06

Typhoid and Torrents

THE LINK BETWEEN DOWNSTREAM HEALTH AND UPSTREAM ACTIONS

This anthology is a project of the Planetary Health Alliance (planetaryhealthalliance.org). The Planetary Health Alliance is a consortium of over 200 partners from around the world committed to understanding and addressing the human health impacts of global environmental change.

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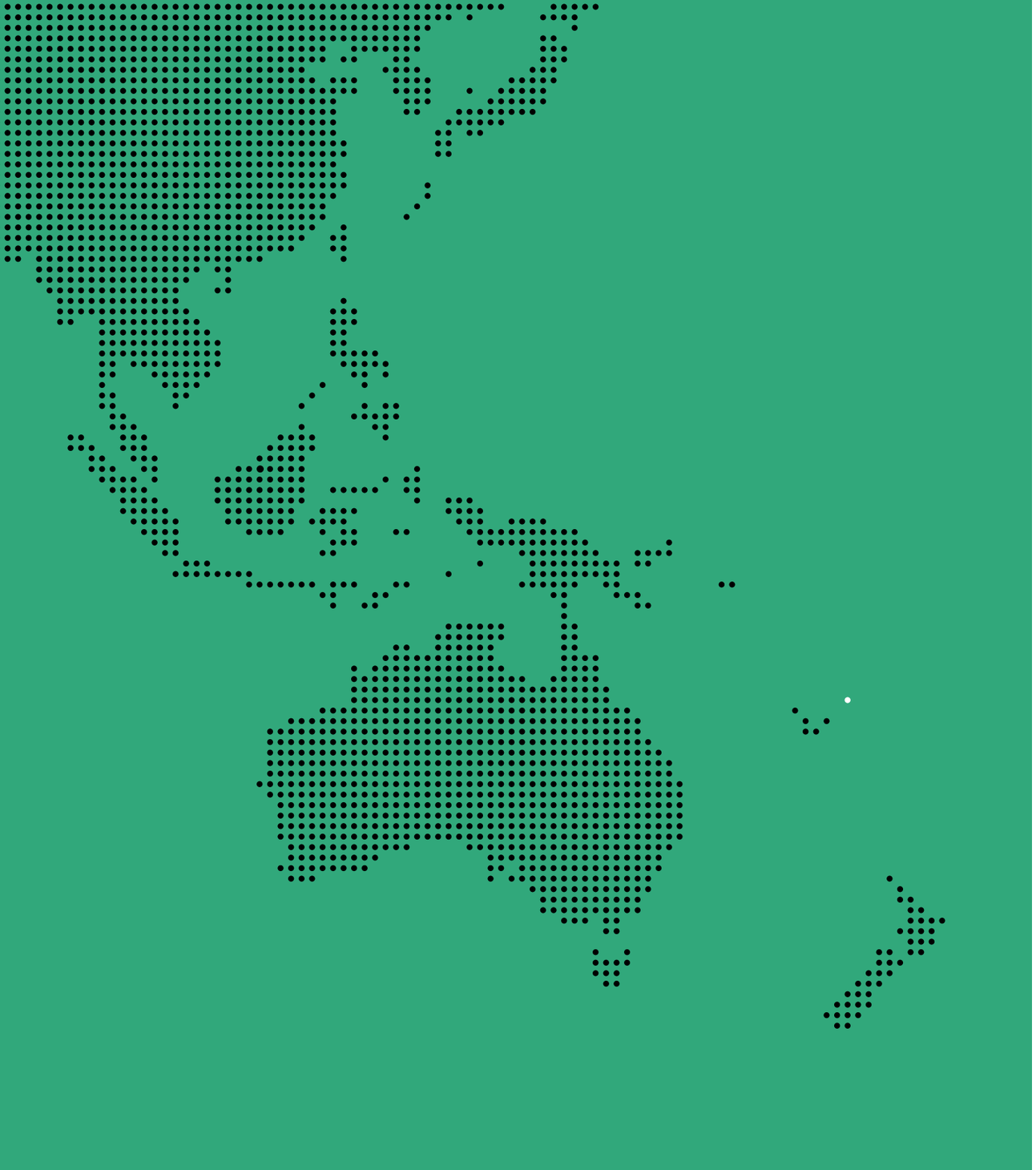


Executive Summary

This case addresses themes of land use change, water quality and infectious disease exposure which are also addressed in more detail in the land use and water sections of chapter 4 and the infectious disease chapter 6 of Planetary Health: ↘ Planetary Health: Protecting Nature to Protect Ourselves.

Learning Objectives

After examining this case, in relation to typhoid fever in Fiji, students should be able to:

① Understand the interlinkages between land-use changes, river catchment areas, and human health.

② Analyze the role of colonial legacies and their impact on land tenure and how these interact with traditional ecological knowledge and natural resources management.

③ Apply an ecological approach to understanding the individual, household, local, regional, and global factors that impact health outcomes.

④ Design interventions that consider scale and an interdisciplinary approach to complex issues such as infectious diseases in rural Fiji.

[i] Regionally, in river catchments, at a community level, and within individual households.

This case study looks at how anthropogenic environmental change and human behavior at numerous scales[i] increases the risk of typhoid fever and the transmission of other waterborne diseases on the Pacific island nation of Fiji. This includes industrial activities such as upstream deforestation and cattle-farming, poor sanitation standards in riverside villages, and poor household practices around water, sanitation, and hygiene (WASH). The setting for this case study is rural communities on a small island nation, a setting where people are particularly dependent on healthy river catchments for their water, food, and livelihood needs.

Further, customary land tenure and *vanua* (the ways in which people identify with the land and sea) are deeply important in Fijian culture. Erosion of these customary rights can have a negative effect on natural resource management and subsequently increase the spread of disease.

In addition to better acknowledging customary rights, reducing disease transmission requires interventions at household, village, river basin, and national levels, and the involvement of community members and policymakers alike. To that end, the Watershed Interventions for Systems Health (WISH) project, led by a multidisciplinary team of academic researchers, NGO staff, and government officials, is one example of ongoing work to improve and restore river catchment health in Fiji.

This case study is based on interviews conducted in Suva, Nadi, Nabukavesi, and Naqarawai, Fiji, in October and November 2018.

Waisea Naisilisili is talking about the value of the natural world when he comes across part of it about to be destroyed. It's an October afternoon, and Naisilisili is driving a large black pick-up truck down from the highlands of Viti Levu, Fiji's largest island. Fiji is an archipelago of more than 332 islands in the middle of the Pacific Ocean.

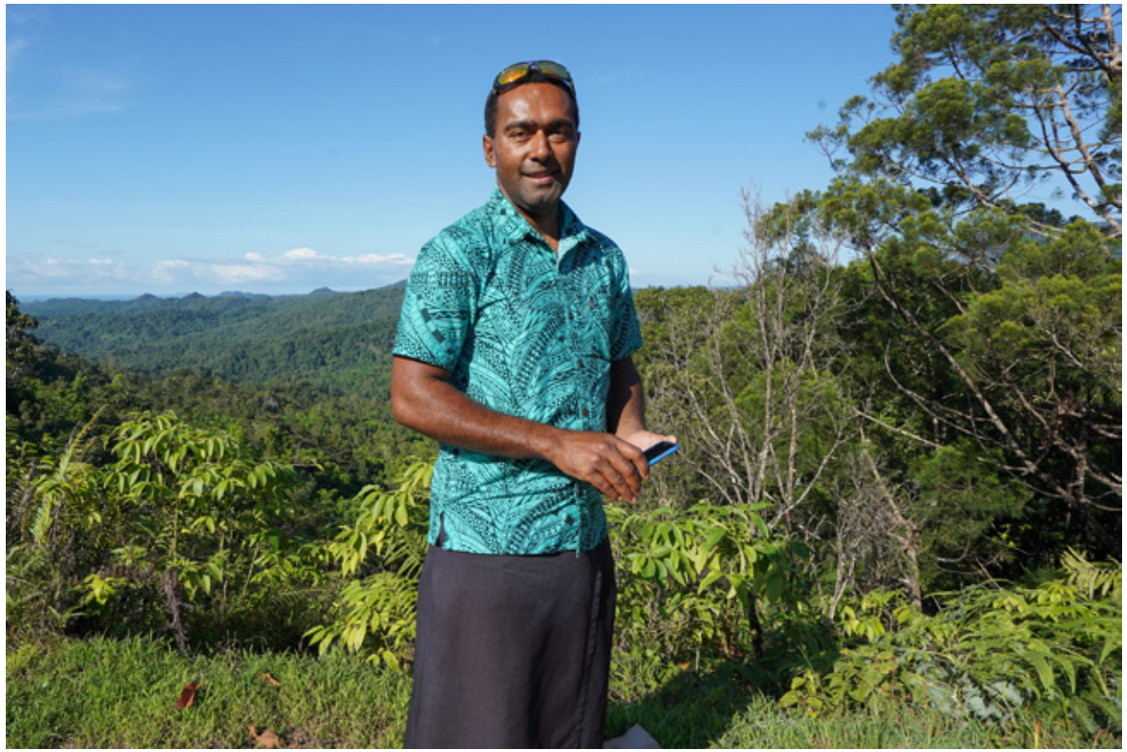
He slows the truck to inspect the land-clearing happening near the riverbank—one man, maybe two, with chainsaws in hand. "This is my family's customary land, and these guys are clearing it," he explains, snapping photos of the scene. "They bought the lease and now this guy is doing big-scale farming." Naisilisili sits back in the driver's seat, shaking his head.

Naisilisili is a Fisheries and Operations Support Officer with the Fiji branch of the Wildlife Conservation Society. Before he was interrupted by the scene at hand, he was describing his love of nature and this land that he and generations of his family have called home: "To me, nature is identity, and to protect nature simply means you're protecting yourself," he shares matter-of-factly. He refers to the significance of totems—the trees, animals, and birds that ground iTaukei (Indigenous Fijians) in their connection to the Earth.[ii]

"Our traditional belief is that the totems signify who we are and where we are from. They're very sacred," Naisilisili explains. This Indigenous wisdom isn't exclusive to his village or clan alone. Oral narratives across Fiji speak of how observations of plant and animal behavior have been used to predict an oncoming cyclone or tsunami, and offer methods of coping with these risks.[1] This knowledge is important for both the advice it offers and the cultural identity it supports. Naisilisili's grandmother was a custodian of this knowledge, and his family's connection to nature is a message Naisilisili is now passing to his own children. He and his family live in Nabukavasi, a small village located along a river of the same name.

The relationship between planetary and human well-being is nothing new to the iTaukei. A connectedness with the Earth is what has historically influenced the way in which clans manage and respect their natural resources—though those beliefs are now being tested by increased connection to the outside world, loss of community self-sufficiency,[2] and the pressures of economic development.[iii]

Those development stressors involve a range of human activities: gravel extraction, mining, and what Naisilisili witnessed today: deforestation to prepare land for agriculture and cattle farming. These challenges are compounded at a global scale by climate change and an increase in storm severity and frequency, and at a local scale by the growing population of riverside communities with inadequate access to water, sanitation, and hygiene (WASH). These changes are more than an affront to Naisilisili's customary land—research in Fiji has confirmed that these various scales of environmental change and behaviors can lead to freshwater contamination. As a result, villages like Nabukavesi are increasingly



Waisea Naisilisili during a road trip break on the way into Viti Levu's highlands.

[ii] Take a minute to try to write down what is your relationship with nature? When did this relationship start? Can you remember when you became aware that "nature" needed to be protected? How has this relationship with nature changed, and why?

[iii] How do you think each of these elements is playing a role as factors that are causing a disconnection between the iTaukei's relationsip with nature?

affected by infectious disease transmission, especially typhoid.[3] This is where one of Naisilisili's colleagues comes into the picture. Dr. Aaron Jenkins has spent the past several years researching the effects of anthropogenic activities on river ecosystems and human health. A fisheries ecologist by training, Jenkins was frustrated by what he found when he first came to Fiji in 1996: sediment and nutrients from upstream activities, manure, sewage, and trash flowing into river basins. This human-produced waste wreaked environmental havoc along the coast and disturbed coral reefs and other marine ecosystems. "That's when I knew I better start working upstream so I could understand the connection between what was happening on the reef and what was going on in the river," explains Jenkins.

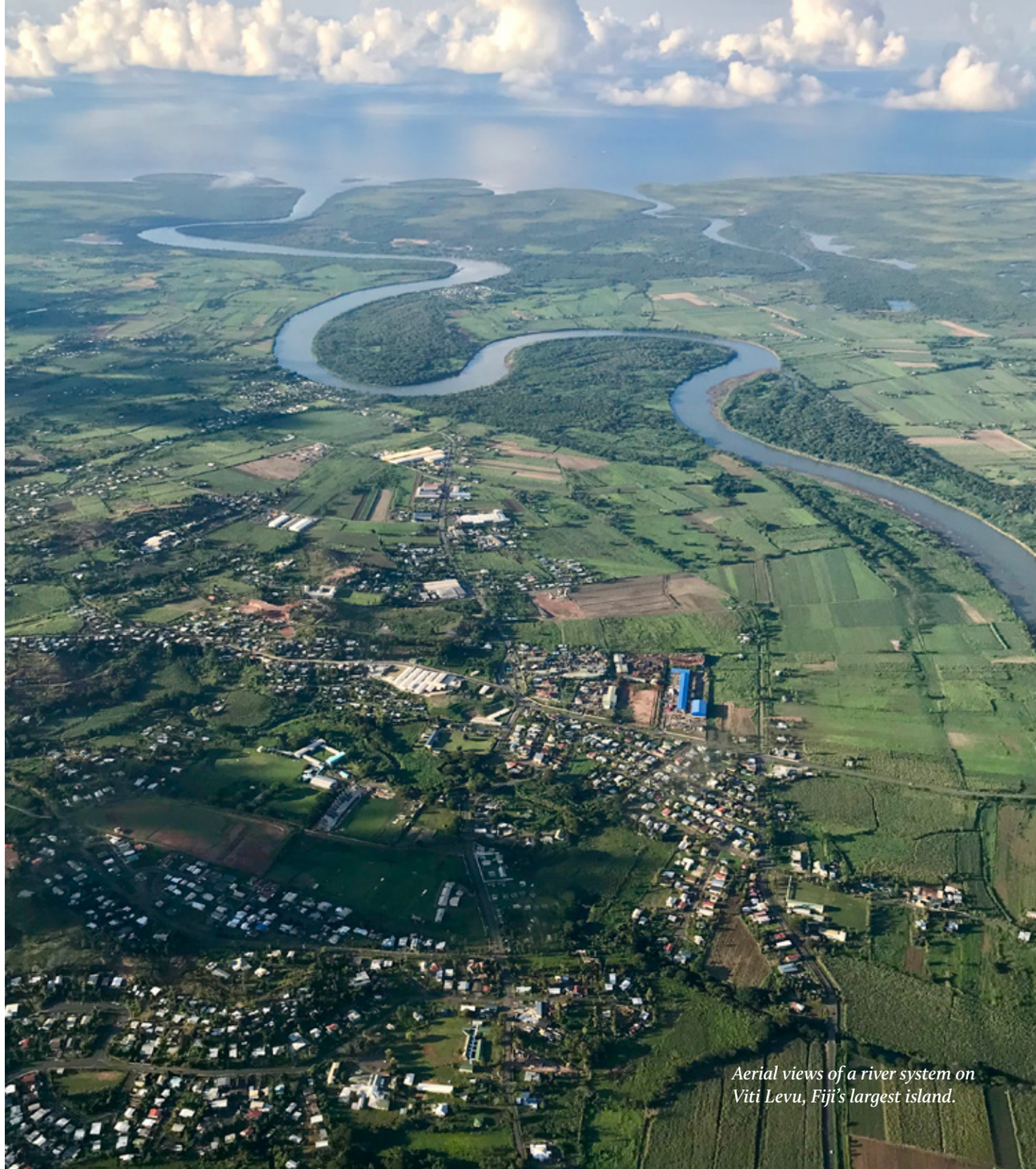
That run-amuck waste was having human health implications in villages like Nabukavesi where Waisea Naisilisili lives with his family. The river is an integral part of these rural, often remote communities, and people depend on it as an essential source of water for household consumption.[iv] "Reading the newspapers, I'd notice a particular area had been quarantined because of a massive typhoid outbreak and I'd think 'wow, the outbreak is next to this really degraded river catchment[v] where there were no fish and the water quality was crap,'" Jenkins recalls.

While the transmission and prevalence of typhoid fever and other water-borne diseases had been well-researched and documented in other parts of the world, there was still a question mark around the local risk factors affecting people living in isolated Pacific island countries like Fiji. Not only that, but it was still unclear how anthropogenic changes could further impact those risk factors.

Today, a team called Watershed Interventions for Systems Health (WISH) is investigating that relationship between the intersection of environmental change and human health—and is attempting to mitigate the negative health outcomes for riverside villages and the river catchments on which they depend.

[iv] Another case in this anthology takes us to the Senegal River Basin in West Africa, where a dependence on the river puts communities at an increased risk of contracting schistosomiasis, a parasitic disease.

[v] A river catchment is a low-lying area where water gathers. Also known as a river basin or a watershed, a river catchment is named quite literally after its ability to "catch" the water flowing into the region, including from other smaller bodies of water and uphill precipitation. River catchments are also where pollution, sediment, and anything upstream end up. A subcatchment is the name for a segment of a river catchment. These two terms come up frequently in this case study.



Aerial views of a river system on Viti Levu, Fiji's largest island.

A view from Viti Levu's highlands down through multiple river catchments and out to the Pacific Ocean in the distance

A Hub in the Pacific

The Republic of Fiji is one tiny piece in the Pacific puzzle that makes up the region of Oceania. Sometimes referred to as the Blue Pacific continent, the region is home to more than a dozen island nations, the likes of which appear miniscule and isolated when looking at a map of the world. Oceania lies in both northern and southern hemispheres, and covers an area of 8.5 million square kilometers. Exclude Australia, New Zealand, and Papua New Guinea, and you have an ocean area greater than that of continental USA, with the landmass of small islands composing an area roughly the size of Cuba.

Fiji and other Pacific island nations are often considered a microcosm for the world. Their isolation, vulnerability to climate change, and size mean the feedback loops that exist between anthropogenic actions and human health are more rapidly apparent than those interactions on continental ecosystems. "Tinker with one part of an island system and almost immediately people downstream are having muddy water and getting more diarrhea. I think this is what makes small island systems an important place to do planetary health research," says Aaron Jenkins.

Oceania includes groupings of low islands—coral atolls like the countries of Kiribati and Tuvalu which sit barely above sea level—to what's known as high islands. High islands are characterized by steep slopes and rolling hills, a testament to their volcanic origin.[4]

The Pacific high islands are unique beyond their geographic immensity: their size lends itself to better water resources.[5] Surface water comes from freshwater rivers and lakes, and groundwater spurts from aquifers in highland and coastal areas. These water sources are also replenished by generous precipitation. The increased water availability in high islands means soil is more fertile than that of low islands, and is better suited for supporting human settlements, agriculture, and mineral extraction.

The verdant green folds of Fiji's highlands are a stark contrast to the turquoise waters that offer a more quintessentially tropical scene. Fijian islands vary in size, from the largest of Viti Levu where the capital city of Suva is located, to more than 500 islets—the name for landmasses that are no more than rock or coral protruding from the ocean. Even Viti Levu is just 146 kilometers from east to west, and a medium-sized propeller plane will get you from the country's main international airport in Nadi to the capital city in a prompt 30 minutes. Press your forehead to the window and you'll see water systems snaking their way to the coast, the geometrics of agricultural plots, overgrown logging roads and, as you land into Suva, the river delta where the muddy, brackish waters of the Rewa River belch into the Pacific Ocean. The obvious interconnectedness between interior and coastal ecosystems observed from the air becomes out-of-sight, out-of-mind as you enter the city.

Fiji's population is becoming increasingly urban. Located on opposite coasts of Viti Levu, Nadi and Suva are the country's major urban centers. Consistent with global trends, national census data from 2017 indicate that 55.9% of Fiji's population[6] of 884,887 live in urban areas, up nearly 10% from two decades earlier.[7][vi] The country is ethnically diverse, with iTaukei (Indigenous Fijians) making up 56.8% of the population, and Indo-Fijians[vii] composing another third.

Those who don't live in coastal cities often dwell in rural river catchment areas in island interiors. That includes in Central Division, a region in the southeastern part of Viti Levu. Central Division is the most populous of the country's four divisions, and is home to 42% of the country's population. Here, most people live along two river corridors: the Suva-Nausori corridor near the capital city, and along the Navua River corridor that runs through various subcatchments on its path from the highlands to the coast.[8] Those two river corridors are part of the 26 river subcatchments that split Central Division into a quilt-work of informal boundaries.

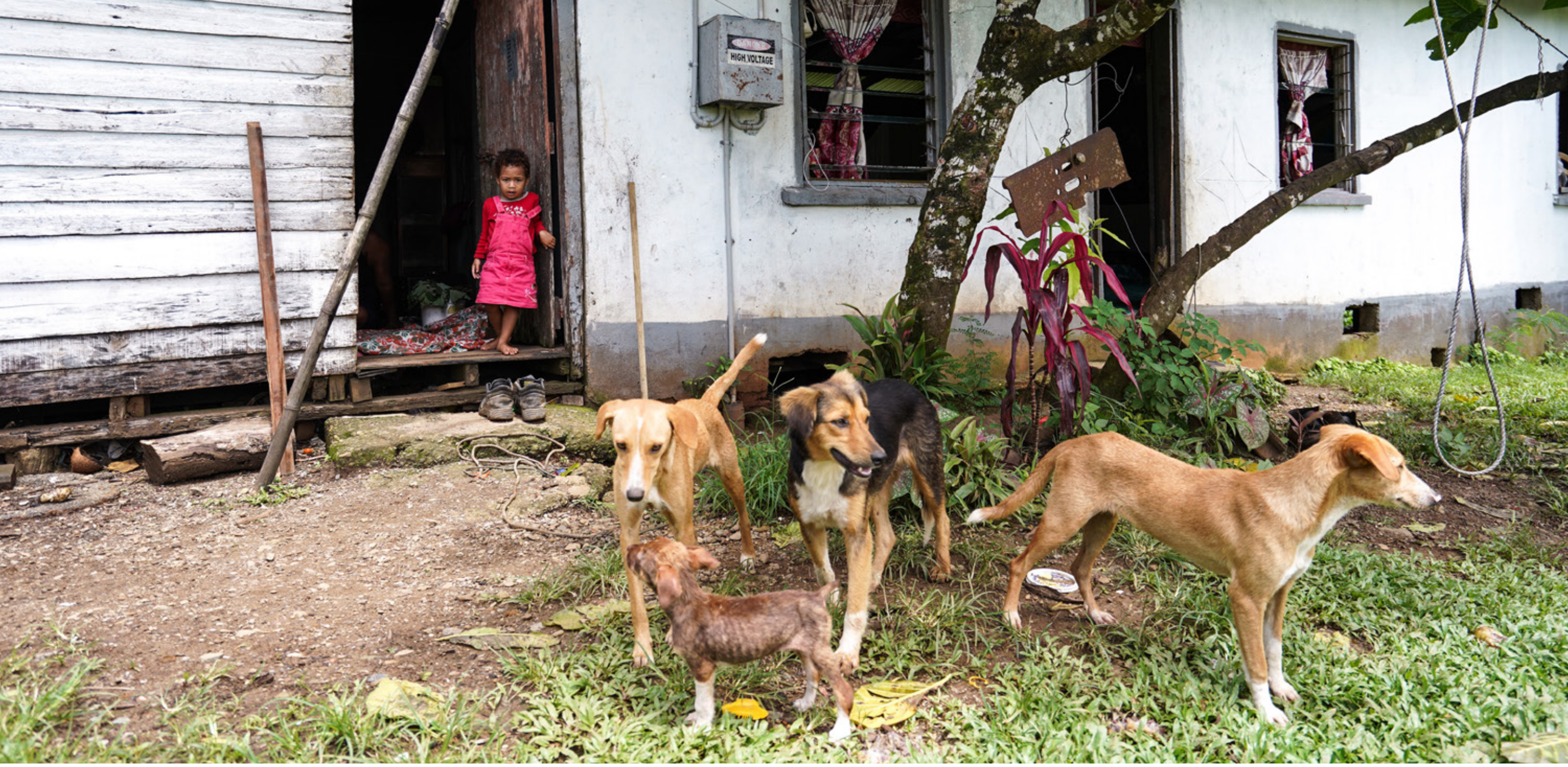
These 26 subcatchments are the focal point of planetary health research in Fiji. Aaron Jenkins says he believes these smaller sections of river catchments are the ideal place to look not only at the public health effects of upstream land-use change, but also the environmental and socio-economic determinants of health at community and household levels.[9] Influenced by these many factors, Jenkins is not alone in his assessment that river catchments—and the water that runs through them—are the most appropriate place to promote community resilience and prevent the spread of disease.[10]

The health vulnerabilities of downstream communities are significant. Central Division residents have been exposed to typhoid fever, with 279 cases reported between 2014 and 2017. Of these cases, rural highland villages had the highest incidence rate of disease and nearly as many cases of typhoid fever as urban and peri-urban[viii] areas, despite having a significantly smaller population.[11]

[vi] What percentage of people where you come from live in urban areas? What percentage of the world lives in urban areas? How has this percentage changed in the last 100 years? ↘ Find out more here

[vii] Many Indo-Fijians were first brought to the country as indentured laborers on the sugar plantations the British administration introduced during the start of their colonial rule. Fiji was a British Crown colony between 1874 and 1970. The impacts of colonialism have had long-lasting impacts on the country, from the introduction of capitalism, to the land tenure system that affects natural resource management, to the language and culture of modern-day Fiji.

[viii] Peri-urban areas are an intermediary between rural and urban areas.



A young girl stands in the doorway of her home in Nabukavesi on Viti Levu. Nabukavesi is just one of many rural communities that relies on its local river when the reservoir in the village runs dry. It's also one of the villages that has faced rising typhoid outbreaks in recent years.

The Nested Nature of Fiji's Typhoid Outbreaks

"A few years back we had a really difficult time." These are the first words Rosa Batiri shares, sitting cross-legged on the floor of her home. Batiri lives in Naqarawai village, a community of 54 homes arranged neatly on the grassy plain that runs uphill from the Wainawene River in the highland interior of Central Division. In 2015, Batiri's youngest daughter Ruci, then four-years-old, contracted typhoid when visiting her aunt in a village downstream. "She got a fever and was really weak. I was worried," Batiri says. "Typhoid was one of the main illnesses that was happening at the time. People were getting sick in all of Fiji because of the disease."

[ix] If you were to guess, which part of the world do you think typhoid fever is more common?

A serious illness caused by a bacteria called *Salmonella typhi*, typhoid fever affects an estimated 22 million people worldwide each year.[12]* Transmission happens in various ways, though the most common is when miniscule particles of fecal matter contaminate drinking water and food, making the disease both waterborne and foodborne.[13] In Fiji, the incidence of typhoid fever has been increasing since the 1990s, and rapidly so since 2005.[14]

Epidemiological studies have found significant differences between Fiji's typhoid outbreaks and those in the rest of the world. Take the population most at-risk. Globally, the World Health Organization considers children under five most likely to contract the disease—kids of Ruci's age. However, a case-control study in Fiji found the average age of infection to be 29-years, with Indigenous iTaukei representing 95% of that group.[15] Epidemiological surveys conducted by Fiji's Ministry of Health between 1995 and 2009 had similar findings, with iTaukei being affected in 82.5% of the 1,509 cases confirmed during the period.[16] iTaukei families are more likely to live in rural and remote communities that depend on clean river water for consumption and household activities.

[x] Another case in this anthology is set in Santiago, Chile, where a contaminated river led to years of public health outbreaks. The solution that has been proposed for that urban center looks different than the approach in Fiji, but both are examples of planetary health solutions in action.

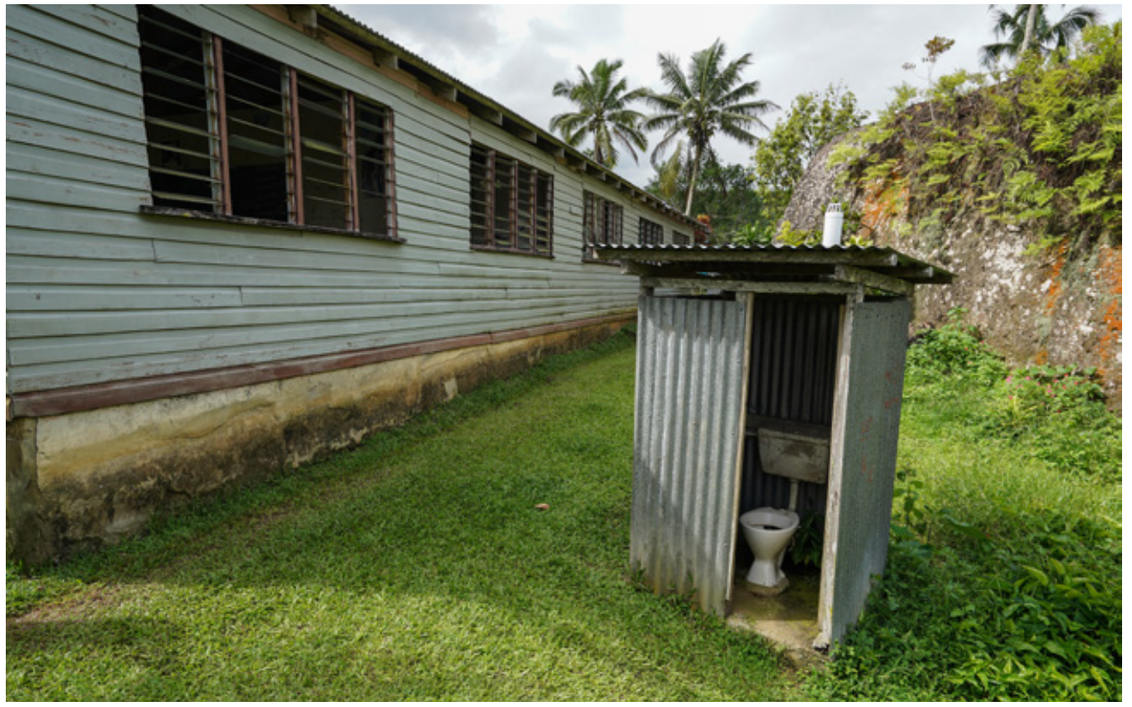
Where does the water you use come from? How is it treated? What is the governing body over the quality of that water? What laws exist in your place of origin regarding the access to drinking water?

Access to clean drinking water and household sanitation are two elements that affect disease transmission.[x]Pacific Island countries have the lowest coverage of improved drinking water and sanitation worldwide. Between 2000 and 2015 Fiji was one of 10 countries worldwide where basic drinking water access decreased.[17][xi] Statistics suggest significant water, sanitation, and hygiene (WASH) inequalities between urban and rural communities: 62% of rural Pacific communities lack access to basic water access (compared to 10% of urban communities), and sanitation coverage is below basic in nearly 80% of rural areas (compared to 29% of urban areas).[18][xii]

[xi] Do you think clean drinking water is a human right?

[xii] What other diseases are higher in prevalence due to lack of access to safe drinking water?

Urban-rural disparities have been even more apparent since February 20, 2016. That's when Cyclone Winston made landfall in Fiji, affecting more than half of the country's population.[19] The category five tropical storm damaged water supplies in more than 500 villages, and caused nearly $1.42 billion in damage and loss, a third of Fiji's gross domestic product (GDP). As of late 2018 there are still interior communities whose water and electricity infrastructure are being rebuilt following the storm.



An outhouse in Naqarawai village in the highlands of Viti Levu.

Fiji's typhoid outbreaks increase following major storm events like Cyclone Winston.[20] They also follow seasonable trends linked to climatic conditions—rates peak between January and June, following on the heels of the rainy season when the flooding of rivers and community septic tanks is more likely. Climate change and the increased severity and frequency of weather events are global factors that affect the spread of disease and water quality, not only in Fiji, but worldwide.[xiii]

[xiii] The case in Santiago, Chile, also examines how climate change affects safe drinking water access in that country.

Oceania's Vulnerability to Climate Change

Cyclone Winston was the most severe tropical storm to affect Fiji on record, but it will not be the last. Capturing international headlines, Cyclone Winston opened the door for Fiji's climate vulnerability to be discussed on the world stage. At COP23 in November 2017, the Fijian government released the country's first climate vulnerability assessment. Among the sobering highlights: climate change could push an additional 32,400 people into poverty each year by 2050,[xiv] and projected sea level rise would put nearly one-third of the country's population at-risk.[21]

Fiji's vulnerability to climate change is reflected in Oceania as a whole. Oceania is repeatedly ranked as the highest risk region for exposure to natural disasters such as tropical storms, flooding, and sea level rise. Not only vulnerable to the disasters themselves, Oceania receives this rating because of the limited capacity its institutions have to respond to those disasters, its geographic isolation, and the relative poverty experienced by its populations. Along with four other small island nations in the Pacific, Fiji ranks among the top 15 countries facing the highest disaster risk internationally.[22] [xv]

[xiv] For example, 37% of Fiji's population derives income from the agricultural sector—this is even more true for people living near or on the poverty line. With climate change affecting precipitation patterns, pest presence, and the water available for irrigation, Fiji's most vulnerable populations could be affected by just the slightest change in productivity. Not unique to Fiji, climate change will disproportionately affect the poorest people in countries worldwide.

[xv] Take a look at the countries with highest degree of climate change vulnerability. Where do you think they rank with respect to greenhouse gas emissions? There are many indexes that address this question, but there are common threads among them. ↘ Here is one think tank's approach to measuring such risk

Regional, local, and household risk factors exacerbate the effects of global anthropogenic change on typhoid transmission. Nestedness, a concept borrowed from ecology, explains the need to consider each of these scales when creating a planetary health intervention. Nestedness[xvi] is about assessing how actions in one environment can exacerbate the changes that take place in another. To conceptualize the idea, imagine an onion.

Just as an onion has many layers, so too does Fiji's vulnerability to typhoid transmission. Each layer represents a complex set of environmental stressors. The outer layer includes human-caused environmental changes at a global scale, including climate change which is simultaneously increasing ocean temperatures, the intensity of cyclones and other disasters, and rising sea levels. The second layer is activity at the river catchment level: forest fragmentation and the resulting erosion, the construction of dams, disposal of waste into the river, and other upstream industry that affects people living downstream. Peel away further still and you have a layer at the village-level, where inadequate sewage systems, outdated water reservoirs, and inadequate water treatment put people at risk. Household activity is at the core of the onion: food and personal hygiene practices including whether water is boiled, food rinsed, hands washed, and toilets flushed or covered.[xvii]

[xvi] This concept is referred to as the "ecological model or approach or framework" in some academic writing.

[xvii] How would you apply this concept of nestedness to a disease that is more common in where you are from? Diabetes? Hypertension? Dengue?

Mass Typhoid Fever Vaccination—A Potential Solution?

Mass vaccination against typhoid fever was trialed in Fiji following category 4 Cyclone Tomas in March 2010. Part of post-disaster response involved Fiji and the Pacific Island region's first-ever large-scale typhoid vaccination program run by the country's Ministry of Health with funding from Australian Aid.[23] More than 64,000 people were vaccinated as part of that campaign, which also involved some community-based demonstrations on hand-washing and other sanitation practices. The campaign was most effective in three disaster-affected areas that had high levels of vaccination, and typhoid fever incidence "increased or remained unchanged in 12 subdivisions where little to no vaccination had occurred."[24]

As of writing, large-scale typhoid vaccination has been limited to post-disaster measures, and are not part of Fiji's national immunization program.[25] An assessment of the 2010 vaccination campaign concluded that more research is needed into the effectiveness of post-disaster vaccination in settings where typhoid fever is endemic, and that the "provision of safe water, adequate sanitation, and good hygiene (WASH) is the mainstay of typhoid prevention and control efforts." [xviii]

[xviii] One issue with the typhoid vaccine has been sustaining the levels of immunity it creates in a person in the long run, needing to re-vaccinate, or give booster doses every 2-5 years.

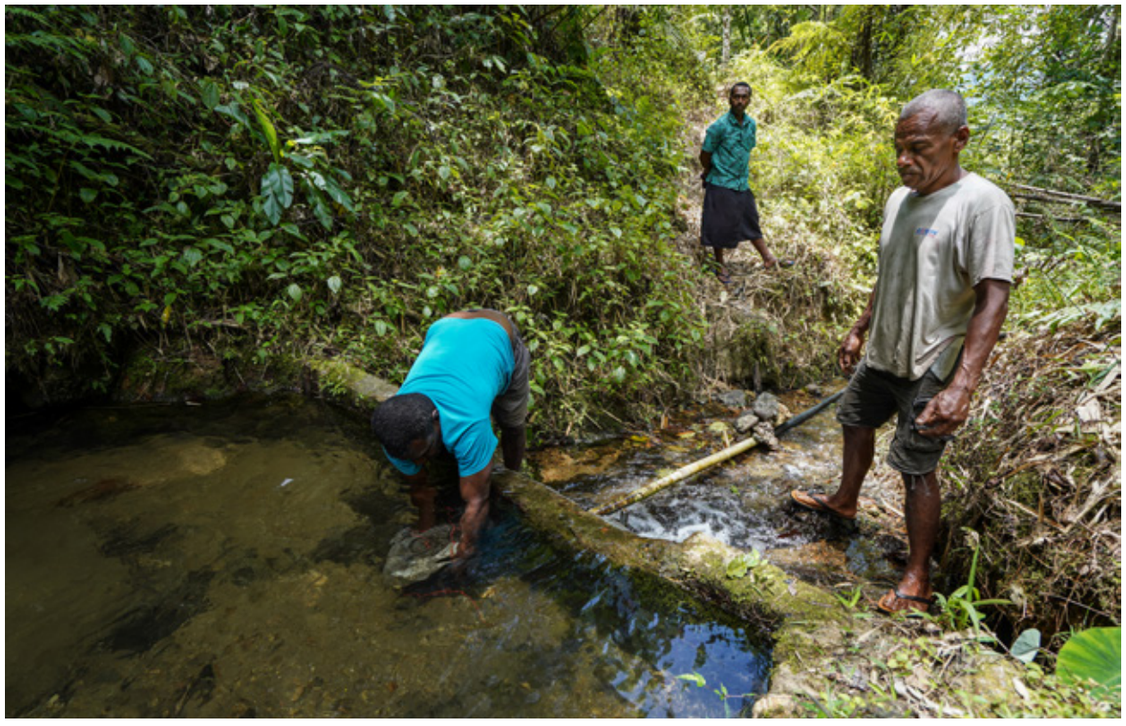
"Once you know the risk at those different layers it allows you to intervene at each. That way you're addressing the problem at multiple levels and across multiple time scales," summarizes Aaron Jenkins. Intervening in river catchment systems allow planetary health practitioners to address many nested problems at once.

Views of Naqarawai village and its proximity to the river.

From Where the Water Flows

Naqarawai, the Central Division village where Rosa Batiri lives with Ruci and her other children, is a scenic spot. Reaching the community requires visitors cross a concrete suspension bridge that offers stunning views of the village on one side, and hillsides speckled with taro fields on the other. Residents gather below the bridge in the evening to play volleyball and rugby near the river's edge.

It's a 15-minute walk from the base of the bridge to reach the reservoir where Naqarawai residents access drinking water. The path runs first along the banks of the river, through swaying cassava plants, and finally, down a steep embankment approaching the sound of running water. The reservoir is a man-made tank with a two-foot high concrete retaining wall covered in tufts of green moss. Upstream, a cascade of waterfalls channels water into the reservoir; the wind blows gently through the dense forest and ferns. This water sprouts from a spring upstream, and Naqarawai benefits from being the only village reliant on this source.



Jovili Mototabua inspects the sediment that's collected around Naqarawai's makeshift water filter.

Once it enters the reservoir's concrete tank, water travels through the retaining wall via a valve and pipe that feeds the untreated spring water directly to Naqarawai's taps. The filtration system on that pipe is far from formal. Jovili Mototabua, head of the village's drinking water committee, crouches and removes the filter: an additional piece of piping with marble-sized holes polka-dotting its surface, and layers of steel mesh to filter smaller particles. This reservoir is characteristic of the primary way in which rural Fijian villages access drinking water.

It's also representative of some of the challenges presented by that source. Constructed in 1997, this is the second location for Naqarawai's reservoir. It was originally found further down the small stream, closer to the village. "But there were many farms in that area, and a lot of people would cross with their animals which would make the water dirty," says Mototabua of the first location. While this second reservoir site has eliminated the animal crossings that polluted the water, Mototabua says the source is still far from ideal.

For one thing, the reservoir's function is easily disrupted when there is too much rain or not enough. Mototabua says a week of heavy precipitation or a cyclone leads to the pipe getting clogged with mud and dirt; not enough rain and the water level in the storage tank is too low to feed the pipe. Water that collects sediment is also prone to transporting other nutrients and bacteria. Once gathered, that material can wash into and potentially contaminate village reservoirs and surface water sources like nearby rivers.[26]

Mototabua blames a logging road upstream for the increase in reservoir clogging sediment. "All the mud from the logging road is swept down the stream and collects here when it rains," he says, gesturing towards the concrete tank. "That clogs the pipe and dirties the water that does get through." That can be problematic, he says, since people often don't boil the water coming from the reservoir since there is the assumption that it's safe for drinking.

Upstream forest clearing also increases the risk of waterborne disease for villages like Naqarawai. Dense forests historically covered subcatchments in Fiji's Central Division; rivers were tree-lined and ripe with vegetation. In recent years, however, economic activities such as logging and its associated infrastructure has reduced river buffer zones—the name for the forested area fringing rivers and streams—in more than 85% of subcatchments.[27] Buffer zones in

[xix] Another case study looks at the ecosystem services provisioned by forests to people living around Gunung Palung National Park in West Kalimantan, Indonesia.

Does your country of origin have regulations on river buffer zones? Are they respected?

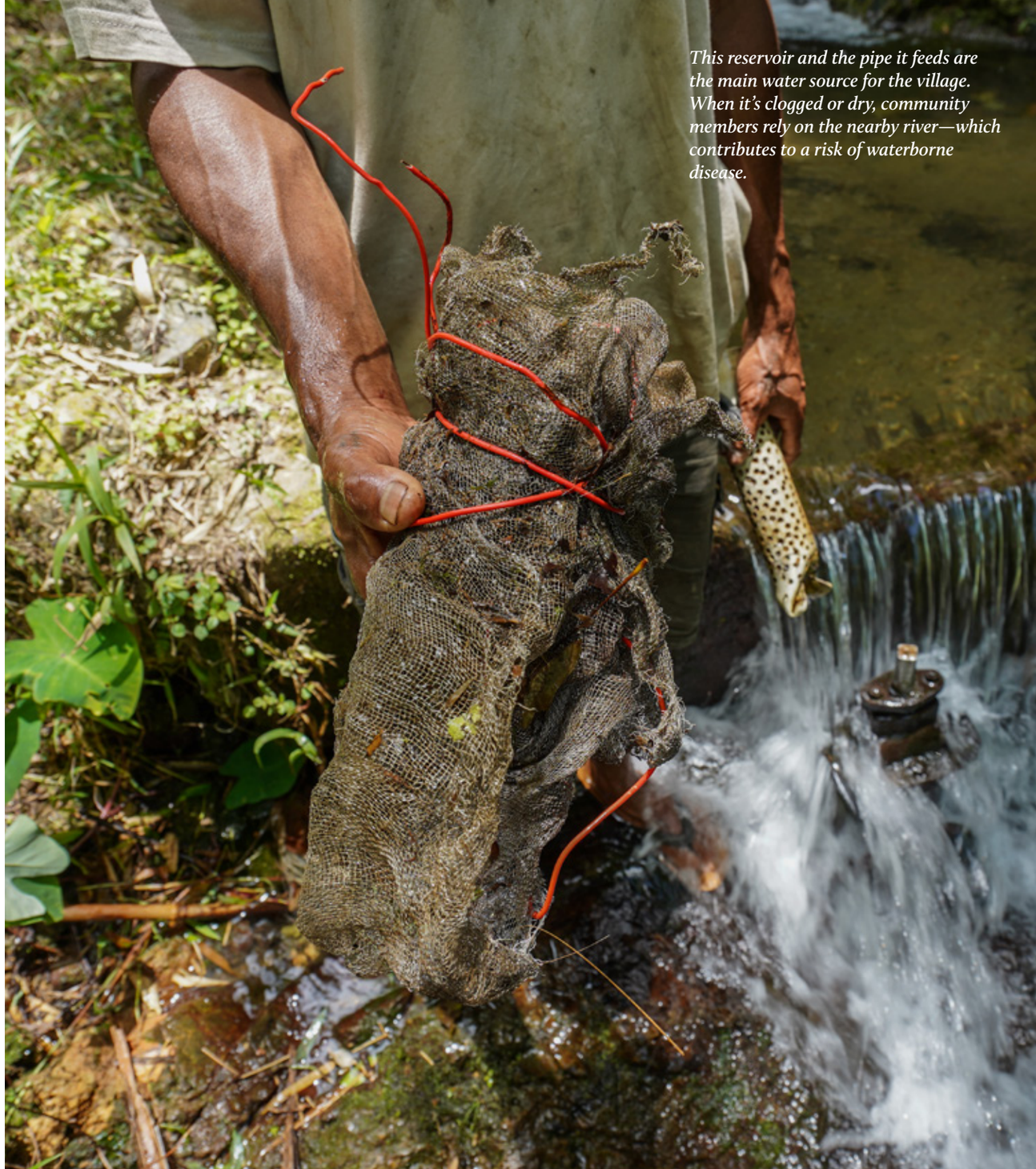
Central Division are "highly fragmented in 69% of subcatchments, without a single kilometer stretch of continuous riparian forest."[28] This affects the ability for those forests to regulate the mitigation of floods, purify water, and limit the spread of diarrheal disease.[29] [xix]

Deforestation or other land use change can influence human settlement patterns, motivating people to live near river flood plains and other low-lying catchment areas, which can increase their exposure to contaminated water and, subsequently, disease.[30] Even if communities understand this added risk, many are hesitant to relocate given the relationship and cultural significance associated with the land where their families have lived for generations. While riverside economic developments reap benefits for certain parties, that often comes at a cost to rural and remote villages like Naqarawai.

Surface water pollution affects riverside villages, even those that do have access to a basic system of reservoir and tapped water supply. The water collected in Naqarawai's reservoir tank is not always enough to provide for all the village. When the reservoir's pipe is clogged by storms or upstream sediment, residents instead depend on surface water from the Wainawene River. Interrupted water supply and contaminated drinking water, including that which is gathered from surface water sources, is yet another commonly identified environmental risk factor for typhoid fever.[31]

Despite its relatively isolated location in the highlands, the Wainawene River that runs through Naqarawai is pollutant prone. This is because of activities like deforestation and cattle rearing, in addition to the behavior of the two villages that sit upstream. "They are using the same river as well, and it has caused us diarrhea, sickness, skin disease, ringworms, and scabies—these are the kinds of issues we face when there is no supply of water in the reservoir and we have to use the river," Mototabua explains.

Ratu Ilaisa Kuruibua, Naqarawai's chief, says he has tried to explain to upstream villages that what they cast into the river can affect Naqarawai's drinking water. Ultimately, he says these messages haven't held much weight. "When they slaughter pigs or cows the waste ends up in the river," explains Chief Kuruibua. His wife, Sereana, has seen an entire cow's head and bones floating down the river, in addition to diapers and vegetable peels. "Those attitudes are hard to change, even though we tell them that if the environment is healthy it brings healthy living," Chief Kuruibua sighs.



This reservoir and the pipe it feeds are the main water source for the village. When it's clogged or dry, community members rely on the nearby river—which contributes to a risk of waterborne disease.

Returning to Naqarawai village after a visit to the drinking water reservoir.

Customary Ownership and the Link to Land Tenure

While more abstract than deforestation and land use change, the stripping of customary land ownership rights of rural, Indigenous iTaukei communities can also contribute to this detrimental behavior towards water resources.

Land tenure—and as an outcome its environmental management—is a contentious and complex topic around the world, and Fiji is no exception. Customary land is any area that has been traditionally overseen by a community-level governance system. In Fiji, the property right to own and occupy customary land exists within village clans (*mataqali*) and resource management is typically overseen by chiefs like Ilaisa Kuruibua.

Despite this Indigenous system of land tenure, the British colonial government brought a system of its own to Fiji. This meant that landscapes were at once governed by two conflicting systems: customary and colonial. Today, Fiji's government legally categorizes land in three ways: iTaukei (customary), Freehold, and Crown lands. An estimated 91% of Fiji is iTaukei land today. These are areas the British administration permanently transferred to clans and other groups of iTaukei landowners in the late 19th century—disregarding that the land was never considered theirs to give.

Community governance of iTaukei land still isn't independent. Ownership and leasing of this land is managed solely through the iTaukei Land Trust Board (TLTB), a body first established by a British colonial-era act, and one that receives a 25% commission on all leasing agreements. TLTB's lease granting motivations have been challenged in the past, with court cases often ruling in favor of the board rather than the landowners it was created to benefit. FijiFirst, the political party that was re-elected in November 2018, ran on a platform that promised the creation of an Independent Lands Tribunal. The purpose of that newly created group would be to mediate complaints between iTaukei landholders and the TLTB and, in theory, ensure iTaukei were able to gain greater economic benefit from their land.[xx]

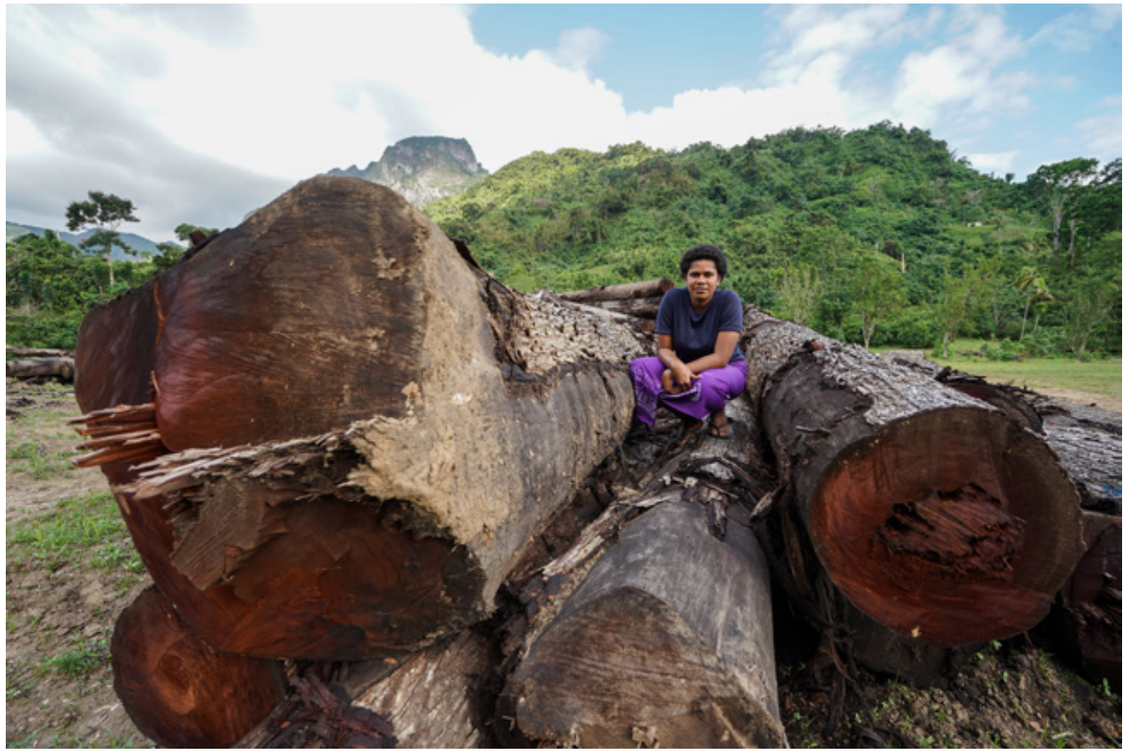
[xx] What type of land tenure laws exist in your country? How and when were they created? Are there different regimens of land tenure? Land leases? Government owned? Communally owned? National parks? Indigenous territories? Special laws for water-basin areas? Coastal zones? Protected forests?

Land tenure has critical implications on natural resource management. For one, colonial land ownership policies can create confusion with customary land policies, and this can affect how and by whom an environment is utilized. This is evident worldwide. In Nigeria, for example, colonial land use policies overlain on communal policies have created significant debate about who has which rights to engage in particular practices in particular locations.[32] [xxi]

[xxi] In your place of origin, are there tensions over land tenure laws that relate to use of natural resources?

In Fiji and other Pacific Islands, *vanua* is the concept used to describe the relationship between people, land, and sea. "[That relationship] may define among other things the due of care that people have to each other, the future generations as well as the environment," says one paper looking at the impact customary land tenure can have on natural resource management in the Pacific Islands. [xxii]

[xxii] What other concepts are similar to *vanua*?

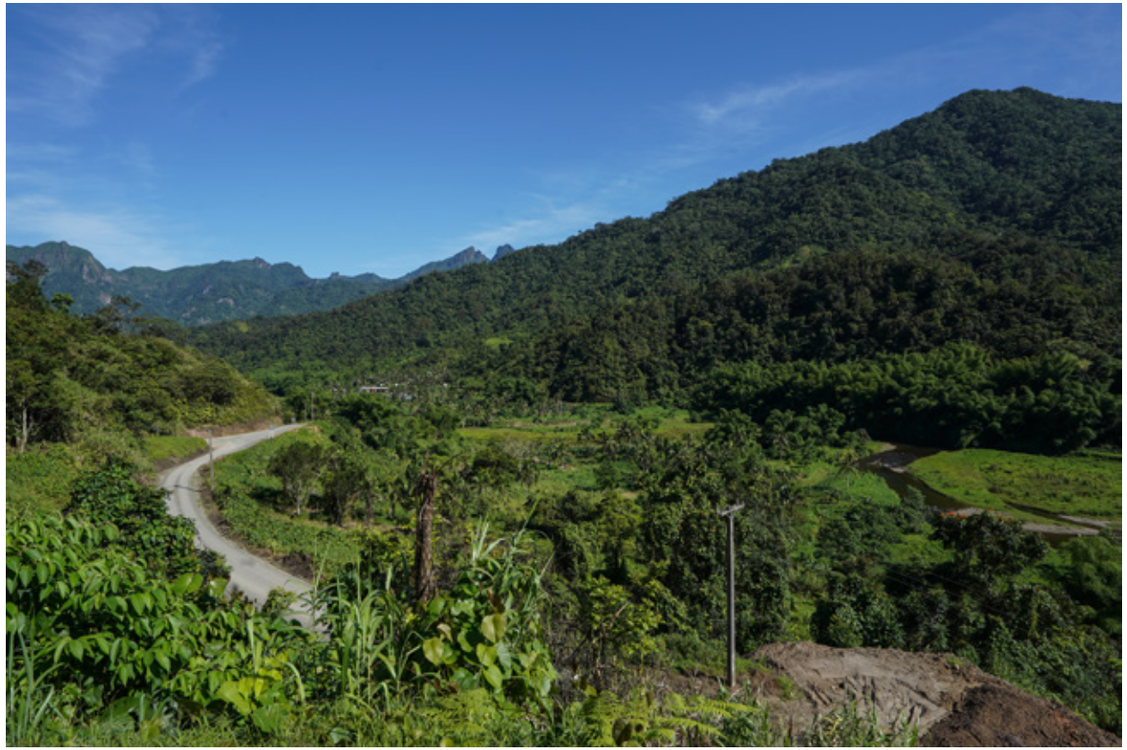


Stacked mahogany sits awaiting transportation in Fiji's Central Division. An invasive species introduced by the British, mahogany trees soon became a valuable part of the timber trade. Like gravel extraction and cattle rearing, logging has affected the water quality in river catchment-dependent villages.

Back in Waisea Naisilisili's pick-up truck, he says he fears this relationship and the respect for traditional *mataqali* authority is being forgotten, and that it's affecting the reverence people have for the surrounding environment. "This is how Fiji has always been governed—by chiefs from respective villages and provinces, and the children are taught to respect and listen. If the children cannot listen at home, then it's useless. Their parents and grandparents cannot advise them of the environmental connection," he says. "If we keep on the track of today, all these connections will be lost for good."

Going forward, Naisilisli suggests the government set rules that safeguard the customary laws of communities. After all, the farming activity happening on Naisilisili's customary land is not illegal—iTaukei land is available to lease through TLTB for periods ranging from 30 to 99 years.

Legally, this new lease holder has to use the land as it was zoned—for agriculture. "He needs to follow the proper rules for farming. For example, he's not allowed to farm too close to the streams and rivers. That's why I took the photo, because there's a stream nearby," Naisilisili explains. If he had his way, the scale of these developments, as well as their environmental impact, would be held to a higher level of scrutiny by the respective government ministries.



An area in the Fijian highlands that has been cleared to make space for the roadway and agricultural land.

Unfortunately, this is not always the case in Fiji. "We're very good at producing laws, but not very good at enforcing them. Lease holders are not monitored or held to task," shrugs Dick Watling, a long-time environmental consultant and Founder of NatureFiji-MareqetiViti, an environmental conservation organization. He says the governance of rivers is particularly confusing.[xxiii]

[xxiii] In your own words, what is meant by governance? In the context of "governance of rivers", what is Mr. Watling referring to?

According to Fiji's Department of Town and Country Planning, "the beds of navigable rivers and streams are Crown land," which, like iTaukei land, cannot be sold but can be made available for lease. "With the state ownership of the river it can still be pretty dicey where customary land ownership ends and state responsibility begins," Watling says. He adds that environmental impact assessments aren't always mindful of the long-term sustainability of natural resources.[xxiv]

[xxiv] How would you include a long-term sustainability component into environmental impact assessments?

While Watling believes gravel extraction from riverbeds is Fiji's most dire environmental challenge, he says the problem applies across any industry: "there is no reason why a landowner should be responsible for a river when the government and the rest of society are not paying for it. We need proper legal structures in place [for environmental development]."

For Waisea Naisilisili, the legal structures around natural resource management already exist through the traditional *mataqali* system. He says a strong sense of customary land ownership would mean a stronger sense of environmental protection: "The majority of people don't want [industrial activities like mining] to take place because it's going to destroy the area and the livelihoods of all the people living downstream."

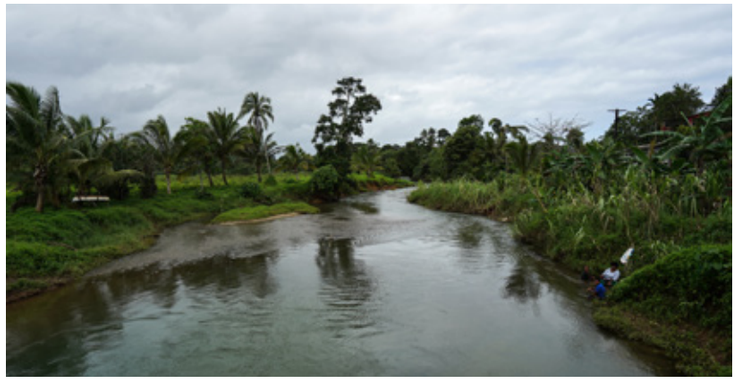
In addition to global and regional challenges like climate change and land use change, the loss of customary control over traditional land is yet another factor that broadly affects water quality and the spread of disease.

Community and Household Sanitation and Hygiene

Confusion over land tenure and interactions between anthropogenic activities, water quality, and health occur in river catchments across Fiji's Central Division. "Coastal villages are at the receiving end of the entire catchment and they can't control the risks that are produced by upstream practices," says Marc Overmars, Chief of WASH with UNICEF Pacific. "Deforestation is one thing, but there are also cows and pathogens that go in the stream and attach to sediment particles. These go down the stream, go into the water intake, and people don't treat the water. You can boil water in a household but it's actually already too late."
Overmars' role with UNICEF Pacific is dedicated to accounting for and improving the water, sanitation, and hygiene (WASH) standards available in villages—the inner layer of the onion when it comes to addressing the risk of typhoid transmission in a nested manner.

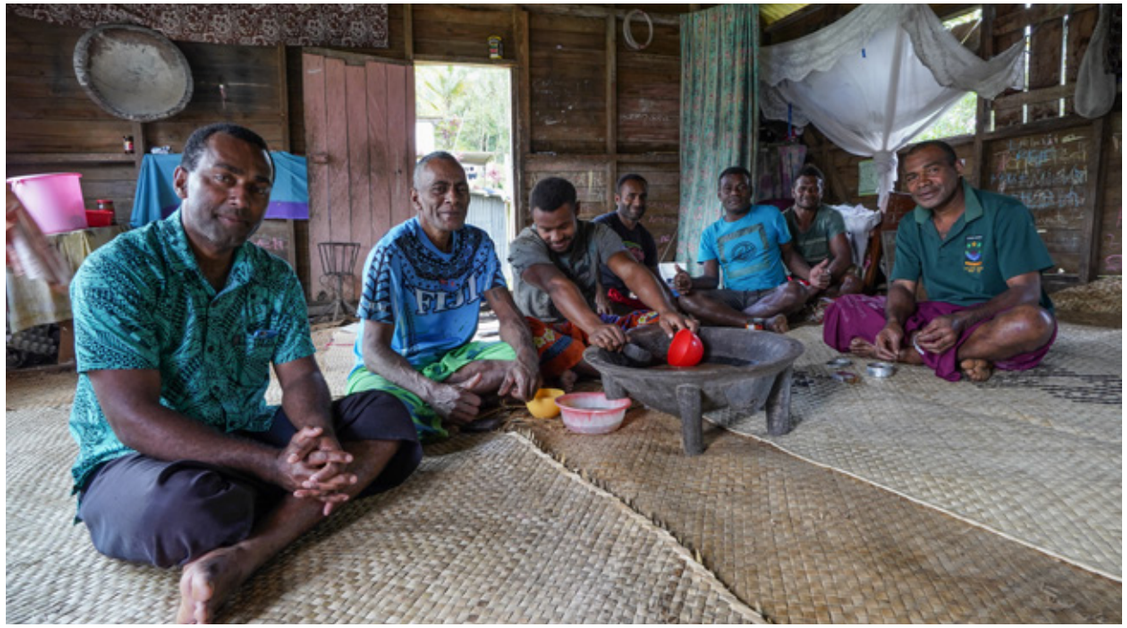
Travel along the Queen's Road highway from Naqarawai back to the capital city of Suva and it's hard to miss the sign announcing your arrival in Nabukavesi—the village's name is emblazoned in bold white text on a billboard advertising Fiji Bitter, one of the country's most popular lagers.

Turn off the highway and the road continues along a concrete bridge crossing the Nabukavesi River. Part of the Navua River catchment that extends into the highlands, Nabukavesi is one of the last downstream communities in Central Division before the river spills into the Pacific Ocean. Along its journey, this river runs through more than two dozen villages and settlements, including Naqarawai, splitting to form smaller tributaries and creeks that serve as primary and secondary sources of community drinking water.



The Nabukavesi River.

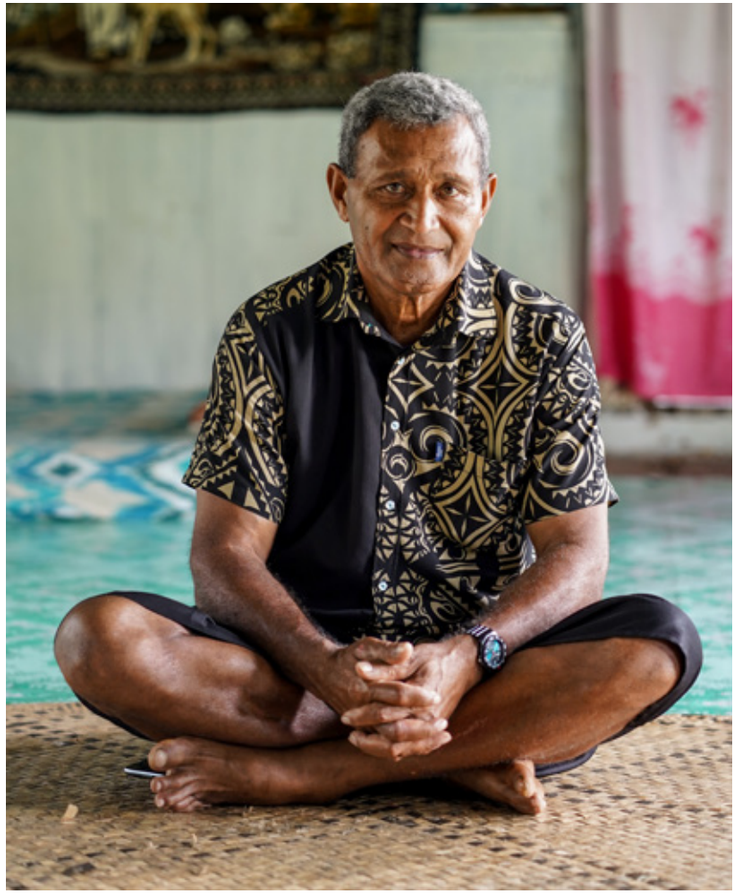
Today, after a month of rain, the river passing through Nabukavesi is some four-meters wide, its current meandering lazily along green banks. Two women squat along the grassy edge washing clothes. A young girl leaps from the bridge, her flip flops bobbing next to the spot where her splash sends ripples downstream. The scene is a good illustration of the role the river plays in the lives of community members: play area, washing machine, and, when the taps are off, a source of water for drinking, cooking, bathing, and cleaning.



On one side of Nabukavesi is the home of chief Ratu Aisea Naisilisili, Waisea Naisilisili's uncle. As is customary when arriving in any Fijian village, the visit starts with a kava ceremony: the presentation of the dried kava root which is ground, mixed with water, and strained to make a drink called *yaqona*. Served in a large *tanoa* bowl, kava ceremonies are considered your passport to a village. In Fijian culture, many important topics are discussed over hours of this slightly sedative mixture. Today, one of those topics is water security.

Waisea Naisilisili (far left) and Naqarawai Chief Ilaisa Kuruibua (far right) with other residents of the village. They're sitting around a tanoa, the name for the carved wooden bowl that holds kava, a ceremonial drink in Fiji and other Pacific cultures. It's often during rounds of kava that important matters are discussed.

Ratu Aisea Naisilisili is the chief of Nabukavesi village



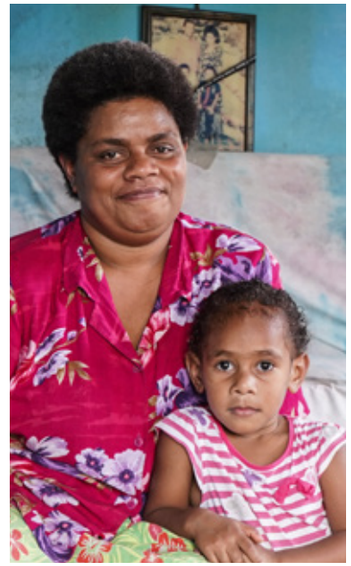
Born in 1957, Chief Naisilisili says Nabukavesi looks a lot different today. He was a teenager when the New Zealand army built the reservoir and pipe system that still supplies the village with water. At the time, the water was enough for the 20 households. Now, that water supply is exhausted daily by the 100 homes and 250 students who come from nearby villages to attend the local school. Household taps are closed mid-morning and in the afternoon to prioritize water for school use. Nabukavesi's reservoir also faces many of the same sediment clogging issues as that of Naqarawai.

There's also the issue of aging or insufficient sanitation infrastructure. That's highlighted in a village tour with Luse Mociwai. Mociwai has been a community health worker in Nabukavesi for the past six years, and is one of two volunteers in charge of tracking village health data and advising on basic community health concerns. She leads the way past homes constructed of corrugated metal and wood slats; stray dogs basking in the sun; and large blue plastic barrels that collect and store piped reservoir water for in-home use, especially when the taps are turned off.

Down the concrete path, you pass nearly as many outhouses as homes. While not the most visually appealing part of a village tour, the type of latrine system used by a family has notable impact on typhoid fever risk. Of the typhoid fever cases included in a Central Division case-control study, 95% of people who tested positive for the disease had unimproved sewage systems or improved systems that had been damaged. Damage can be caused by the aging of infrastructure, but also by externalities like increased use due to the growing population of communities and natural disasters. When damaged, the buried steel drum systems can corrode and flood, contaminating surface water and everything in its path, including food sources.

Baulina Tabuamoli, head of Nabukavesi's women's committee, is one of the residents who has changed her behavior since the typhoid outbreaks affected her community. As part of the committee, she and other women gather weekly for communal meals of bele (a type of cabbage), cassava, taro, and other boiled vegetables with coconut milk. Large community gatherings are an important part of Fijian culture, and everyone in the village is put at risk if unhygienic food preparation is practiced. The meals served at those gatherings now involve boiled water for drinking, the washing of vegetables, and cleaning thoroughly afterwards. "Cleanliness is close to godliness, isn't it?" chimes in Elenoa Lewavunivalu, another Nabukavesi resident. "We have to be clean in everything. Prevention is better than a cure."

The role of WASH practices in the broader context of environmental changes like land use change and climate change support the need for a nested solution to improve water quality—one that addresses actions and behaviors at various scales. A new project has set out to consider these nested, water-related complexities at a household, community, river subcatchment, and national level, and get stakeholders at all levels working together in addressing them.



Baulina Tabuamoli is the head of the women's committee in Nabukavesi. Communal food preparation is common in Fijian culture, and in Nabukavesi the women's committee has taken it upon themselves to ensure everyone is using clean water to wash vegetables, clean, and cook. She's pictured with Asela, one of the younger residents of Nabukavesi.

An Integrated Approach to Fiji's Water Challenges

For all the damage Cyclone Winston caused in 2016, the natural disaster is often seen as a turning point in the way Fiji deals with issues of water safety and water-related disease. At no time are new and multidisciplinary ways of working together more urgent than in the weeks following an emergency.

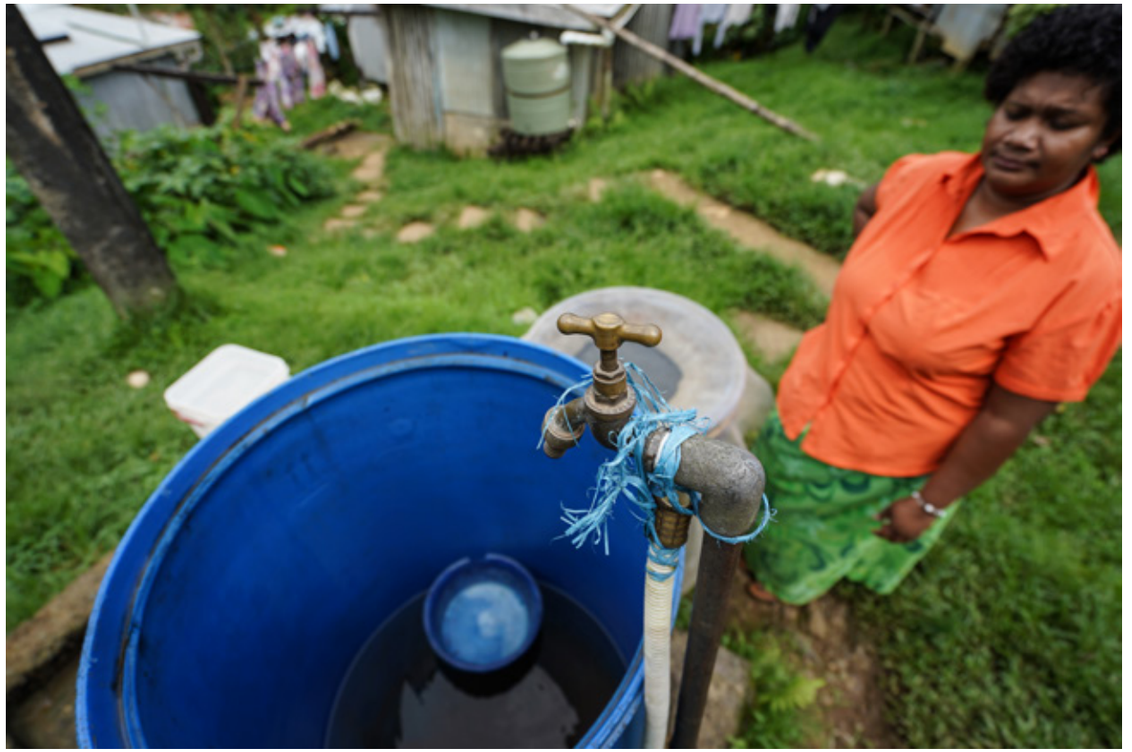
Much of that collaboration was out of necessity—Fiji had depleted its emergency WASH kits within four weeks of Winston's landfall, and was left scrambling to prioritize disaster and recovery response. The national government needed more data about water quality to do that, and turned to surveillance from the four Fijian ministries that deal with the issue. "During Winston, our lack of coordination as key government agencies working in the WASH sector showed up," says Suliasi Batikawai, a Senior Environmental Health Officer and WASH Coordinator with the Ministry of Health. Batikawai says there was duplication of services and overlap between government agencies once the recovery process began in mid-April 2016. Each agency was doing their own water sampling and monitoring.

Winston was the first time multiple sectors collaborated on the issue of drinking water safety, says Dr. Aalisha Sahukhan, the Head of the Health Protection Division with Fiji's Ministry of Health. She says the monitoring data the country needed was challenging to gather. "We had existing surveillance systems but these were often hampered by delays in the time from reporting to action, which was not helpful for early warning for outbreaks," says Sahukhan.

Post-Winston disaster response and recovery pressed the government to make monitoring more effective.[xxv] The country started using a World Health Organization system called EWARS (Early Warning, Alert and Response System) to better detect and respond to disease outbreaks. It has since become one of Fiji's permanent surveillance systems. The country also started creating a National Drinking Water Quality Committee and National Drinking Water Standards, and Sahukhan hopes both can be formalized through the multi-sectoral collaboration.

At a national level, Sahukhan sees an opportunity for the Ministry of Health to better collaborate with other groups focused on water quality. "While drinking water quality and the spread of disease is our responsibility, we don't control all the moving pieces that affect water," she says. "So the ministry's role in [the Watershed Interventions for Systems Health (WISH) project] is very much addressing this responsibility while also pulling in other stakeholders who are in charge of aspects like access to water and infrastructure."

[xxv] A silver lining of disasters and emergencies is that if done right, one can look back and learn a lot from the original response. What are some examples of lessons learnt of disaster and emergency response in your country, and how these have been incorporated in new legislation or procedures?



These large plastic vats are a familiar scene outside of homes in rural Fiji. While some homes have indoor taps, many families rely on these containers filled with tapped water from the local reservoir.

The WISH project is the latest intervention to address integrated water management in Fiji. The project launched in October 2018, and brings together stakeholders from various academic disciplines, Fijian ministries and agencies, and international and Pacific region NGOs.

An Integrated Watershed Approach in Guam

WISH isn't the Pacific Region's only example of an integrated watershed management project. Another is underway on the tiny island of Guam, a U.S. territory in the West Pacific. It's called the Guam Restoration of Watersheds initiative (GROW), and it's a project of the University of Guam's Center for Island Sustainability.

Similar to Fiji, Guam faces a number of inland challenges that affect the island's marine environments. The most urgent of those is southern Guam's badlands. Badlands are once forested areas that are now bare, with topsoil wiped away to expose bedrock that makes the regrowth of vegetation difficult. The island's badlands area has grown by nearly 9% between 1973 and 2001, and research has found that badlands are the category of land cover that contribute the largest amount of soil erosion each year—much of which ends up in waterways and coastal ecosystems.[33] The expansion of badlands can be attributed due to natural causes like heavy rainfall and cyclones, as well as human activity.[34] That activity includes irresponsible off-roading, arson fires, and invasive species such as deer and pigs.

GROW is experimenting with several creative and low-tech approaches to replant and restore the badlands. One method involves the use of sediment filter socks—sausage-shaped, biodegradable socks that stretch across a high-erosion area, preventing sediment from reaching waterways. A study on the effectiveness of this method found 19 kilometers of sediment socks, installed with 11,000 replanted trees, could trap enough sediment to allow the coral reefs of one bay in southern Guam to recover from the effects of erosion.[35]

Two other innovations more specifically target reforestation. Seed balls and sling stones are easily-produced creations of soil, clay, seeds, fertilizer, and compost. Dropped from drones or tossed onto the badlands by hand, the seed sling stones take root and begin revegetating erosion prone areas. "We deliberately chose native plants that were easy to recognize and gather so there's enough availability of seeds," says Else Demeulenaere, a botanist and the Associate Director of the Center for Island Sustainability. There's also a traditional link—sling stones were historically an almond-shaped weapon crafted of limestone and clay and thrown during battles.

According to Demeulenaere, getting the community and the off-roading industry involved in badlands restoration is key. "The watersheds are so big, and we really wanted people to take reforestation into their hands, even if the degradation is often not their fault," Demeulenaere says. "We also made it a fun activity. I think it's more sustainable to engage communities rather than just solving the problem yourself and not talking about it."

A $2 million project funded by the Australian government through its Indo-Pacific Centre for Health Security, WISH addresses the water, sanitation, and river catchment management tactics that could reduce outbreaks of Fiji's "three plagues": typhoid fever, dengue fever, and leptospirosis.[xxvi] Just as typhoid cases are increasing in Fiji, so too is incidence of the latter two diseases. There were more than 15,000 confirmed cases of dengue fever, a mosquito-borne disease, during an outbreak in 2013-2014.[36] Similarly, there's been a three-fold increase in leptospirosis in Fiji, another water-borne disease transmitted when people come in contact with infected urine. Like typhoid, leptospirosis outbreaks are more common after flooding events, with 83% of cases occurring within six weeks of a flood.[37] Landscape changes such as deforestation and river damming are suspected to affect the spread of all three diseases.[38]

[xxvi] Before moving forward, what common risk factors do you think these three diseases have?

The WISH team is made up of 10 chief investigators from universities in Australia and Fiji, including Dr. Aaron Jenkins and Dr. Joel Negin, the WISH project lead and head of the University of Sydney's School of Public Health. WISH also brings in 10 associate investigators, experts from the Pacific Community, UNICEF, the World Health Organization, and Fijian government bodies including the Ministry of Health and Medical Services and the Water Authority of Fiji. All have worked on some aspect of health, water, or sanitation before, though this is the first time the group is gathering as part of a project with a common aim.

Dr. Aaron Jenkins—a self-portrait.

Building on the work of many researchers, public health officials, and NGOs in this room, WISH has determined river subcatchments to be the most relevant scale in which to investigate and intervene in water-related diseases. Over the next three years, the project will work in 18 rural and peri-urban villages in three Central Division subcatchments. A baseline survey at the beginning of the project will measure the water access and sanitation behaviors of 15 households in each of those 18 villages, and a community mapping exercise will plot where people get their water and which latrines are most likely to pollute those sources. This will allow the project to address the inner layers of the onion—the community and household behaviors that can mitigate the spread of disease.

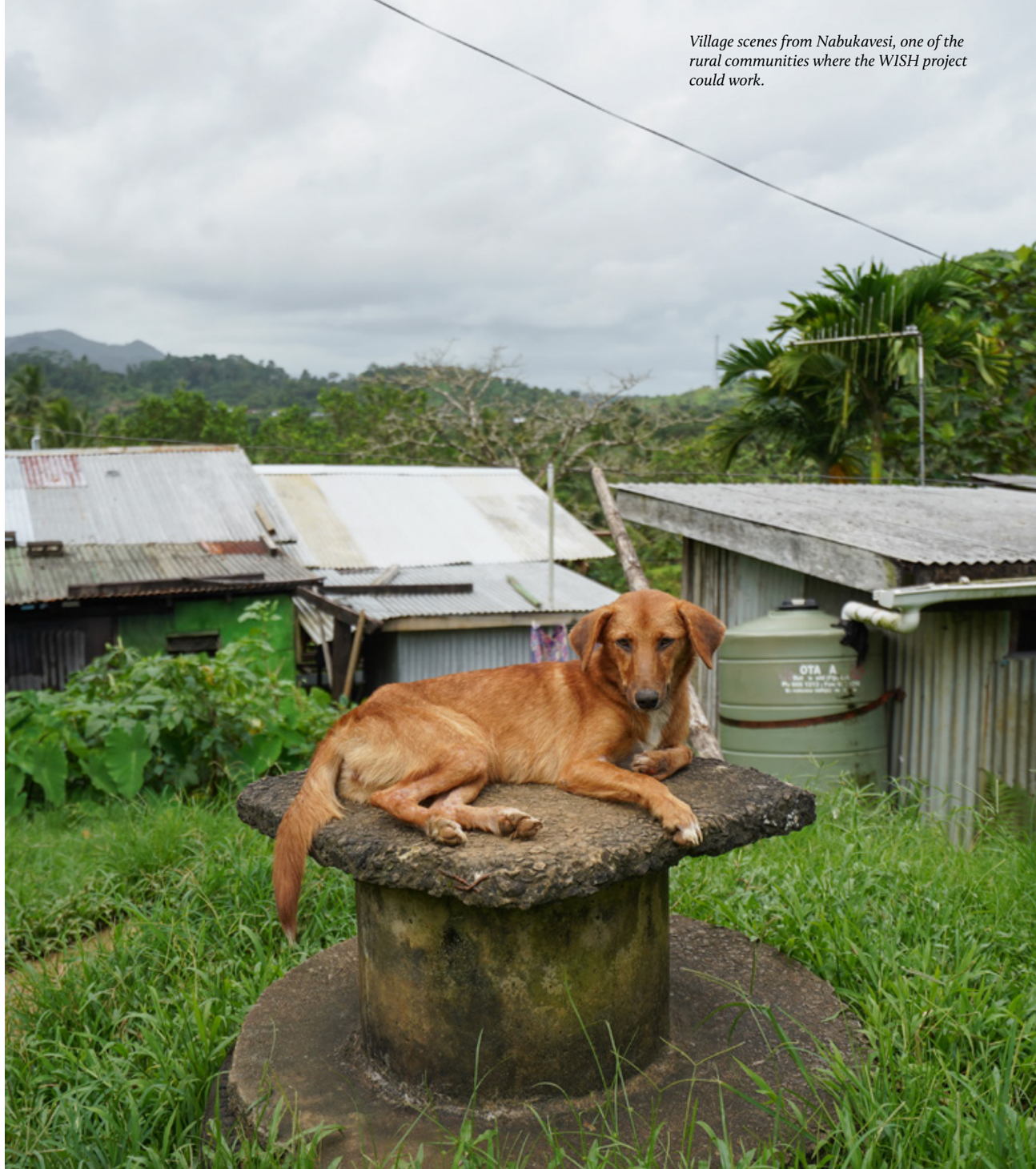
The WISH project also relies heavily on village-level participation in data collection. An objective is to gather as much real-time information on the layered factors that put people at-risk of water-

borne and water-related diseases—those upstream, community, and household actions identified in the 2014-2017 typhoid case-control study. That information could populate a national database and, after integrating with meteorological and rainfall data—the outer layer of the onion that includes global climatic shifts—create a score for each community based on its risk of waterborne disease.

That score could then be used for informed decision-making at both a village and national level. Village-wise, community members could learn which simple actions to prioritize in order to secure their drinking water quality—anything from cleaning water tanks to repairing a leaking reservoir pipe to deciding which water source to use for cooking versus cleaning. The project also involves an education component: working with safe drinking water committees and other village groups to protect ecosystems like forests that provide natural protection from waterborne disease—the regional layer in the onion analogy.

At a national level, a risk score could be used by relevant government agencies to prioritize funding and water safety interventions before disaster strikes. Finally, when a natural disaster does inevitably occur, the national government could use the information platform to see which villages are most vulnerable to water-related disease outbreaks and prioritize emergency response. The ease of access and interpretation of this data is key—"we're drowning in data but starved for information," reminds one individual at the WISH project launch.

In the case of outbreaks, WISH is training a team of Fiji Outbreak Field Officers (FOFOs), a group that will rapidly respond to disease outbreaks and use the EWARS tool to do local surveillance. "If information is being regularly collected every time there's an outbreak, then we start to learn about the conditions in which those events normally occur," says Aaron Jenkins. "You can then program machine learning into the database and that would allow us to improve the prediction and response to water-related disease. This is what we're thinking about in the long-term."



Village scenes from Nabukavesi, one of the rural communities where the WISH project could work.

WISH is just one project to address the relationship between healthy environments and healthy people. Addressing these intersections at individual, household, and community levels is not enough. Regional restoration of landscapes can contribute to addressing poor water quality at its source. There's some history of this being successful in Fiji.

River buffer zone protection—the fringing of trees next to water bodies—and reforestation can improve an ecosystem's ability to provide critical services such as clean water. In 2017, research linking forest clearing and typhoid was successfully used to lobby Fiji's Forestry Department to commit to enforcing river buffer zone laws. These policies set aside areas ranging in width from 10 meters to 30 meters, preventing development too close to the riverbank.[39] That commitment came as part of the national strategy for typhoid prevention and control—a key acknowledgement of how public health research can be used to influence natural resource management and policies. Buffer zone restoration could also reduce the amount of eroded sediment that washes into streams, which could translate to healthier freshwater and marine fish species, a win for conservation, food security, and local livelihoods.

To that end, the WISH project also fits into the goals of a larger ridge-to-reef approach in Fiji. While WISH will implement and measure interventions that affect the inland health of people and ecosystems, a complementary project called Vibrant Reefs assesses how those interventions affect marine ecosystems. The project is being led by the Wildlife Conservation Society in Fiji.

Prior research has connected algae growth and coral bleaching to sediment and nutrient run-off from commercial agriculture and mining activities.[40] Those impacts on marine ecosystems can collapse fisheries, which affects the food security and well-being of people who depend on the resource.[xxvi] Vibrant Reefs intends to monitor the impact that reduced sediment runoff and improved water quality has on coral reefs and food fish. Like WISH, that information will then be used to drive policy-making—by establishing which river subcatchments should be prioritized in order to offer the best return-on-investment for inland and coastal ecosystems as well as public health.

[xxvi] Coastal ecosystems are explored in depth in the Sri Lanka study. How does eutrophication and coral bleaching affect human health, both directly and indirectly?

While the restoration of physical ecosystems could reduce disease transmission, so too could the restoration and respect of cultural traditions, customary land ownership, and the agency of Indigenous iTaukei clans to manage their lands. Only then can people fully maintain reverence for that environment, treating it with the same care as past generations as opposed to with a sense of complacence. "Our villages are very unique, and there are rules of the chief that bind them," says Waisea Naisilisili. "When outside development and worldviews come in it makes people do whatever they want to do, and that includes disrespecting the environment."

Naisilisili is optimistic the WISH project can successfully work with local communities, and respect their cultural traditions. This, he says, is because the work deals with peoples' lives and their source of water—a key medium for physical health and cultural well-being.

According to him, projects must tap into the traditional connections clans have with their local environment. "This is the only way we can understand more, because this is our identity and this is how we connect ourselves to nature. It's always important that scientific research respects traditional knowledge," Naisilisili says. "There is a place where the two will meet, and in this case it's that they agree on the importance of water."

Keeping Track of Who's Who

Suliasi Batikawai

Senior Environmental Health Officer and WASH Coordinator, Fijian Ministry of Health

Rosa Batiri

Naqarawai resident, mother of Ruci

Luse Mociwai

Community health worker in Nabukavesi

Jovili Mototabua

Head of Naqarawai's drinking water committee

Marc Overmars

Pacific WASH Coordinator, UNICEF

Dr. Aalisha Sahukhan

Head of the Health Protection Division with Fiji's Ministry of Health and Medical Services

Dr. Aaron Jenkins

Fisheries ecologist; planetary health researcher whose PhD focused on the environmental determinants of typhoid

Ratu Ilaisa Kuruibua

Chief of Naqarawai village

Elenoa Lewavunivalu

Nabukavesi resident

Ratu Aisea Naisilisili

Chief of Nabukavesi village

Waisea Naisilisili

Fisheries and Operations Support Officer with the Wildlife Conservation Society, Fiji; resident of Nabukavesi

Dr. Joel Negin

WISH project lead, Head of the University of Sydney's School of Public Health

Baulina Tabumoli

Head of Nabukavesi's women's committee

Dick Watling

Environmental consultant and Founder of NatureFiji-MareqetiViti.

Acknowledgements

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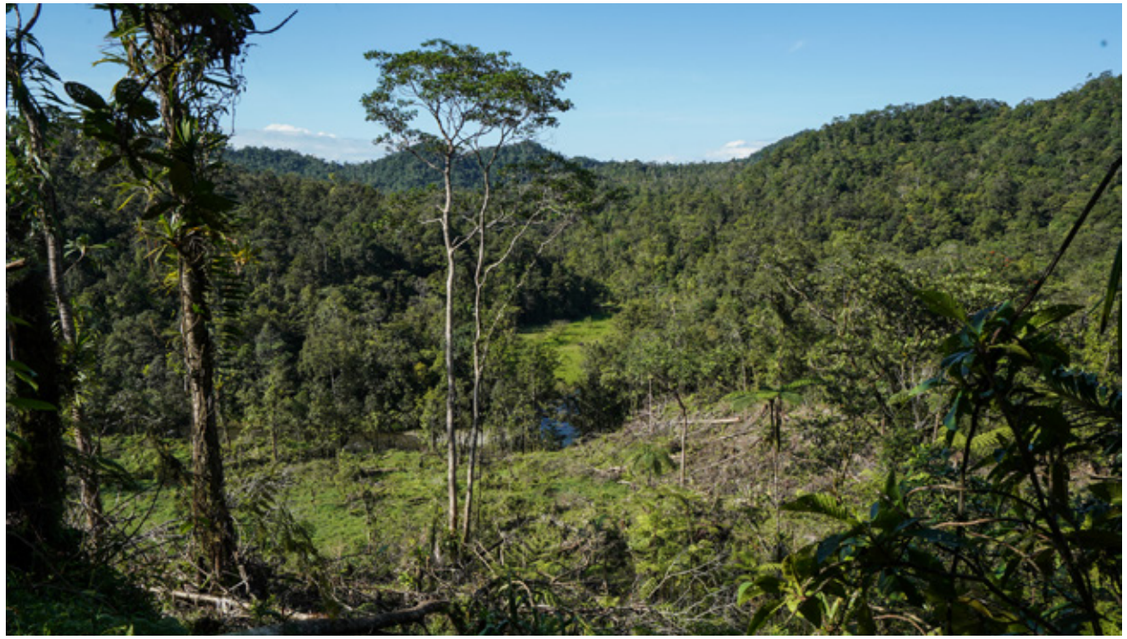

An area of cut forest in the highlands of Viti Levu, Fiji's largest island.

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