves <input type="checkbox"/>
	Other (Please list)		Reinforce pipe stands <input type="checkbox"/>
			Other (Please list) <input type="checkbox"/>

Figure 2 | New section on cyclone risk and preparedness in DWSSP Participants Guide.

The facilitators guide has also been updated to include additional references to climate change throughout it. For example, a section outlining future predictions of climate change, and the impacts climate change can have on water is now included in Step 3 on risk assessment (See Figure 3). DWSSPs facilitators reported in interviews that the new climate change sections were easy to discuss with communities because the edits were embedded throughout the documents, in the existing format. In fact, facilitators mentioned that community members often bring up climate change themselves during the process. One DWSSP facilitator reported, ‘Communities are noticing changes to their water source already. If you go to any community and talk to the older people, they mention the water is changing and ask why.’ Another DWSSP facilitator, noted that communities now include, ‘how to manage water in dry season and floods in their discussions’ so he incorporates those ideas in the improvement plans.

- *Weaknesses that come from climate change*

Including: Future predictions of the impacts of climate change show that in Vanuatu 1) Tropical cyclones will be less frequent, but more intense 2) Extreme rain events will occur more often 3) Overall temperatures and extreme elevated temperatures will increase 4) Sea levels may rise 3-17 cm by 2030 5) Ocean acidification will continue, causing damage to coral reefs and vital ecosystems. Climate related cyclones, floods and sea level rise has negatively impacted drinking water systems in Vanuatu. It is anticipated intense winds, flood waters, and landslides from climate change will result in additional bacterial contamination, seawater intrusion and physical damage.

Figure 3 | New section on climate change risks in DWSSP Facilitators Guide.

Table 2 | Status of all DWSSPs compiled before January 2020

Description	Number	Total	Percentage
Community DWSSPs Risk Ranked by DoWR	163	199	82%
Community DWSSPs Follow-Ups conducted by DoWR in the previous year	65	199	33%
Communities that completed no/low cost improvements outlined in their DWSSP	43	199	22%

Table 3 | Status of DWSSPs contracted out to NGOs and the private sector in 2018

Description	Number	Total	Percentage
Community DWSSPs Follow-Ups conducted by DoWR within nine-months	21	48	44%
Communities that completed no/low cost improvements outlined in their DWSSP	10	48	21%
DoWR created design and calculated cost estimates	11	48	23%
DoWR procured materials and started construction	4	48	8%

CONCLUSION

In Vanuatu, most of the rural population has access to an improved water source. This desktop review, analysis of current DWSSPs, site visits and discussions, reveal a range of service delivery challenges, fragile infrastructure, and some potential threats from climate change. These threats could impede the Government of Vanuatu’s progress towards reaching the SDGs and related Vanuatu National Sustainable Development Plan objectives to ‘ensure all people have reliable access to safe drinking water and sanitation infrastructure’. However, now that the impacts of climate change in Vanuatu have been identified, the effect of climate change on water infrastructure can also be predicted and the consequences mitigated.

Previously, DoWR had adapted the water safety planning approach to include considerations of water security, some natural hazards and sanitation. Since DWSSPs are used as a community water planning tool, mainstreamed throughout existing legislation, and serving as a prerequisite for infrastructure funding, it was determined to be an

Table 4 | Possible climate change impacts on water infrastructure

Expected Climate Changes	Possible Impacts on Water Infrastructure
Tropical cyclones will be less frequent, but more intense	<ul style="list-style-type: none"> High winds during cyclones could blow items into uncovered water storage devices, overturn empty poly tanks, pull off rainwater collection roofs/gutters, and move trees on pipes crossing roads/ivers and exposed fittings
Extreme rainfall events will occur more often	<ul style="list-style-type: none"> Flood water from extreme rainfall events could contaminate groundwater wells. Heavy rain could cause landslides could move unburied pipes and poorly positioned tanks
Overall temperatures and extreme elevated temperatures will increase	<ul style="list-style-type: none"> Increased temperature could cause the evaporation of more water Water related diseases geographical range could increase (Kurane 2010) as a result of increased temperatures Stronger El Nino variability from increased temperatures could increase drought (McPhaden <i>et al.</i> 2020)
Sea levels may rise 3–17 cm by 2030	<ul style="list-style-type: none"> Near shore wells could become contaminated with sea water Communities displaced by higher sea levels could need new water infrastructure

appropriate tool for communities to assess climate risk and identify climate resilient infrastructure improvements. This research found that with minor adjustments of the current approach, DoWR could improve how communities prepare and cope with increased exposure to extreme climate events. As a result of this research and recommendations from academics (Kohlitz 2018), and UNICEF (UNICEF 2020), DoWR has further adapted water safety planning, to not just achieve the SDGs but also address climate change risks. As a direct outcome, the NIP/CAP now includes community analysis of climate related risks and activities to address those risks. While Vanuatu has limited resources and has set ambitious targets, by integrating climate elements into the DWSSP, DoWR now has a plan to support communities to enhance the resilience of community's water supply infrastructure. As the impacts of climate change on water infrastructure become even more apparent over time, the DWSSP format should be reviewed again to ensure that the work described here is indeed improving community water system resilience.

Globally, as the impacts of climate change becomes clearer, it will be easier to predict the consequences of those changes on water infrastructure. As shown in the supplementary material, potential climate hazards can already be identified now. To improve sustainability, more climate resilient infrastructure can be built, and existing infrastructure can be upgraded. For Vanuatu, including climate resilience as part of the existing risk analysis under a comprehensive drinking water safety and security approach leveraged existing legislation to ensure communities are looking beyond routine development to address climate change risks. Other countries may find similar simple ways to improve climate resilience by integrating climate into existing community water planning activities.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories.

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