The Lost Treasure of King Cane: How the Death of an Industry Can Bring New Life to Oahu

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Problem Statement

The Pearl Harbor aquifer is the most important freshwater resource in Oahu, Hawai`i, providing water to nearly 40% of the state's population. Recent studies show that current water demand is reaching or exceeding sustainable use [1]. Climate change and increasing resident and visitor populations are predicted to further reduce sustainability of the aquifer.

Ref: Urban coastline of Oahu, Photo by R. Dahlquist, Fine Art America

After the collapse of the sugar industry on Oahu (mid-1990s), the Waiahole ditch—a massive stream diversion bringing water from the island's windward to the leeward side—became a hotly disputed resource. Commercial interests and traditional farmers have clashed over the water, which could also serve to support the Pearl Harbor aquifer. **Considering competing interests, impending scarcity, and uncertain future conditions, how can this resource be put to the best use? The Water Diplomacy Framework offers a model for analyzing such complex issues through multiple disciplines, identifying intervention points, and proposing sustainable solutions.**

Water Diplomacy Framework

We explore 3 key tasks that are central to Water Diplomacy: identifying stakeholders, modeling possible future scenarios, and finding options to create value for mutual gains [2].

THE WATER DIPLOMACY FRAMEWORK

ACKNOWLEDGE KEY ASSUMPTIONS

- Water is a flexible resource.
- Science, policy and politics combine to create water networks.
- Water networks are complex.
- Assumption #1: Water networks are open and continuously changing.
- Assumption #2: Water network managers must take account of uncertainty, non-linearity and feedback.
- Assumption #3: Water networks need to be managed using a non-zero sum approach to negotiation.

THEORY: CHARACTERIZE WATER NETWORKS PROPERLY

- Distinguish among simple, complicated and complex water networks.
- Identify appropriate domains, levels and scales.
- Recognize that the natural, societal and political domains (NSPD) are interconnected.
- Locate problems on the certainty-uncertainty and agreement-disagreement continua.
- Understand what it means to operate in the Zone of Complexity.

PRACTICE: MANAGE WATER NETWORKS PROPERLY

- Recognize that simple, complicated and complex water networks require different management approaches.
- Ensure appropriate stakeholder representation.
- Engage in scenario planning and joint fact-finding.
- Emphasize value creation.
- Mediate informal problem-solving and seek consensus.
- Commit to adaptive management (AM) and organizational learning.
- Implement an appropriate management strategy for each water network.

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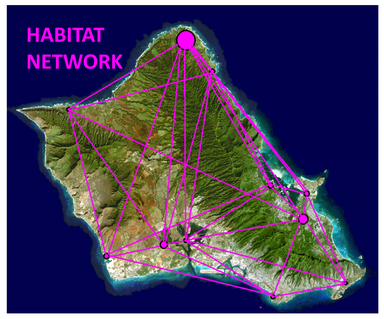
Stakeholder Identification

A professional neutral party can help identify relevant stakeholders, summarize their values, interests, and concerns, and distribute that information to all parties involved in negotiations [2].

CATEGORY	EXAMPLES
Federal Agencies	US Army and Navy, Environmental Protection Agency
State of Hawaii	Department of Agriculture, Commission on Water Resource Management
County of Honolulu	Department of Planning and Permitting, Department of Environmental Service
Leeward Parties	City of Honolulu - Board of Water Supply, Large Land Owners, Large Water Users
Windward Parties	Native Hawaiian groups, Makawai Stream Restoration Alliance
Other	Research Centers, Conservation Groups, Community Associations

Creating Value

Wetlands in the Hawaiian Islands support >25 endangered or threatened species [3]. Populations of endemic waterbirds like the Hawaiian gallinule (*Gallinula galleata sandvicensis*; below left) travel between wetlands creating habitat networks. Those networks consist of wetlands (nodes between which animals move) and paths ("links" between habitats) (right). Human land use affects habitat networks by altering the quality of nodes and paths [4].



As Oahu's human population and water demands grow, it will be important to preserve wetlands essential to the network. Wetlands also provide ecological services, so maintaining the habitat network can create mutual benefits between anthropogenic and wildlife objectives. For example, managed golf course water hazards might provide valuable habitats for migrant waterbirds.

As of 2005, there were ~13,000 acres of former sugarcane land on Oahu. Combining diversified agriculture with agri- and eco-tourism offers an opportunity to preserve that land from urban development, provide wildlife habitat, and create economic growth.

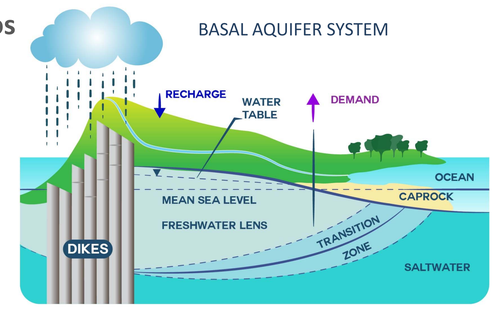
Ref: Hawaiian Gallinule, Photo by D. DesRochers

Ref: Sugarcane land in transition, Photo by B. Amstutz

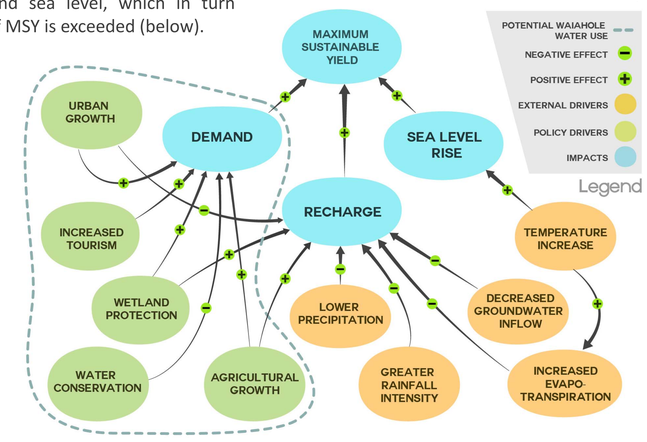
Identifying Critical Scenarios

Key System Drivers

Pearl Harbor has a basal aquifer (right), which is a freshwater aquifer in contact with seawater. When pumping exceeds recharge, the freshwater lens contracts and saltwater elevation increases. Maximum sustainable yield (MSY) is the pumping rate at which acceptable well depth salinity levels are sustained and depends on recharge rate and sea level. A series of drivers influences demand, recharge, and sea level, which in turn determine if MSY is exceeded (below).

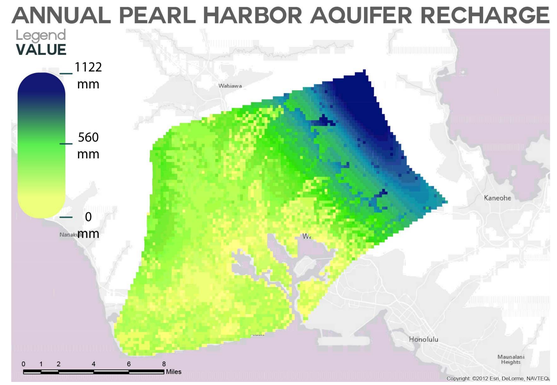


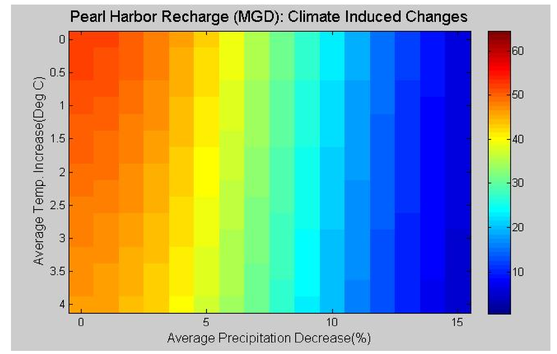
Adapted from [11]



Robust Analysis of the Pearl Harbor Aquifer

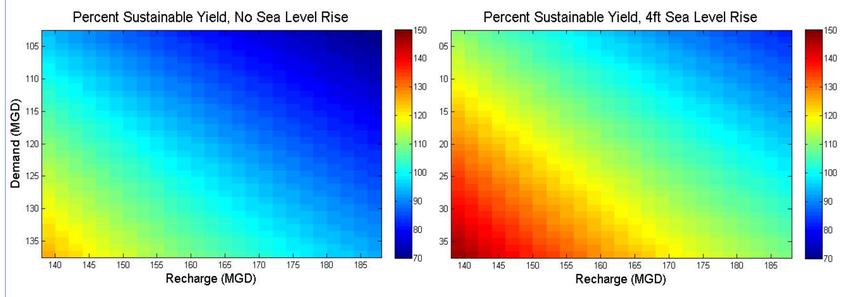
To support the Water Diplomacy Framework, we used a robust analysis to model the Pearl Harbor aquifer to identify critical scenarios (scenarios in which policies would fail to meet their goals) [5]. We developed a simple recharge model based on the Soil Conservation Service (SCS) runoff method and the Thornthwaite water balance model. The model uses soil properties, land cover, and precipitation contours to characterize the basin, and daily rainfall and temperature to drive the model [6-9]. The model outputs the spatial distribution of recharge (top right) which can inform policy decisions such as where to allow urbanization by highlighting areas where most of the recharge is occurring.





We then ran the model for a range of temperature and precipitation changes and averaged results to get mean values for each combination [10]; the results (above right), show that **climate changes could significantly reduce recharge because temperature increases cause higher evapotranspiration, increased rainfall intensity increases runoff and lower precipitation decreases total water available.**

We then conducted a sensitivity analysis of MSY to the 3 primary drivers using the steady state RAM2 model developed by Liu to update sustainable yield for the Pearl Harbor Aquifer [11]. Demands modeled ranged from current to those projected for 2030 [12]; the range of recharge is based on modeling results. The figures below show the percent of MSY required for demand and recharge sets for both zero and 4 feet of sea level rise. **Results suggest climate change and population growth will significantly reduce the sustainability of the PHA.**



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350-1000 C.E. Polynesians colonize Hawaiian Islands

1778 Captain James Cook reaches Hawaiian Islands, Western economic influence begins.

1848 The Great Mahele: Water and land rights shift from public trust to private ownership, western agricultural interests gain political power.

1875 The Reciprocity Treaty signed by the U.S. and the Kingdom of Hawai`i; allows free trade of sugar, fuels the explosive growth of the sugar cane industry.

1893 Queen Lili`uokalani overthrown, due in part to western business interests

1898 Hawai`i annexed by U.S.; sugar magnates hold the majority of political power.

1912 Waiahole Ditch completed by Oahu Sugar Company.

1959 Hawai`i statehood; economy starts shift away from agriculture, urban populations expanding rapidly

1991 Population growth in Pearl Harbor Basin causes concerns regarding housing shortages and huge increases in residential, industrial and commercial water demand.

1992 Sugar industry in Hawai`i crashes; massive water-transfer infrastructure and land freed

1995 Oahu Sugar Company closes operations on Oahu; water transferred by Waiahole ditch; cultivated land available for reallocation.

1997-2013 Multiple attempts by Commission on Water Revsource Management do divide Waiahole ditch water between leeward and windward interests; all decisions opposed; revisions called for by state Supreme Court; millions spent on litigations; disputes currently unresolved.