Haven Atolls Discussion Paper

The Haven Atolls Project is a proposal to enable Pacific Island Nations to adapt to ocean warming, acidification and sea level rise in ways that will deliver economic growth and investment, protect coral reef ecosystems from climate change, and contribute to global security priorities in food, energy and climate.

Haven Atoll projects are generally what Pacific Islanders have been implementing but with some newly evolving science and larger scale considerations. We, Ocean Foresters,[1] represent some thirty seaweed experts, water and wastewater resources engineers, ocean engineers, oceanographers, and business people. We would like to learn what and where Island peoples would like small and large scale demonstrations. We will assist with pro bono proposal preparation and can be available to follow-through over the decades needed to support Haven Atolls.

Local authorities and communities would select which of the following general components would start their Haven Atoll, including the location for the first Haven Atoll. The first Haven Atoll should involve more research and demonstrations of the many ways to provide each component. While, all components can be provided with current products and technology, the economic sustainability of Haven Atolls will be improved by establishing products new to Island Nations in ways enabled by emerging technologies.

1) Resource cycling: There will be no wastes on Haven Atolls. Waste engineers are moving toward economic resource recovery. Haven Atolls will include transformation of biomass, plastics, and other wastes into energy even while all the pathogens are killed and organic nitrogen, phosphorous and minerals are recovered as commercial grade fertilizers.
2) Deep Ocean Water (DOW): Raising cold water from the deep ocean can protect the coral reef ecosystem from hot surface water and prevent coral bleaching.
3) Intensive multi-trophic aquaculture: Growing micro-algae and macro-algae (seaweed) for food, to support growth of other foods such as fish, to reduce DOW acidity, and potentially to provide energy and carbon storage.
4) Land and infrastructure raising: Haven Atolls will employ natural methods, such as mangrove forests, mixed with mechanical means to adapt to sea level rise while increasing freshwater supplies and protecting houses, farms, schools, etc.
5) Economic growth: Haven Atolls aim to deliver local jobs, capacity and skills, through export of food, fertilizers, and energy and improving tourism. Attracting private investment partners will enable replication at scale.
6) Other opportunities: Cleaning up polluted lagoons, contributions to global ocean science.

Examples of Possible Haven Atolls

Eventually, we envisage that many coral reefs, island lagoons, and even bays, could become Haven Atolls to protect their ecology and engage with the world economy. Haven Atolls will provide field locations for small and large scale research, trials and demonstrations, while providing local jobs, food and fertilizer. The diverse features of the four atolls pictured on the next page are intended to help Island Nations suggest an initial atoll and what might be the first phase of development priorities.

Funafuti, Tuvalu is relatively remote with medium population and a large lagoon.

Beqa Lagoon, Fiji is relatively easily accessed with a resort population, and a large lagoon.

Kanton, Kiribati is relatively remote, but with a large runway, a tiny population, a large lagoon, and could double as a base to enforce fishing laws.

Tarawa, Kiribati, is a larger atoll with population over 50,000.

[1] http://oceanforesters.org/Contact.html

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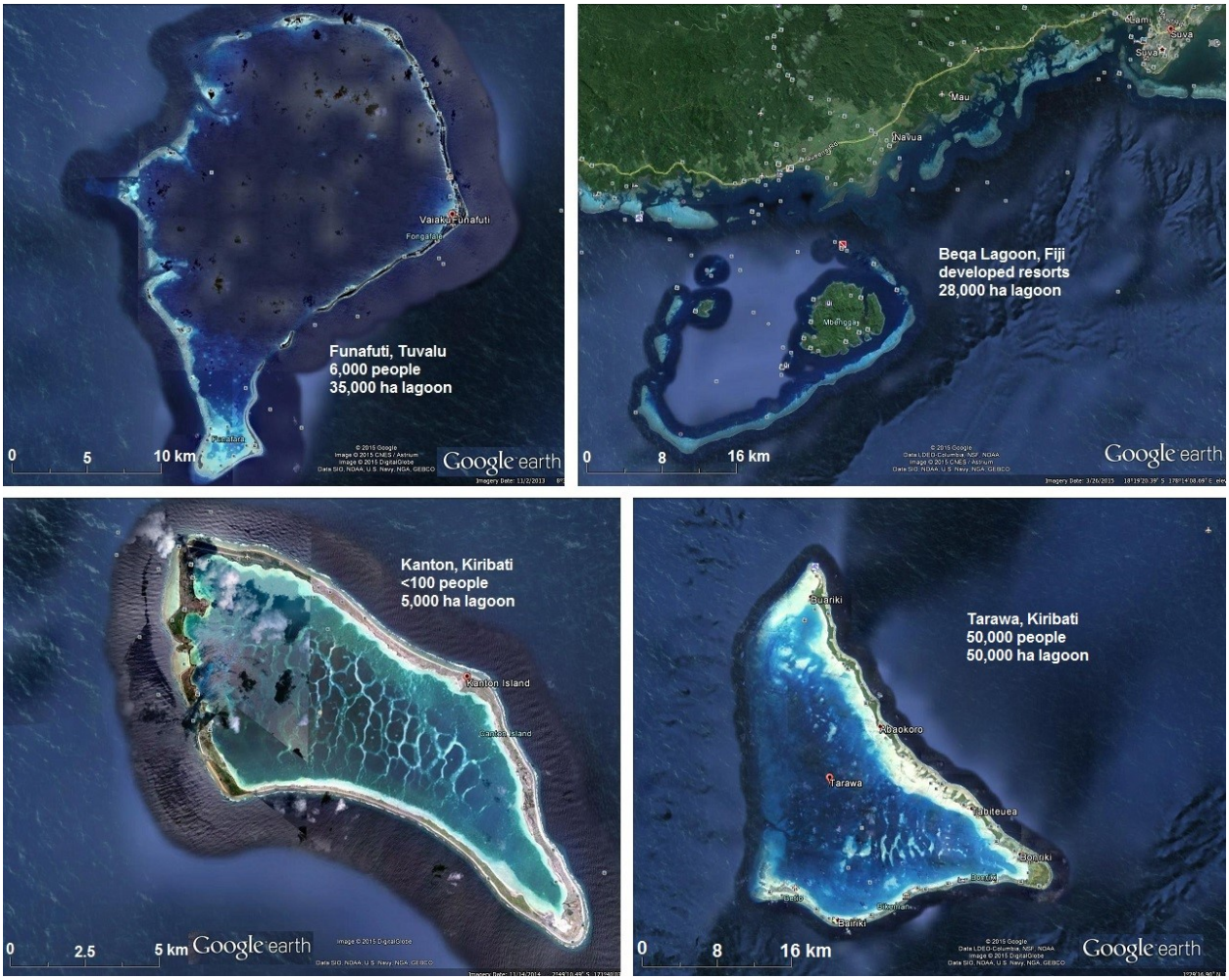

There are hundreds of candidate atolls.

The first phase of development for large lagoons with small populations might emphasize: a) saving coral reef ecosystems from bleaching with cool deep ocean water (DOW); b) growing food while conditioning DOW by growing seaweed to remove CO_2, add O_2, and reduce acidity; and c) trials of raising land levels to sustain agriculture.

For larger populated atolls, Haven Atolls' Phase 1 might emphasize: a) waste-to-energy with nutrient recovery systems; b) growing local food in pristine water with the recovered nutrients; and c) demonstrations of raising land by assisting nature. It may be practical to lift DOW for crop research. Lower temperature water could enable new high-value export products.

As Haven Atolls develop, they will become economically self-sustaining havens delivering mutual benefits for communities and their coral ecosystems. The Haven Atolls aim to be an important frontier in global efforts to respond to climate change. They will:

a) Preserve the livability of atolls in spite of global human impacts.

b) Sustain healthy coral ecosystems around the atoll and for the many species dependent on them while keeping the natural coral breakwater growing as fast as sea level rises.

c) Substantially increase global food, energy and climate security.

d) Implement technologies to reduce local oceanic CO_2 concentrations (thus decreasing ocean acidity) with oceanic seaweed forests in and around each Haven Atoll.

Why Haven Atolls

Atoll communities face the real danger of becoming climate refugees due to sea level rise. This existential risk can be averted with benefits for all of humanity, and for Earth's oceans, by protecting the coral reef ecosystems which atolls support. The lifecycles of many open ocean species use coral reef ecosystems as havens. The collapse of coral ecosystems, which has already started in some places[2] and which scientific research indicates is possible globally this century under business-as-usual scenarios, is preventable through the Haven Atolls Project.

Many atolls have declining subsistence populations. These atolls can be transformed to attract private investment and scientific researchers and support local populations as the Haven Atolls project creates sustainable food, energy, and jobs. The techniques used to create Haven Atolls have ocean-wide potential application. On the continents, food production is constrained by extreme weather and unsustainable mining of groundwater. The possibilities for increasing food production on the Earth's land surfaces are low. By contrast, the opportunities for increasing food production on the 71% of Earth's surface covered by oceans (361 million km^2) are considerable. Currently, oceans contain 97% of Earth's water, yet are estimated to yield less than 2% of our food and none of our biofuel. With Haven Atolls, economic and environmental sustainability combine to address these global concerns.

The Science of Haven Atolls

Biological research has intensively studied the role of heat and acid variability in conditioning water quality to enable coral growth. Experiments indicate that providing a safe temperature oscillation range will promote resilience, and can switch on rapid adaptation pathways in the coral to reduce the risk of bleaching. That is, by stressing and resting the coral, the coral will adapt more quickly to survive in warming oceans. Major coral bleaching and death can be prevented with water temperature as little as 1°C below ambient for a month. Deep ocean water (DOW) is 10°C to 25°C cooler than surface water, depending on depth, location, and season. Raising deep water to the surface in a lagoon offers possibly the best way to prevent coral extinction.

DOW also contains more dissolved CO_2, nitrate and phosphate than typical surface water. Algae consumes all three, plus other nutrients, during photosynthesis. The removal of CO_2 and plant nutrients, plus the release of oxygen (O_2) during photosynthesis raises the DOW pH such that the cool, low CO_2, low plant nutrient, high dissolved oxygen water is ideal for sustaining coral reef ecosystems affected by warming and acidification. Lagoons can serve as laboratories to work out the most efficient way to grow algae in a controlled way and optimize coral growth. This offers promise to establish major new industries for Small Island States to protect and enhance their biodiversity while growing food and making energy.

Economic Benefits of Seaweed Production

Seaweeds contain 10-30% protein, as well as oil, carbohydrates and trace products. One recent analysis found that additional annual global production of 500 million dry tons of seaweed is feasible in the near term, and would produce about 150 million tons of algae protein and 15 million tons of algae oil. The sheltered water in the world's atolls might produce 50 million dry tons of seaweed per year, worth $5 billion, within a few decades. An extrapolation of one job per 20 tons of seaweed results in a potential direct employment of 5 million jobs, while a standard seafood industry secondary-employment multiplier of 2:1 suggests 10 million

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[2] Australia Great Barrier Reef: 93% of reefs hit by coral bleaching

jobs could be created overall. Production may be more limited by the number of available local workers than any other resource.

Algae protein and oil have a wide range of current and potential uses. For example, highly nutritional long chain omega-3 fatty acids and protein can compete immediately with fish oil and soy meal markets. 500 million tons of seaweed would represent about 32 percent of current soy-protein production, while algae oil on that scale could represent a 750% increase over current fish oil production. These long chain omega-3 fatty acids would be a significant boost to human health, while protecting fish stocks which now supply oil in aquaculture and animal feeds. Current price per ton for soy meal is about $550, meaning the Atoll-produced protein fraction could be worth about $3 billion. Current price for fish oil is about $1500 per ton, making the algae oil worth about $2 billion.

Pollution Remediation

In 2014, the world used 124 million tons of nitrogen fertilizer, of which up to 30% entered waterways to pollute coastal waters. Excess nutrients have contributed to 245,000 square kilometers of dead zones, harming locations such as the Great Barrier Reef and the Gulf of Mexico. Seaweed production could absorb both organic nitrogen and phosphorous as concentrated fertilizers for shipping globally through methods developed at Haven Atolls.

Carbon Sequestration

Increasing atmospheric carbon dioxide is causing ocean acidification with serious harm to marine life by reducing the availability of shell-forming minerals needed by corals, mollusks and microorganisms. 50 million tons of seaweed would absorb 14 million tons of carbon, offering the potential of carbon abatement credits plus globally applicable carbon capture and sequestration techniques.

Biofuel

Dry seaweed is about 50% carbohydrate dry mass, ideal for biofuel production. The energy in seaweed can be captured by microbial anaerobic digestion to produce methane or microbial breakdown into sugars followed by fermentation for ethanol production, or hydrothermal processes to produce bio-oil and biogas. Annual global seaweed production needs to exceed about a billion dry tons before people will want to switch its primary use from food to energy. In the meantime, processes refined at Haven Atolls can extract significant energy and recover fertilizers from seaweed processing discards and the wastes of people and animals eating seaweed.

Examples of commonly cultured types of seaweed: red (left), and brown (right).
Photos by RE Brummett (L), Chen Jiaxin (R).