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Mangroves: Salt-resistant allies in the fight against hunger and poverty

Planting mangrove forest along the coasts of arid countries would contribute significantly to food security and help eradicate poverty and combat environmental degradation according to Dr. Gordon H. Sato (76), the founder of the Eritrea-based Manzanar Project, which has recently planted 600,000 mangroves near the Red Sea port of Massawa. Sato could hardly have picked a better place to test his ideas. Located on the Horn at the northeast edge of the Sahel, Eritrea is particularly prone to drought and famine. Even in good years, conventional agricultural activity is limited, and over half of the food consumed comes from food aid.

Ravaged by 30 years of war, Eritrea is one of the world's poorest countries, with a per capita income under US$200. Although much progress has been made since independence, social indicators continue to reflect the long years of neglect, deprivation and destruction. Life expectancy is only 46 years, infant mortality is shockingly high, and much of the population is chronically hungry.

Eritrea is one of Africa's barest countries, with forests covering less that 1% of the total land area,[1] But this was not always the case. In 1900, 30% of the land was still forested despite massive logging during the colonial era. Today, however, nearly all forest precuts must be imported.

The Manzanar Project

After conducting hands-on research in aquaculture and biosaline agriculture in Eritrea's coastal region for over a decade, Dr. Sato is convinced that mangrove plantations hold the key to putting Eritrea and other arid counties with desert coasts on the road to sustainable development and prosperity. Incensed by photos of starving children, Sato traveled to rebel-held areas in 1987 and began converting algae into protein, "making do" with ingenuous "low-tech biotech" methods and the only resources available: sunshine and seawater. Sato dubbed this undertaking "the Manzanar Project" after the detention camp in eastern California, where, as a Japanese-American teenager, he first began dreaming of growing food in the desert.

Adapting ancient Asian fish-farming methods, Sato raised mullet in seawater ponds spike with fertilizer to stimulate algae growth. With four weeks, the mullet were harvestable. Sat's fish produced 15 tons of fast, inexpensive protein per hectare. Similar methods for cultivating brine shrimp *(Artemia salina)* yielded the equivalent of 10-15 tons per hectare of these tiny creatures, which can be fed to fish and shrimp, or used to supplement poultry and live-stock fee.

No rest for Sato

After retirement, Sato returned to Eritrea determined to pump up the Manzanar Project and develop more novel ways to increase food production. Equally important, he resolved to train Eritrean scientists and local villagers in his methods. Sato began recruiting science graduates from Asmara University and set up headquarters at the Ministry of Fisheries in Massawa, close to the project area.

Eritrea's 1,150 kilometer-long coastal plain accounts for a third of the country's land area, but virtually none of its agricultural production. With climate conditions like a frying pan, this is the poorest part of a poor country and almost completely barren except for patches of semi-desert or salt-tolerant vegetation and scattered mangrove thickets.

Only 15% of the inter-tidal zone is blessed with mangroves, the only trees that flourish in the searing heat and negligible rainfall of this desert coast, since mangroves occur naturally only in *mersas*, low-lying basins where the seasonal rains flow into the sea. Analyzing this problem, Sato made a discovery that soon changed the primary focus of the Manzanar Project from aquaculture to silvaculture. The reason mangroves thrive in mersas but fail to grow elsewhere is one of simple plant nutrition. Rainwater and renewed silt deposits in the mersas furnish three essential elements that seawater lacks: nitrogen, phosphorous and iron.

How to grow mangroves

Sato reasoned that mangroves would grow outside the mersas, if they had a time-release capsule with the missing nutrients. Experiments with various delivery systems showed that the simplest, most effective way to nourish mangrove seedlings was to seal 500 grams of diammonium phosphate (DAP) and a few grams of ferric oxide (FeO_2) into a plastic bag, punch a few holes on one side and plant the bag with the seedling. Seeping slowly through the holes, the DAP/ FeO_2 mixture supplied the little tree with just the right amount of nourishment without wasting any fertilizer. Sato's team also discovered that seedlings got an optimal start if they were first rooted in six-liter plastic bags filled with sand. Holes in the bottom of the bag ensured drainage and facilitated root development. Transplanting the trees was a simple matter of putting the bags where the trees should grow.[2] Using this method, Sato and his helpers, mostly women, have planted hundreds of thousands of mangrove at seven locations near Massawa where no mangroves had ever grown before.

Mangroves grow rapidly, and the ones planted at Hargigo[3] three years ago are already well-developed trees, four to five meters tall. Their shiny green leaves area refreshing sight against the rust-colored sand. In time, their spreading crowns will provide welcome shade and help create a more temperate micro-climate. In the tangle labyrinth of their roots, a "magic muck" of decaying leaves and other organic matter will provide a perfect medium for myriad tiny organisms, including algae and plankton. Innumerable fish, shellfish, reptiles and birds will find food and sanctuary among the roots. By filtering out silt, excessive nutrients and pollution, the mangroves will also encourage the growth of nearby seagrass beds and coral reefs, thus ensuring ideal habitats for fish and marine animals, and protecting fishing and tourism revenues.

In addition to their economic importance as tidal ecosystems, mangrove forests have great commercial potential. The list of saleable products directly derived from mangroves includes cork, paper pulp, tannin, dyes and medicines. Many species are also excellent sources of fodder and wood, characteristics that make these trees particularly attractive for desert countries like Eritrea.

Forest riches

One of Eritrea's native species, *Rhizophera mucronata*, is such a valuable source of lumber and fuelwood that it has become quite rare. Considering that Eritrea currently spends US$20 million per year on lumber imports and consumes 1.5 million tons of fuelwood annually, *Rhizophera* farms could bring great economic benefits both to the communities that owned them and the country as a whole.

Sato estimates that a single *Rhizophera* would yield lumber worth US$400 in 20 years at a cost of only US$3 per tree for labor and fertilizer. And there are additional rewards, some of them inestimable. Besides providing employment and income for thousands of local people, mangrove plantations would help reverse the environmental damage and soil degradation caused by burning dung and crop residue for lack of firewood.

Greening the coast

Since Eritrea's coast is characterized by gradually sloping beaches, shallow bays, and low-energy waves, mangrove forests could be established on at least 10,000 hectares of the intertidal zone. Sato proposes planting 10 million trees on this area to ensure thick canopies at maturity.[4] since the tidal zone extends inland for about 500 m, the forests could eventually cover 50,000 hectares. Sato estimates that harvesting these trees for lumber in a sustainable way would bring annual revenues of

US$200 million and significantly boost the Eritrean economy.

But this is only the beginning. Sato has shown that mangroves can also be grown outside their natural habitat on dead coral reefs or even in the desert if the trees have adequate drainage, nourishment and seawater. He envisages vast mangrove plantations on the coastal plain, with seawater supplied by gravity irrigation, and salt-resistant fodder grasses, such *Distichlis spicata* or Spartina planted as ground cover.

Fine fodder indeed

Generations of Bedouins have fed their camels on juice mangrove foliage, and Sato learned quickly that mangrove seedlings must be protected from wild camels. The leaves of Eritrea's most common mangrove *Avicennia marina*, are 19% protein by dry weight, and thus more nutritious than alfalfa. Sato observed that goats and other small ruminants prefer mangrove leaves to acacia and other desert fodder, and do will even on a steady diet of the leaves.

Experiments with sun-dried mangrove seeds showed they are a good food for goats. Like dried peas, the seeds are easy to transport and can be stored indefinitely, advantages that make them particularly valuable in times of drought when other food is not available and many animals would starve. Mature mangroves produce 3-4 tons of leaves per hectare, ensuring quantities of fodder that would help pastoralists increase their livestock production considerably. The economic benefits would be enormous, particularly in regions where animal husbandry is the only productive form of agriculture.

Tomorrow the world?

Are Sato's plans Utopian? Probably not. Projects with similar aims are already underway. The International Center for Biosaline Agriculture in Dubai, U.A.E., for example, also conducts research on mangroves and other halophytes with the aim of greening the deserts. In any case, the success of the Manzanar Project in Eritrea points to the feasibility of similar operations elsewhere, particularly in extremely arid regions where rural populations dependent on foraging and livestock herding are frequently threatened by drought and famine. Introducing innovative, low-tech biotech strategies like Sato's that exploit hardy native plants and local resources could break the deadlock conventional agriculture faces in such areas to make food security a reality.

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1 Acacia thickets are excluded from this estimate.

2 Nursery-raised seedlings are not necessary for success. Mangrove propagules can be planted directly, provided the DAP?FeO_2 time-release capsules is planted with them. Mangroves are viviparous: the seed germinates on the parent tree, where the propagules remain until they have become well developed little trees with the strong roots they need to anchor themselves in shifting tidal sediments.

3 Hargigo made headlines briefly in May 2000 when the new power plant there was heavily bombed shortly before it could be commissioned. Reconstruction was co financed by the OPEC Fund and other Arab aid institutions.

4 4. Considering that Eritrea succeeded in planting 61 million trees on 205,000 hectares between 1991 and 2001, Sato's figures are not unrealistic.