



Availability, usage, and threats to freshwater resources on low carbonate islands in Micronesia

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Federated States of Micronesia (FSM) is an insular nation in the western Pacific. It consists of 4 high volcanic islands and 37 low carbonate units, mostly coral atolls. The high islands are relatively large, and are developing socioeconomic centers of the country, whereas low islands are small and remote outposts of traditional subsistence lifestyle. The latter are inhabited by a fifth of the nation's population of 107,000 people. Total land area of a typical low island is a fraction of a km², yet may be home to hundreds of people, creating some of the highest population densities in the Pacific. The resultant extreme pressures on natural resources are exacerbated by severe weather hazards, especially typhoons and unusually high tides which have recently flooded some islands in entirety, damaging homes and food sources.

Freshwater resources are particularly sensitive. Crowded low islands have some of the world's most unfavorable relationships between population density and freshwater availability. As there are no communal or municipal facilities and government operated infrastructure, people have only two sources of water available for consumption: rainwater and groundwater. Rain is captured by individual households' thatch or corrugated iron roofs and transferred by gutters to concrete or fiberglass tanks. It is used for drinking, cooking, and dishwashing, and depending on availability, for laundry and showering. Such arrangement are highly unreliable, because they depend on sufficient rainfall and islanders' ability to capture and store it. Some communities have actually run out of water in the past, as a result of prolonged droughts or typhoons' damage to the catchment systems. In addition, tropical climate and pervasive organic matter and microorganisms make the tanks' maintenance difficult, because even most conscientious cleaning cannot ensure that stored water remains potable. Stomach problems and more serious health complications are common.

Groundwater resources are meager and vulnerable. The minuscule size and elongated shape of atoll islets mean that they contain diminutive and dispersed groundwater bodies. Unlike groundwater lenses of typical islands, they are long sausage-shaped "groundwater cylinders", with inconsistent depth and width, and discontinuities depending on local geography. As land reaches barely a few meters above the sea, water penetrating from the surface to base level undergoes practically no filtration in the vadose zone. Furthermore, atoll islets' highly permeable compacted sediments and diagenetically immature reef limestone means that groundwater moves in all directions via high primary porosity and undergoes little filtering even within the phreatic zone. For those reasons, groundwater is easily contaminated by human and animal waste (from outdoor toilets and piggeries) and certain household waste (such as detergent and battery acid), as well as by human burials (for traditional reasons performed in immediate vicinity of households). Local people extract groundwater from shallow hand-dug wells and use it for laundry, showering, and watering animals. During major droughts or other emergencies, groundwater is used for other purposes as well, even for drinking when situation is dire. However, groundwater on some islands is losing its potential as emergency source due to excessive pollution and saltwater intrusion from storm waves and overwhelming tides.

The extent of specific problems is different on various islands, but cannot be presently evaluated due to lack of data. This study is the first systematic effort to examine the current availability, usage, and condition of freshwater resources on each and every low island in the FSM. Results are being released in individual island

reports as they become available, and are being provided to government planners, resource managers, engineers, educators, environmental scientists, and others dedicated to sustainable use of freshwater resources and alleviation of environmental hazards related to living on small and remote carbonate islands.