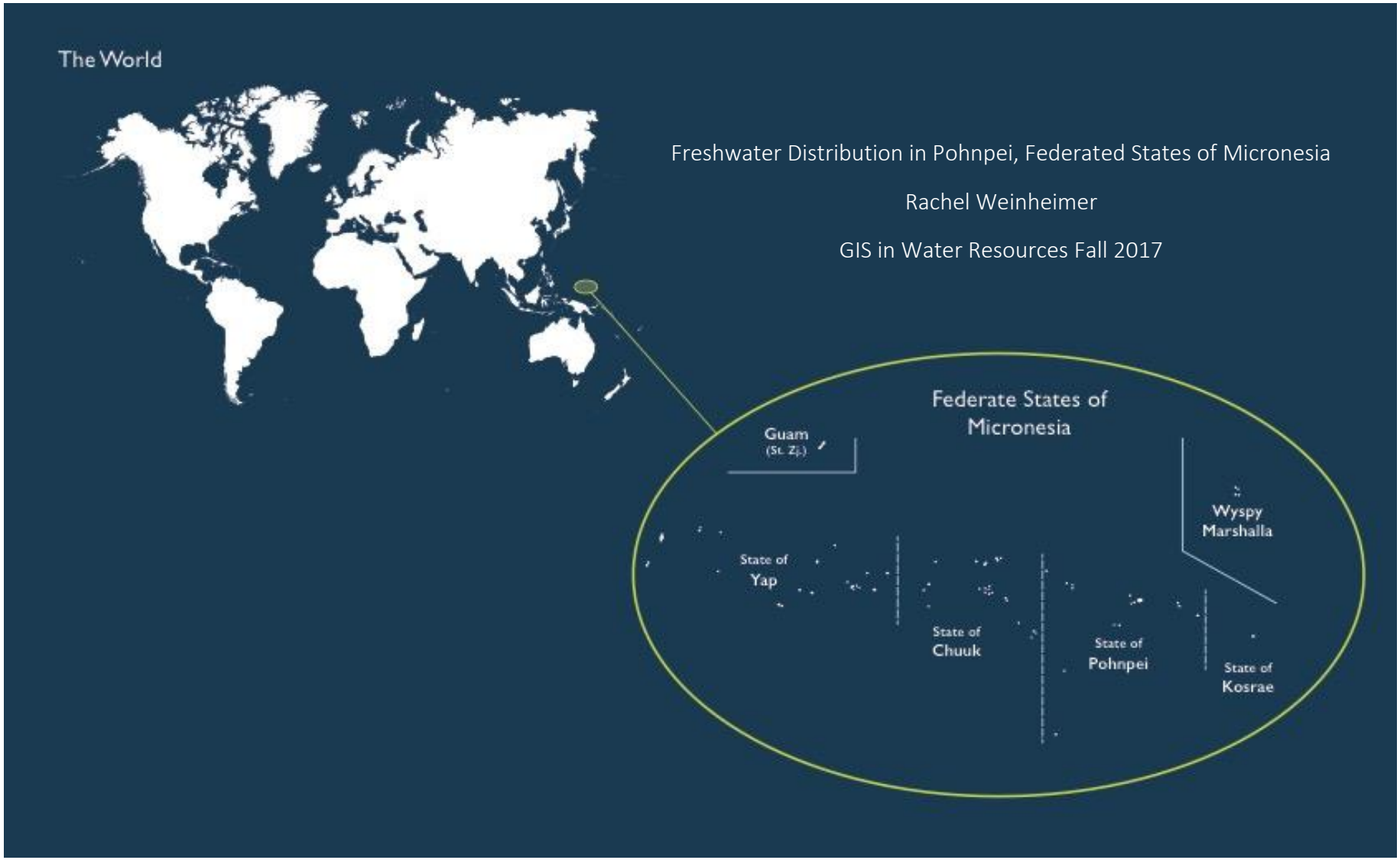

Freshwater Distribution in Pohnpei, Federated States of Micronesia

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Introduction

The Federated States of Micronesia (FSM) is made up of a chain of over 600 islands spanning one million square miles in the Pacific Ocean. Although it is an independent country, the FSM is considered "freely associated" with the United States. Through a Compact of Free Association, the U.S. provides economic assistance to the FSM and visa-less migration rights to its citizens in exchange for exclusive military control of its territories.

Because of the Compact, the U.S. government is legally obligated to respond to disaster declarations in the FSM. Though the Compact is designed to address acute disasters, a gradual trend of water degradation throughout the islands remains unaddressed. Insufficient access to clean water is a direct contributor to disease and illness and indirectly effects migration patterns, development, education, and the distribution of aid from international donors. Despite millions of dollars in aid, inadequate progress has been made in improving access to safe drinking water for island communities.

Water availability directly impacts the number of people these small islands can support. Whereas island populations were previously limited by resources available on the islands, Micronesians migrate to the U.S. (especially Guam and Hawaii) when resources become scarce. Both Guam and Hawaii receive additional funds from the U.S. Government to help mitigate the impact of Micronesians on services related to health and social welfare.[1] Increasingly, aid organizations are called to respond to islanders' dependence on water catchment systems and in extreme situations, they provide islands with reverse osmosis machines to deliver potable water during droughts.

Objectives

Although this project began with the intention of assessing water quality issues across the four primary islands of the FSM, the available data was inconsistent and the markedly different climates do not lend themselves to easy comparison. The capitol island of Pohnpei is the most-studied of the FSM islands (in terms of land use and water resources) and is the seat of government. This paper attempts to synthesize data and studies related to water quality in Pohnpei, with particular attention to:

- Comparative maps of elevation and precipitation data
- Land cover trends and analysis
- Demography – population and water resources distribution

On Data in the FSM

When the political status of the Federated States of Micronesia with the United States changed from Trusteeship to Free Association in 1986, all the stream flow gages that were built and monitored by the US Geological Survey were halted and effectively abandoned. In 2005, researchers from the University of Guam formed the Water and Environmental Research Institute of the Western Pacific, funded by the U.S. Geological Survey and the U.S. Department of the Interior. Their mission is "to seek solutions through research, teaching and outreach programs, to issues and problems associated with the location, production, distribution and management of freshwater resources in Guam, the CNMI and the FSM."[2]

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[1] https://www.doi.gov/oia/reports/Compact-Impact-Reports
[2] http://www.weriguam.org/index.html

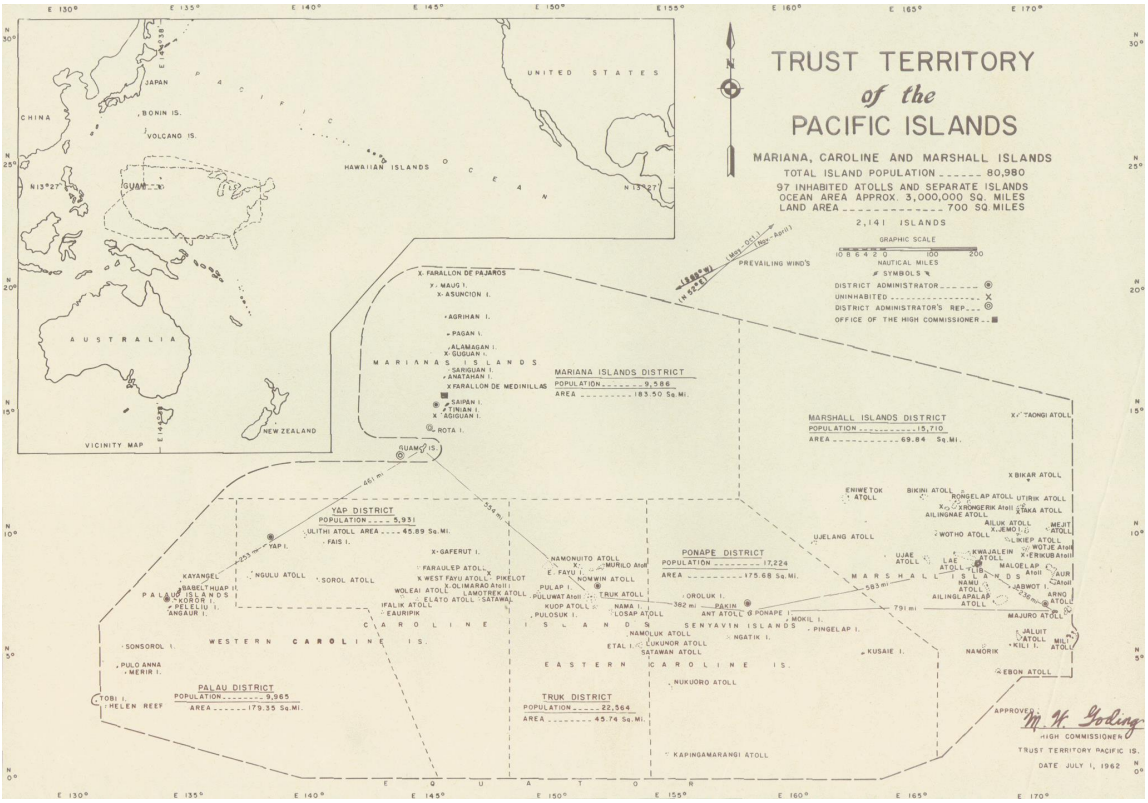
Their website provides a comprehensive list of publications related to freshwater issues in the region.[3] The Island Research and Education Initiative (iREi) is also an invaluable source of current information for environmental data related to the FSM.[4] The all-volunteer team engages directly with the island communities to better understand the unique aspects of implementing sustainable environmental practices in a culturally complex region. They attempt to balance the preservation of island cultures with the growing pressure of island governments to request and accept vast quantities of aid from foreign governments, primarily the U.S. and China.

Description of Study Area: The Federated States of Micronesia

The FSM consists of rural, remote and least-wealthy (RRLW) small islands. This means that they are impacted by their physical geography and relative lack of exchange of information and technology with the outside world.

The geographic location of the Federated States of Micronesia is in the western Pacific, between the Republic of Marshall Islands (RMI) and Palau. It consists of 607 islands scattered over more than one million square miles (three million square kilometers) of ocean. The islands consist of both small basalt (high) islands and coral (low) atolls. Many islands are extremely isolated and difficult to access. This affects the implementation of national policies, maintenance of technologies, effectiveness of government regimes, and communications.

Map of the U.S. Trust Territory of the Pacific, 1961



[3] http://www.weriguam.org/publications/weri-technical-reports.html
[4] https://www.islandresearch.org/

Figure 1: Pohnpei Elevation Model Stream Network

Data from USGS and the University of Hawaii[5]

Description of Study Area: Pohnpei

The state of Pohnpei includes the main, high island of Pohnpei and the low outer-islands of Pingelap, Mokil, Ant, Pakin, Ngatik, Nukuoro, Oroluk, and Kapingamarangi. Pohnpei is the largest (334 km^2) and most populous (34,000 people) island in the FSM.

Pohnpei's growing population and the development of a cash-based economy which taxes natural resources is threatening Pohnpei's fragile habitats. Large areas of native forests and ecologically sensitive areas are being cleared for housing and road development, in addition to the growing prevalence of unmanaged agricultural activities (primarily sakau[6] planting areas). Unregulated development has also contributed to unsanitary water conditions which pose serious health risks to the islanders. In 2000, a cholera outbreak resulted in several deaths and hundreds of cases of severe illness. Land and mudslides are also an issue due to increased soil erosion.

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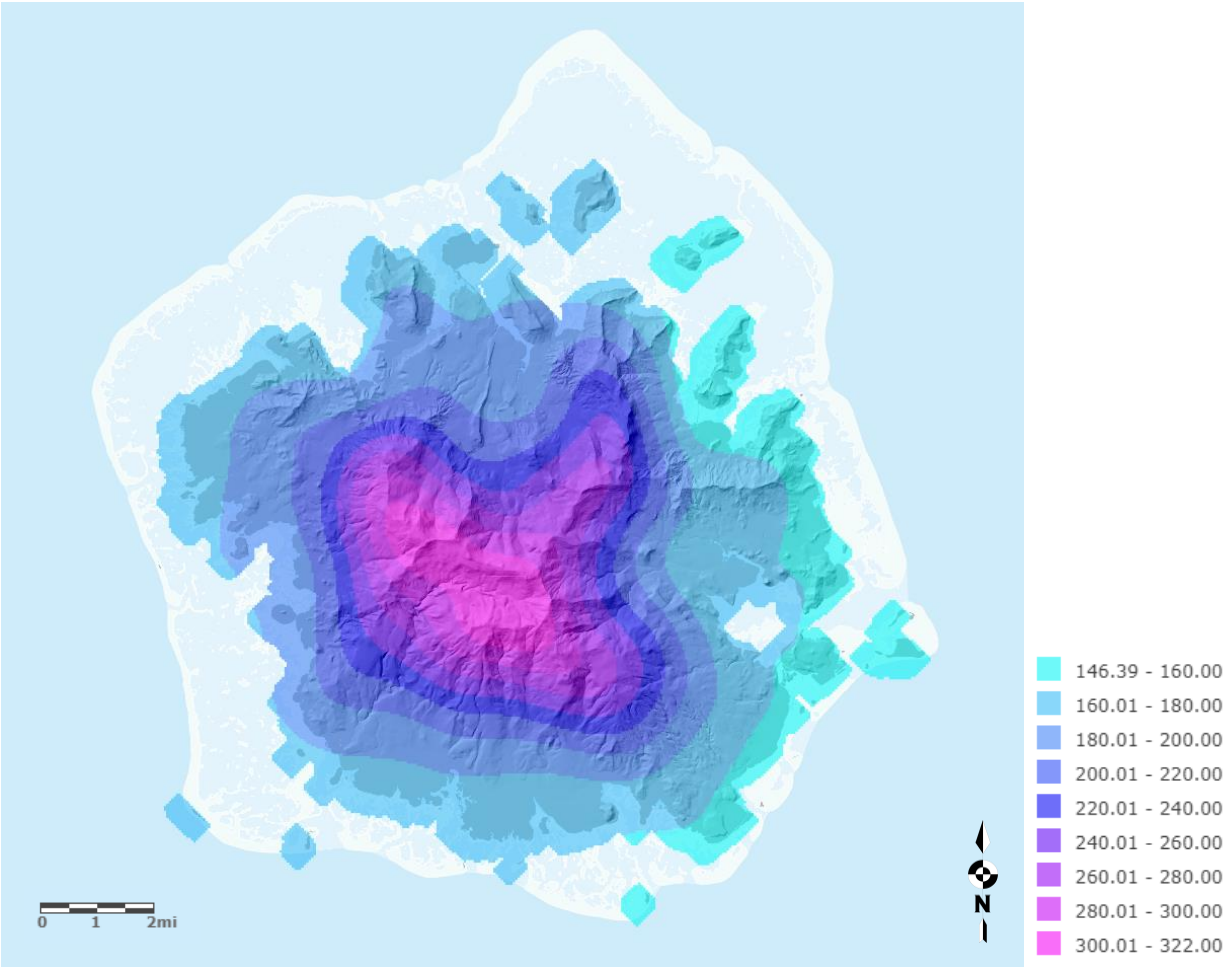
[5] http://www.pacioos.hawaii.edu/metadata/usgs_dem_10m_pohnpei.html

[6] Sakau – also known as kava – is a type of pepper plant native to Pohnpei. When the roots of the plant are pounded and prepared, a mixture is produced which, when consumed, provides a mild narcotic effect. The consumption of this drink was traditionally reserved for special ceremonies amongst traditional leaders, but is now consumed more frequently.

Figure 2: Pohnpei Annual Precipitation (inches)



Climate of Study Area

The average annual rainfall in Pohnpei is 150 inches at the coast and approximately 310 inches in the upper part of the Nanpil River, towards the mountainous center of the island, which is classified as a tropical montane cloud forest.[7] The Nanpil River, a tributary of the Kiepw River, has an average discharge per square miles of 15.1 ft^3/s or 9.8Mgal/d). The peak discharge of the Kiepw River below the Nanpil River was determined by the USGS to be 26,000 ft^3/s or 16,800 Mgal/d from an 11.2 mi^2 drainage area. A cursory comparison between the elevation map (Figure 1) and the precipitation map (Figure 2), shows a strong correlation between elevation and precipitation.

[7] Raynor B. (1995) Montane Cloud Forests in Micronesia: Status and Future Management. In: Hamilton L.S., Juvik J.O., Scatena F.N. (eds) Tropical Montane Cloud Forests. Ecological Studies (Analysis and Synthesis), vol 110. Springer, New York, NY

Figures 3 and 4: Land Cover Comparison in Pohnpei[8]

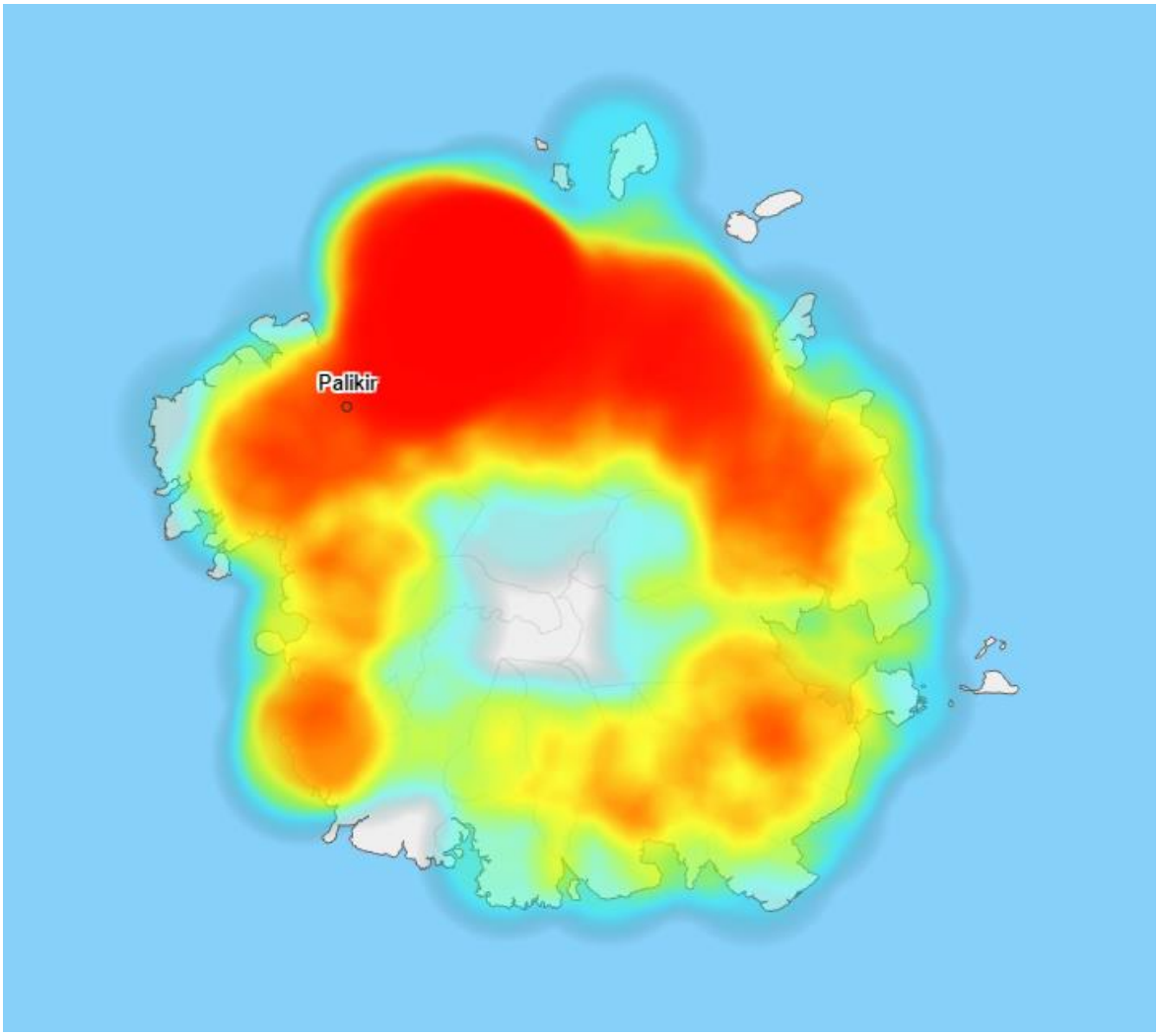
1995

2005

This land use comparison spanning a decade reveals that Pohnpei's upland forests are gradually disappearing in favor of agroforests, which are managed ecosystems. This type of agricultural activity on an island with limited land resources and a diverse ecosystem will tax the delicate endemic flora and fauna. The growth of secondary vegetation is also significant. These areas have been degraded to the extent that natural species are no longer able to grow in the new environment, giving way to 'pioneer' species (both invasive and endemic) which are not typically found in the area. The urban growth appears limited and is mainly concentrated on the north side of the island near the town of Kolonia.

[8] All data collected by the Island Research and Education Initiative

Figure 5: Heat Map of Population Density Generated from 2010 Census Data



Demography of Pohnpei

This heat map reveals that the majority of the island's 34,000 inhabitants live in the northern districts of the island. Very few live in the center due to its rugged, mountainous terrain and harsh living conditions. This map is meant to give a general idea of the population distribution. I was not able to find a way to generate a legend which would describe the exact range, but the upper limits (in red) represent a population density of approximately 3,000 people per square mile.

Prism Analysis of Water Usage

All Data Generated from FSM Government Census Data (2010)[9]

Figure 6: Percent of Households Using Streams or Rivers as Primary Source of Drinking

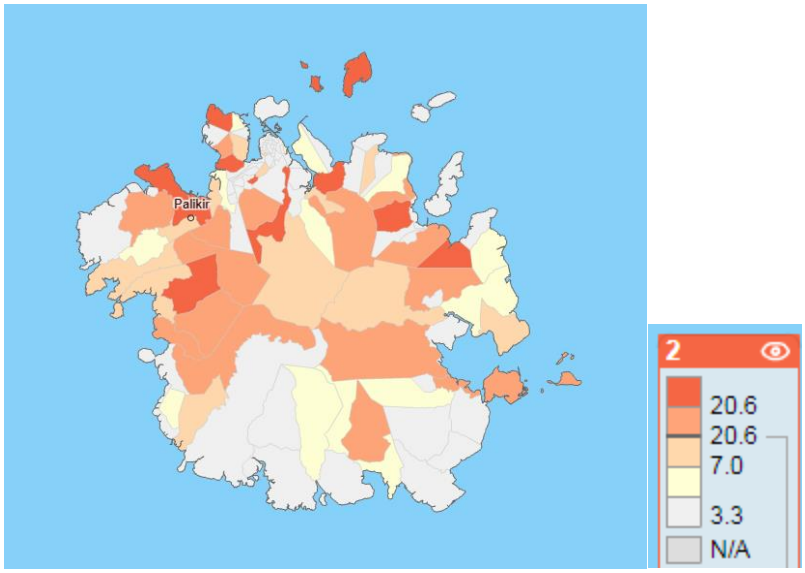
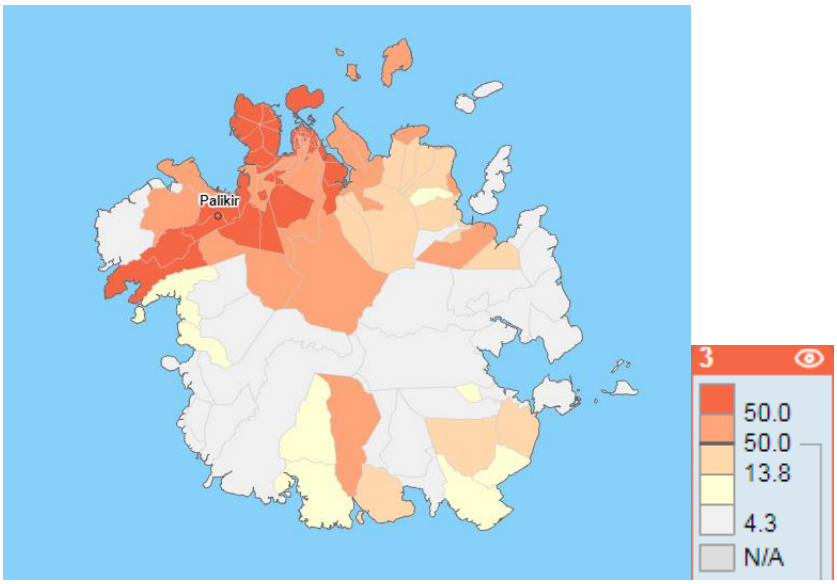


Figure 7: Percent of Households Using Piped Water as Primary Source of Drinking



[9] http://prism.spc.int

Figure 8: Percent of Households Using Bottled Water as Primary Drinking Source

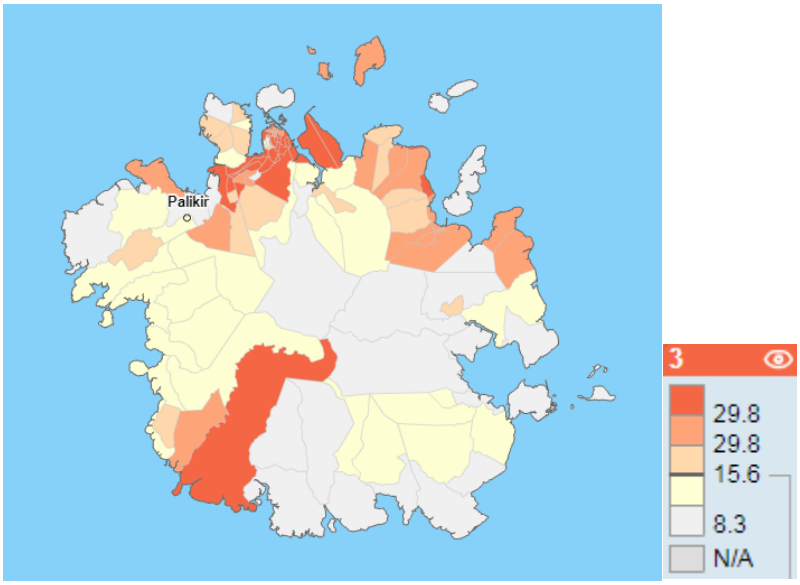
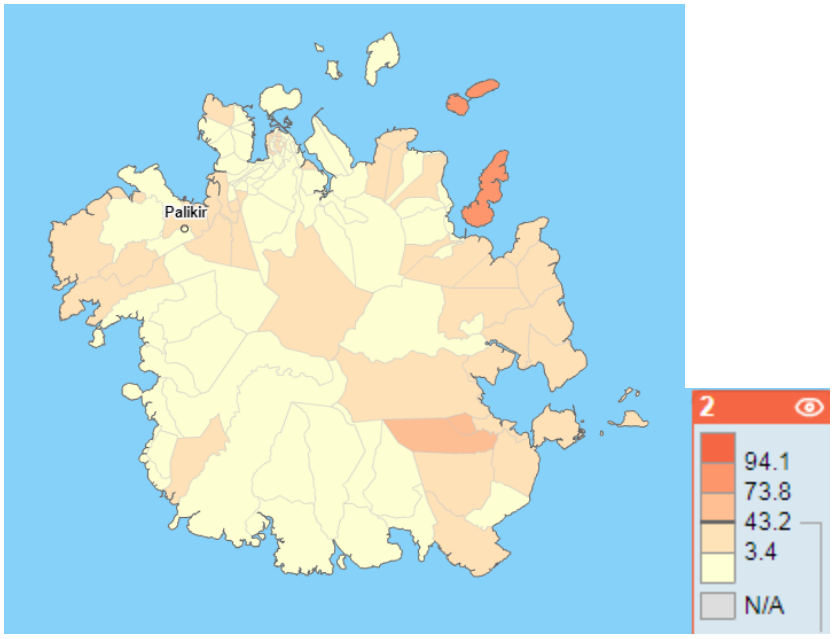


Figure 9: Percent of Households Using Water Tanks as Primary Drinking Source



Analysis of Water Consumption Data in Pohnpei

The combination of the four maps above provides a general overview of how people consume water in Pohnpei. I generated these maps by using data incorporated in the census, which is conducted every ten years and largely follows the same protocols as in the U.S.

Figure 7 shows that around half of households in the northern part of the island use water provided by public utilities. It is not clear, however, why so many households in the north and around the periphery of the island utilize streams and rivers as opposed to piped water. My hypothesis is that (1) the households are too sensitive to the price of piped water, (2) the households perceive that the water in streams and river is clean enough for human consumption, or (3) the water infrastructure is in need of repair or non-existant.

Although bottled water is the safest form of potable water in Pohnpei and widely available, it is expensive. Figure 8 shows that its use is limited to households living near the town of Kolonia and in the southwest district of Kitti.

Watertanks are a ubiquitous feature on islands across the Pacific. Two comprehensive studies of rainwater catchment systems have been conducted in the FSM – one in 1985[10] and the other in 2015.[11] The literature on this subject confirms that rainwater catchment systems are the primary source of potable water in Micronesia.[12] Therefore, it was surprising to see the extremely low percentage of islanders using water catchments in Pohnpei. According to Figure 9, catchment systems are mainly utilized on the islands of the northeast district of U. These islands would not have the infrastructure for piped water and according to the precipitation map (Figure 2), receive the lowest amounts of rainfall. Additionally, the groundwater may be brackish or contaminated. Because Pohnpei receives rain on an almost daily basis, there is little perceived need to store and collect water for times of scarcity.

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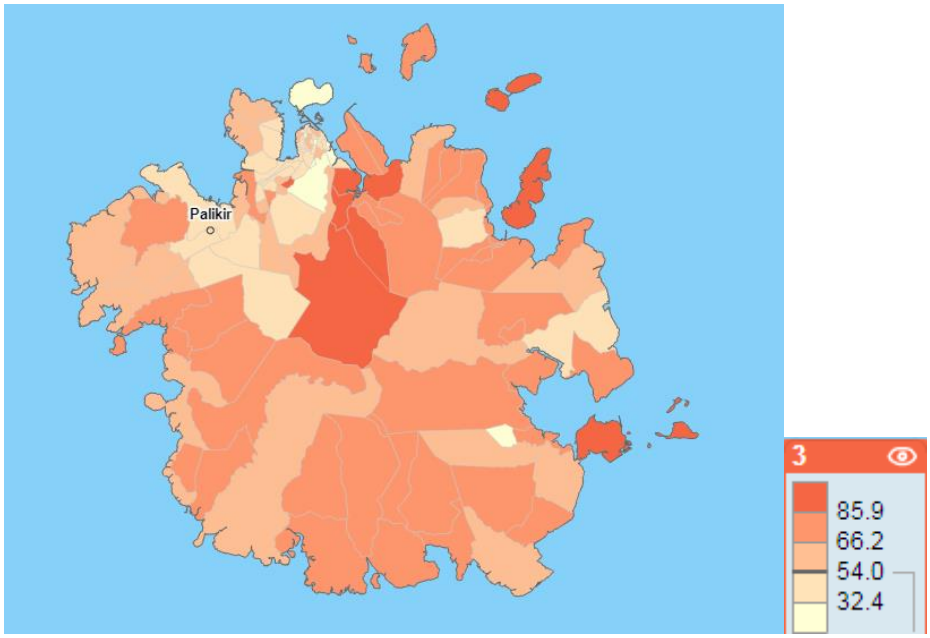
[10] Dillaha III, Theo A., and William J. Zolan. "Rainwater Catchment Water Quality in Micronesia." Water Research, vol. 19, no. 6, 1985, pp. 741-746.
[11] Wallace, Corey D., Ryan T. Bailey, and Mazdak Arabi. "Rainwater Catchment System Design using Simulated Future Climate Data." Journal of Hydrology, vol. 529, 2015, pp. 1798-1809.
[12] Ibid.

Figure 10: Percent of Households Owning At Least One Pig



Impact of Piggeries on Water Quality

One critical factor in the assessment of water quality in Pohnpei is determining the impact of pig pens. Although pigs are not endemic to the islands of Micronesia, they have become an important part of the cultural fabric, especially in Pohnpei which has a 'feasting culture' not seen on other islands.

A 2016 assessment[13] of 40 freshwater rivers and streams found that 68% were not safe for recreation and none were safe to drink. When this data is analyzed in conjunction with Figures 5 and 6, the health implications are alarming. Figure 6 shows that the majority of residents in Pohnpei are concentrated in and around the northern districts. The majority of those drinking from streams are also concentrated in the north. Although Figure 10 shows a diffusion of pig-owning households throughout the island, the geography of Pohnpei is mountainous and pig waste from the center districts will flush out towards the periphery of the island, where many people drink from streams.

The fresh water quality standard for E. coli bacteria is 0 mpn/100mL for drinking water and less than 576 mpn/100 mL for recreation or bathing. According to the impact assessment, the rates of E. coli contamination in Pohnpei rivers and streams ranged from 115 mpn/100 mL to 58,500 mpn/100 mL.

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[13] Fukumoto, Deenik, Hura, Kostka. *Piggery Impacts to Water Quality of Streams in Pohnpei, Federated States of Micronesia*. College of Tropical Agriculture and Human Resources, University of Hawai'I at Manoa, 2016.

Additionally, each of the 4,000 pigpens in the state of Pohnpei utilized 233 gallons of water per day for wash-down operations.

Conclusions

In Pohnpei, water use by residents is often unrestricted and water-conservation measure are difficult to regulate. Conserving water is not intuitive on an island considered to be one of the wettest-inhabited places on earth. However, an increasing population taxes public utilities systems and water outages spanning from hours to days are not uncommon in Pohnpei. Those without safe access to drinking water may turn to streams and rivers, which are polluted and can lead to disease and even death. The main findings of this report are particularly relevant to health policy. Hospitals could be equipped with a data application that correlates health risks with particular water sources. Using a GIS tool, a hot-spot analysis of outbreaks could quickly inform health practitioners which streams are polluted (even over a specified time interval). A mechanism could then be developed to warn residents living near contaminated streams that the water is not safe for consumption or recreation.

The data from these maps also point to a need for alternatives for islanders who utilize streams and rivers as their primary source of potable water. Although the use of water catchment systems is low, their utilization could be encouraged through an awareness campaign. However, this does not address the root cause of the pollution – the improper maintenance of piggeries. Pohnpei's Environmental Protection Agency maintains strict laws and guidelines related to pigpen management, but levels of enforcement remain low. Previous studies in similar contexts[14] show that streams and rivers are resilient; once waste disposal into a stream is halted, safe water quality can be re-established within 4-5 months. The USDA in Pohnpei is currently taking steps to incentivize proper maintenance of piggeries through a program in which islanders can collect and sell pig manure for fertilizer. It is unclear at this point if this will be adopted on a larger scale by the islanders.

Finally, it became clear during the literature review that water initiatives throughout the islands of the Pacific are only successful with community buy-in. Island cultures are extremely diverse, yet most are sensitive to outside influence. Projects which incorporated traditional practices concerning water management proved far more effective than those that imposed complex and difficult-to-maintain infrastructure systems.

[14] https://www.epa.gov/sites/production/files/2015-11/documents/as_afuelo.pdf

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