

The Pressing Need for Resilient, Equitable, Safe, and Sustainable Decentralized Wastewater Solutions for the Pacific Islands

Nora Nelson, Robert Bair, Stuart Coleman, Christina Comfort, Stephen Gasteyer, Joyce Huang, Chris McKay, Allan Smith, Zhiyue Wang, Tao Yan, Paul Young, and Daniel Yeh. The authors are part of a National Science Foundation Convergence Accelerator team addressing equitable water solutions. Corresponding author Daniel Yeh (dhyeh@usf.edu), University of South Florida.

Islands are unique environments with a number of resource constraints. Island water resources are vulnerable to myriad threats, including freshwater depletion due to groundwater pumping and aquifer contamination primarily as a result of saltwater intrusion (UNESCO-IHP and UNEP 2016; Spellman et al. 2021). The World Health Organization (WHO) estimates that only 31% of the population in the Pacific Islands has access to adequate sanitation (WHO 2015). The UNICEF/WHO Joint Monitoring Program on Water and Sanitation identifies numerous threats and climate risks to equitable, sustainable, and resilient water, sanitation, and hygiene (WASH) systems in the Pacific Islands. The high degree of climate exposure and vulnerability in the Pacific region, coupled with the inherently fragile nature of island freshwater resources, exposes communities and systems to numerous risks and shocks, including deterioration of the quality and quantity of freshwater resources in a warming climate, landslides, floods, droughts, typhoons, and hurricanes. These phenomena act as drivers of freshwater pollution, erosion, and saltwater intrusion (UNICEF and WHO 2015; UNICEF Pacific 2018). Pacific Islands may also face unique geologic events related to volcanoes and earthquake-induced tsunamis.

Wastewater management on islands is particularly challenging. Centralized wastewater systems (with sewer collection networks) have high initial (CapEx) and recurring (OpEx) costs, necessitate a high customer density and proximity, and are vulnerable to common sewer infiltration/inflow, a problem exacerbated by high coastal water tables and sea level rise (Fleming et al. 2019). High energy and chemical costs on islands also bring into question the feasibility and sustainability of conventional activated sludge treatment processes. For these reasons, and due to the geology and geography of islands, onsite wastewater management is prevalent on islands. Ordinarily, onsite systems are based on septic tanks, which involve a holding tank and a drainfield. To function correctly, the drainfield itself has unique requirements in terms of size, soil drainage, and unsaturated subsurface conditions. These three conditions are often not met on Pacific Islands due to small property lot sizes, overly-porous soil (such as volcanic rock), and high water table, respectively. All the above limitations on centralized and onsite systems, coupled with a historical underfunding of infrastructure especially in rural or low-income areas, have left many Pacific Islands in a general state where cesspools (a subsurface porous holding tank of excrements) are the norm for onsite

wastewater management (Mahler et al. 2008).

As an example, the islands of Hawai'i alone have over 83,000 cesspools (Department of Health 2022). Unfortunately, cesspools do not provide wastewater treatment and represent a silent, diffused, and persistent source of hazard to human and ecological health. Nutrients (nitrogen and phosphorus) and pathogens contaminate aquifers and coastal environments, including beaches and coral reefs. In short, the prevailing onsite wastewater infrastructure on most islands is grossly inadequate and poses a threat to island water supplies, damages fragile marine ecosystems, and often disproportionately affects disadvantaged communities. The State of Hawai'i mandated that all cesspools must be converted by 2050 (Act 125, 2017), opening up significant opportunities for innovations in wastewater management technology and funding.

Cesspool conversion in Hawai'i presents a number of cross-cutting opportunities to make a positive impact for communities, climate, and the environment, and Hawai'i has many strengths that contribute to the enabling environment required to engage in such widespread conversion. Hawai'i established a Cesspool Conversion Working Group (CCWG) to holistically investigate the feasibility of total conversion by 2050; the CCWG developed three priority levels that will support progressive scaling up of conversions over the period from 2030-2050 as part of Hawai'i Senate Bill 427 (2024, carried over from 2023). SB 427 also establishes an income tax credit for cesspool upgrades and outlines how cesspool

upgrades could be mandated as part of property transfers.

Hawai'i's tourism-based economy and the nation's highest average property values also provide opportunities to leverage tax revenue for funding of cesspool conversions. Additionally, there are technical assistance resources through programs such as the Rural Community Assistance Cooperation (RCAC), and the Hawai'i Rural Water Association (HRWA). The U.S. Environmental Protection Agency (USEPA) also just launched a new wastewater technical assistance program titled Closing America's Wastewater Access Gap Community Initiative, which plans to assist up to 150 communities in the coming years. Hawai'i's Department of Health (DOH) is also rolling out homeowner assistance programs such as the Cesspool Pilot Grant Program, which provides a \$20,000 cesspool conversion reimbursement credit for homeowners with a household income at or below 140% of the area median income and have cesspools in priority level 1 or 2 areas as determined by the CCWG. Across the US, there is also increasing interest in ecosystem services valuation at the state and landscape levels; the Office of Management and Budget (OMB) just released new guidance for assessing environmental and ecosystem service changes as part of cost-benefit analyses. Such analyses that consider the impacts of wastewater pollution and the avoided costs associated with cesspool conversions can help make the "business case" for funding and scaling conversion.

The effects of untreated cesspool discharge compounded with population growth and climate change stretch freshwater resources thin in islands, in addition to negatively

impacting coastal resources such as fisheries, coral reefs, and beaches, impacting tourism. The proximity of dense housing close to coastlines; the extra expense of infrastructure projects in inland economic developments; socio-economic and cultural barriers; and the unique geology, geography, and land-uses in islands have helped create an environmental crisis that largely goes unseen and unaddressed. For reasons mentioned earlier, the cesspool crises on many islands cannot be solved by building more centralized sewer-based wastewater treatment systems, or by replacing them with septic tanks; the issues are immensely complex. New technologies and approaches, drawing upon the convergence of innovative thinking from diverse disciplines, are sorely needed. These challenges require the development of equitable solutions that: (a) include affected communities in the identification of problems, challenges, and solutions—preferably leveraging local knowledge; (b) address the problem without stigmatizing the communities impacted; and (c) do not create burdens often associated with new technologies such as high life cycle costs and/or management burden. Solutions also need to consider current and future threats from climate change and

development. New approaches can also lead to new opportunities; if wastewater can be treated to a high level of purity, the recycled water can be used to meet a number of freshwater demands for households, agriculture, firefighting, and industry, thereby alleviating the over-extraction of islands' freshwater supplies.

The U.S. National Science Foundation (NSF) recently funded a team of researchers through its Convergence Accelerator program to investigate and develop new solutions for decentralized wastewater management challenges in the Pacific Islands. The multidisciplinary team, comprised of researchers from the University of South Florida, University of Hawai'i at Mānoa, Michigan State University, Wastewater Alternatives & Innovations, and Swiftwater Solutions, LLC, includes engineers, social and natural scientists, economists, writers, community organizers, and analysts. The team, called RESSI-H₂O, aims to develop and promote resilient, equitable, safe and sustainable water solutions for islands through innovative decentralized wastewater technologies (onsite and cluster) and new service delivery models. Barriers and

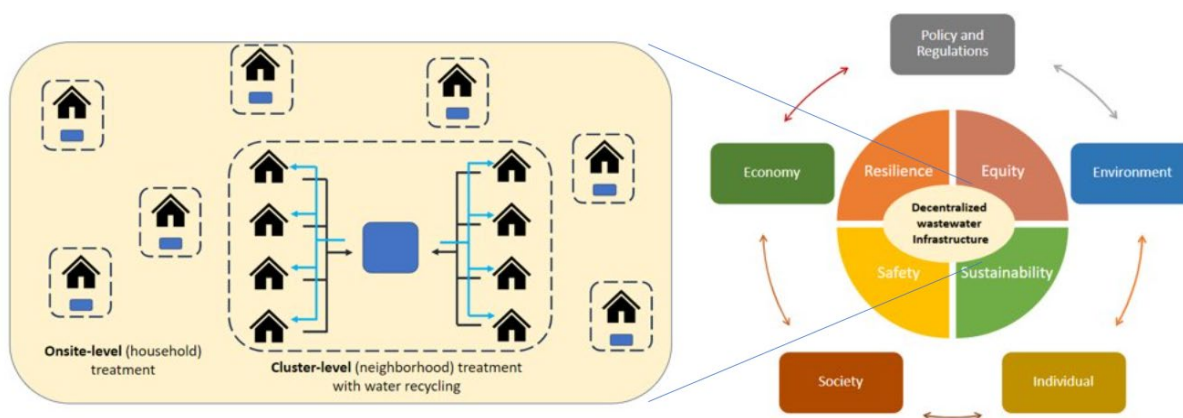


Figure 1. The RESSI-H₂O decentralized wastewater infrastructure approach.

opportunities for decentralized wastewater innovations, as related to the individual, society, economy, policy/regulations, and the environment, will be identified and analyzed (Figure 1). The project is eager to develop partnerships throughout the Pacific Islands region. For more information, please contact project lead Daniel Yeh (dhyeh@usf.edu).

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