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Tanzania, Factor 1: Plant Science

Taking on Disease and Malnutrition with *Spirulina* in Tanzania

Roughly 2.7 billion years ago, the first cyanobacteria appeared on earth., an earth ravaged by meteorites, volcanos, and no atmosphere for its protection. Fast forward to 2017, and earth is now full of flourishing life and potential, a full atmosphere, boundless oxygen, and diverse ecosystems. All thanks to these amazing little cyanobacteria. If only these wonderful little organisms existed today, they could solve so many of the world's problems, from global warming to world hunger. Too bad they're extinct, right? That's not actually quite true. Cyanobacteria have actually left behind many descendants that are alive and well today, some are being researched to be used as biofuels, and others as medicinal supplements. And another of these variants, *Spirulina*, could help solve disease and malnutrition, and save an endangered species of flamingos in Tanzania.

The average family size in Tanzania has been in decline recently due to urbanization and is currently estimated to be at 4.7 people per household. The most prevalent family structure in rural farming families is extended (where extended family members live together). Primary school fees were eliminated in 2002 and net enrollment is now estimated to be at 98%, the main language taught is Kiswahili, and the overall literacy rate is currently 71%. Secondary school in Tanzania remains financially out of reach for most families with only 26% of all eligible males enrolled and 24% of all eligible females. (Unicef).

Most Tanzanian meals consist of one of the following key staple crops: corn, rice, cassava, sorghum, or plantains; mixed with fish, beef, chicken or other meat, as well as vegetables or condiments. The average life expectancy is 60.9 years old (Unicef), and access to health care is extremely low, this is driven by fee-based health care facilities and a physician to person ratio of 2 per 100,000 (Nutrition Country Profile United Republic Of Tanzania). Tribal healers are much more commonplace, they utilize herbal medicine and spiritual healing techniques. A serious health issue faced by Tanzania is iodine deficiency, there very little to no salt or iodine in the Tanzanian diet, iodine is critical in brain development in children and causes goiters if left untreated. Almost 20% of the population was found to have goiters in some parts of rural Tanzania (FAO).

Most of Tanzania's economy is based on agriculture, 49% of Tanzanian farmers are "medium" farmers, or farmers who farm on between .712 to 1.62 hectares of land. "Small farmers" (from .004 to .71 hectares), accounted for 25% of all farmers, and 19% were "large" farmers (greater than 1.623 hectares) (Where The Rain Falls). Currently, the main agricultural exports are tobacco, coconuts, brazil nuts, and cashews.

Many of Tanzania's currently grown crops are heavily dependent on rainfall, and as irrigation systems in the country are still very limited in rural areas, the production of these crops suffers severely when seasonal droughts occur. This is a critical issue because agriculture accounts for 30% of Tanzania's GDP, and 67% of its labor (USAID), which means that the failure of these staple crops not only decreases Tanzanian's access to food, but also their income and ability to buy it. Women are particularly affected by this instability as they are typically expected to be responsible for most of the agricultural work, accounting for 70% of Tanzania's agricultural labor force (USAID). Poor rural farmers who do not have

access to the irrigation more widely available in urban areas are also particularly disadvantaged because rainfall is their only source of water.

Unfortunately, the situation is likely to only get worse. Globally, climate change is expected to increase the frequency and severity of droughts, floods, and storms greatly. This trend has held brutally true for Tanzania lately. A recent case study done by the United Nations University found that Tanzania's average rainfall has been decreasing and becoming more sporadic (throwing off locals' farming cycles) since the 1950s, and that droughts are rapidly increasing in frequency and intensity (Where The Rain Falls). These factors make it very clear that it is simply not sustainable for Tanzania to keep relying on traditional rainfall-dependent crops, and that there is an urgent need to find a new plant to overcome these critical challenges.

Using plant science to develop a new type of crop not dependent on rainfall, with high protein and iodine concentration could eradicate malnutrition and iodine deficiencies suffered by much of Tanzania's population. For such a crop to be implemented successfully would also require it to be easily integrated into Tanzanians' current diets, this could be achieved through something that is potent enough to still be effective when used as a condiment that could be used with staple crops. If this crop could be grown and harvested from a natural body of water rather than on land and with rainfall, it could protect rural farmers who do not have irrigation available to them from the increasingly dangerous threats of droughts and climate change. Such a crop would also be extremely sustainable because it would not occupy arable land that could be used for other crops in the future.

Spirulina, or *Arthrospira Platensis*, is an edible form of cyanobacteria that grows in water, similar to regular algae. The health benefits of consuming Spirulina are incredible, so much so that supplements are even valued in developed nations. Even in small quantity, they are extremely potent in protein, iodine and amino acids (Spirulina, The Edible Microorganism). Adding them to the Tanzanian diet would eradicate serious iodine deficiencies and curb malnutrition. Of course, there are inherent challenges that come with introducing a new food into any traditional diet; however, due to their potency in iodine and protein in small quantity, Spirulina could be used as a condiment on top of traditional Tanzanian meals consisting of other staple crops.

Spirulina require an environment of very alkaline water to flourish (optimum PH levels are from 8 to 11 (Spirulina, The Edible Organism)), as well as CO₂ from the air and sunshine. Tanzania is home to several extremely unique lakes that are extremely alkaline naturally (Lakes Natron and Manyarna for example, with pH of 10.5 and 9.5 respectively). Spirulina actually grow naturally in these lakes already.

Rural farmers who live near the lake could simply extend this growth and harvest Spirulina directly from the lake. Simple microfiber cloths have been used to harvest Spirulina in amateur operations across the world, something similar to these, but potentially larger in area and tougher (able to withstand the high PH levels) could easily be developed for harvesting Spirulina directly from Tanzanian lakes. A portable storage tank system could be developed to store lake water and grow Spirulina right outside the homes of more urban farmers who live further away.

Spirulina will replicate very quickly by themselves in the right conditions, so farmers would not have to worry about planting or collecting seeds of any kind, just making sure to not harvest more than two-thirds of the population at once. Droughts and other climate volatility would also have minimal effect on a large

body of water, such as a lake meaning that small farmers without access to irrigation would not suffer the effects of drought or irregular rainfall when cultivating Spirulina.

From 2009-2014, the World Bank had an accelerated food project whose goal was to improve Tanzanian farming techniques by providing improved seeds and farming techniques to Tanzanian farmers. (World Bank) This project could be expanded by potentially distributing Spirulina as a new crop of focus to families that the first run was not able to help (especially women who did not own land), or rural farmers who are still challenged by rainfall shortages, even with the improved techniques.

When dealing with utilizing a natural biological structure such as a lake for human farming purposes, it is very important to consider its current ecosystem and how it may be affected. Being so alkaline, not many animals find it hospitable and the ecosystem is therefore not very robust. An exception to this is the Lesser Flamingo, one of the only animals that is able to call Tanzania's alkaline lakes home. To them, the lakes serve as both an important food source (the flamingos feed on Spirulina naturally growing in the lake) and breeding ground. Unfortunately, the lesser flamingo has been listed as endangered by Tanzanian officials and have been dying in mass from exposure to toxic *Arthrospira Fusiformis* that has been growing in the lakes due to climate volatility and human activity. (Cyanobacteria blooms) There are also plans to create a soda ash mining facility in lake Natron that could greatly upset the flamingo breeding process and the lake itself. Such a plant was created in lake Magidi and resulted in a mass-death of the lesser flamingos that attempted to breed there in 1962 when chicks' legs were congealed by soda deposits. Since lake Natron is not a national park, it is very possible for something similar to happen there. All of these threats are man-made, and their potential solutions similarly lie in human action.

With the right cooperation between the right organizations, along with the right people, a Spirulina implementation could benefit both Tanzanian humans and flamingos. The first step in implementing Spirulina would be for a third party organization such as the UN, World Food Bank, or US (via foreign aid) to gain sufficient funding and sponsor the implementation. Next, that organization would have to make brief preliminary preparations to develop harvesting techniques suited for Tanzanians (such as large harvesting nets and storage tanks suited for the rugged climate). After that, the organization would work with the Tanzanian government to oversee and administer the lakes and Spirulina to ensure safety and fairness throughout the operation. A portion of the lake would be dedicated to lesser flamingos, this portion would be monitored for conditions that could lead to toxic algae blooms (extended droughts and nitrogen concentration) and correct those conditions to prevent an outbreak that otherwise could have brought harm upon the lesser flamingos or humans that they would have come into contact with. The administration would also ensure the general well-being of the flamingos (prevent development that could potentially harm the ecosystem, and limit human activity during the mating season). After all these things have been established, Tanzania's government infrastructure would be utilized to inform its citizens about the opportunity to grow Spirulina. Interested local families would volunteer to receive training and basic materials for the implementation, they would learn about Spirulina and the process of harvesting it. Those families would then receive the necessary tools and begin growing the algae. Communities already located near the lakes could grow their Spirulina directly inside the lakes, and urban families could keep specialized tanks of lake water right outside their homes and grow and harvest Spirulina there.

Once a stable harvesting procedure is established families could then use the harvested Spirulina to feed themselves and their families, or sell it to others, both locally and internationally in order to support themselves financially. A non-profit third party could also be involved in this step, working with the local families to find markets internationally and acting as a trade middleman.

Tanzania is an ideal location for the implementation not only due to its natural resources that lend themselves to Spirulina production, but also because it is stable and free from conflict. Tanzania was ranked number 54 on the global peace index, the third highest African nation (Global Peace Index 2017). This means that the Tanzanian government is focused on its economy and has many reasons to cooperate and allow Spirulina harvesting to have the chance of bringing food security and prosperity to its people. It would also empower it to protect its natural lakes and the lesser flamingos by setting up sites to monitor and preserve the health of the lake, as well as prevent any kind of commercial development. The Tanzanian government could also enact a tariff on the exportation of Spirulina, this could help fund the project as well as help keep Spirulina grown and harvested in Tanzania remain affordable for Tanzanians to buy and benefit from.

Many Americans are convinced that the U.S. is financially strained enough as it is, and that foreign aid is a waste of money. However, increasing foreign aid to Tanzania, specifically for a Spirulina implementation is simply the right thing to do morally, and also has the potential to transform Tanzania into a strong ally for U.S anti-terrorism interests in Africa, benefit from Tanzania's greatly increased agricultural output, and even create more American jobs, making it more of an investment than an aid effort. Morally, the Spirulina facilities overlooking the lake would protect an entire endangered species (Lesser Flamingos), helping to preserve and protect the world's ecosystem. The Spirulina would also help nourish, increase income and food security, and protect millions of Tanzanians from malnourishment and disease. Economically, Tanzania has huge potential to become an agricultural powerhouse, currently, only about 10.1 Mha of its arable land (or about 23%) (Global Yield Gap) is being utilized. This is because small farmers in Tanzania do not have the resources to use all of that land and are faced with issues such as dependency on erratic rainfall as discussed earlier. Supplemental income and increased nutrition from farming Spirulina could pave the way for irrigation and the growth of more traditional crops, utilizing this land. Doing this would not only bring prosperity to millions of Tanzanians but also create a need for farming equipment, a need that could be fulfilled by American companies importing such equipment, creating many new American jobs as well as a valuable new trading partner. While Tanzania may be a relatively peaceful and safe country, its neighbors are infested with large terrorist organizations such as Boko Haram and Al-Shabaab. Empowering and developing a relationship with Tanzania would also be supporting a stable and peaceful democracy in a volatile area full of enemies, a key goal of U.S. foreign policy. U.S. foreign aid to Tanzania for a Spirulina implementation would have the effects of a long term investment and

The introduction of Spirulina algae into Tanzania, along with the utilization of its natural lakes has the potential for solving serious diet-based health issues that plague many Tanzanians. Its unique properties of being grown and harvested in water also would provide an easily grown and extremely profitable crop not affected by droughts or climate volatility to rural farmers who struggle against a restrictive and insufficient irrigation system and increasingly unreliable rainfall. Spirulina are a very promising path forward for Tanzanian farming, with huge potential to adequately nourish the Tanzanian population, bolster the Tanzanian economy, and preserve Tanzania's environment for years to come.

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