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Malawi, Factor 11: Malnutrition

Food scarcity is not something many of us have to deal with. Our grocery stores are filled to the brim with bins and boxes full of nutritious foods. Such is not the case for many people in this world. In fact, most of the planet has some type of food insecurity. The people of Malawi are no exception. Malawi is a country defined by extremes with resorts catering to wealthy tourists while almost all of their population is plagued by the effects of living in a food insecure region. This paper will explore the causes of malnutrition in Malawi, and how aquaponics can solve the nutrient deficiency crisis.

Malnutrition is, and has been, a huge problem for Malawi. A harsh climate coupled with a lack of resources make farming inefficient compared to other regions of the world. An article written by One, pertaining to worldwide hunger said that Africa, as a continent, had not seen near the improvements in agriculture as other countries. It went on to say that not enough research was done by other nations that support Malawi to adapt agricultural technology to the unique environment of Africa. Climate, lack of resources and poor farming techniques are huge factors to the malnutrition and nutrient deficiency crisis in Malawi. Consequently, a majority of Malawi's population struggles with disease. Disease then weakens the farmer making them unable to cultivate their crops which, in turn, means that the family has nothing to eat.

The climate of Malawi is one of extremes. Their year is commonly broken up into three seasons; cool-dry, hot-dry and rainy. During the rainy season between November and April, the country gets approximately 35 inches of rain accounting for 95% of their yearly rainfall amount. The rest of the year is dry. Farmers wait through the floods of the wet season and two days after the rains stop, they scatter seeds on any piece of available land. Getting these seeds to grow takes hard work during the dry months, but their success is paramount to survival. Our Africa (15) states that 80% of Malawians rely on maize, or corn, to feed their families. Corn has been the primary food source of Malawi for generations. Most of the corn that is harvested is ground into flour and cooked into a paste to create 'nsima, a thickly mashed starchy meal. But corn is far from a perfect crop. According to the Aggregate Nutrient Density Index (ANDI), on a scale of 1 to 1,000 yellow corn only has a nutrient score of 45 and white corn scores a 41. Clearly, the people of Malawi are seriously lacking in micronutrients.

The International Micronutrient Malnutrition Prevention and Control (IMMPaCt) a subdivision of the CDC states that globally more than 2 billion people suffer from micronutrient deficiencies and that at least half of the world's population of children ages 6 months to 5 years suffer from one or more micronutrient deficiencies. Aquaponics food systems are designed to grow food in places where the soil is unable to provide optimum growth.

The Borgen Project (8), , a national campaign that works with U.S. leaders to improve their response to the global poverty crisis, reports that 90% of the national population of Malawi lives on under \$2.00 USD a day. Because of their extreme poverty, most of the population relies on subsistence farming. However, the harsh growing climate makes it nearly impossible for the

average family to produce enough food even for themselves. An example of this was reported by The International Weekly Journal of Science (5) in March of 2012 about Eneless Beyadi. This woman is responsible for feeding her family of six. Her day begins at 4:00 a.m. when she goes to water and weed her 2.5 acres of corn. In the afternoon, she teaches school and then again in the evening, she goes back to her field. Beyadi was fortunate, however, and was able to borrow 4,000 Malawian kwachas from a European friend to buy 110 pound of fertilizer. This is a luxury most cannot afford as typically a family like Beyadi's isn't this fortunate as they have neither the income nor a way to borrow money to invest in better food production. The article went on to describe the distinct difference between Beyadi's corn and that of her neighbors which had very little grain. This story exemplifies how most struggle to grow anything in this country.

In the past few years, however, Malawi has seen some economic growth. The African Development Bank Group reported that in 2012, Malawi's GDP increased 2.1%. They project the 2016 GDP to significantly raise to 5.7% assuming improved investor confidence, favorable weather conditions, high agricultural exports, lower inflation and moderate interest rates (1). Malawi also has tourist attractions which contribute up to 7.3% of their economy according to The Times Group (13). Malawi's main export is tobacco (14) while other exports include sugar, tea and coffee which are grown in the highlands.

An aquaponics system similar to the one we have at Stafford High School, could alleviate malnutrition and micronutrient deficiency by being able to grow nutrient dense food in spite of all the difficulties farmers in Malawi face. Our primary goal is to teach locals the concept of aquaponics and how it works, that is why the aquaponics system at Stafford High School is based on an idea of simplicity. Because our research is not funded by the school, or a third party benefactor, we have to use what we have on hand. This teaches us the concept of taking what we have to build something that can be of use. Our design is extremely simple and easy to teach. This makes it significantly easier for individuals in third world countries to be self-sufficient, and not have to rely on another government's funds or supplies. Not only will aquaponics solve civil issues, but will solve the nutrient deficiency crisis.

The system at Stafford High School was made with a 250 gallon food grade IBC container which we cut in half. The top one fourth of the container is used as the growing bed and the bottom three fourths is used as the fish tank. The water flows by gravity between these two tanks. There is also a separate container aside from the system used as a growing environment for mealworms. The system that we have developed is designed to produce its own energy. Anything the system needs, it can make. The fish are fed by mealworms, the mealworms are fed by the plants, and the plants are fed by the fish. It's a constant cycle, each step depends on the previous. We are also working on a pump that does not require electricity to pump the water back into the fish tank from the growing bed. We have developed a hammer pump that is capable of achieving this, however it is 80% inefficient. Our research is mostly focused on using what the people have to produce food for themselves. We don't want farmers to have to buy a product from a company in another country because then they would have to rely on that country to give them the tools they need to produce food. Aquaponics food systems are designed to produce at a

high rate no matter what the environment. This system will require very little adaptation to begin food production to Malawian farmers.

An aquaponics system can still produce to its full potential in the harsh African climate. One way the system remains efficient is that the fish are able to regulate their body temperature according to the outside temperature and the temperature of the water. Also, aquaponics systems can be set up inside their house where produce is not exposed to the elements. If farmers choose to do this they would have to modify their house to be able to allow sunlight in for the plants. Having the produce in a system that is set up inside a house or under a shelter leaves nothing to chance as far as weather is concerned.

An aquaponics system set up by the University of the Virgin Islands Aquaculture Program (7) occupies about one tenth of an acre of land and can produce nearly five metric tons of tilapia along with 1,400 cases of leaf lettuce annually (Pg.35). Beyadi would be producing more food with this system and would do so with much less time and effort and will gain the nutritional benefits of a variety of fresh greens, the protein value of fish, and the supplementary protein value of mealworms if necessary. With the quality nutrition that comes from an aquaponics food system, Beyadi would not have to go in debt to provide a decent crop and she would also not have to work in the field each morning and evening. This would increase her quality of life and allow her to expand her teaching career.

The research that we have done at Stafford High school and The University of the Virgin Islands unanimously concluded that aquaponics food systems are an efficient, simple, and low cost way of producing all the necessary nutrient rich foods along with fish as a source of protein, with no carbon input. Although there are no current aquaponics systems in Malawi, I believe a completely self-contained system like the one we have at Stafford High School would feed Beyadi and her family forever.

Our research at Stafford High School shows that aquaponics has many benefits over traditional farming. Our observations have shown that it is currently the best way to grow fresh produce efficiently. An aquaponics system could produce a more nutrient dense crop at the same volume as what the people of Malawi are currently producing corn. In the spring of 2016 we began an experiment to calculate water usage over time comparing red romaine lettuce grown in pots filled with soil and the aquaponics system. It was observed that the lettuce in the aquaponics system reached maturity faster, had better flavor, color, and looked to be an overall healthier plant compared to the lettuce grown in the pots.

Another advantage to aquaponics food systems is that they are easily adaptable to fit the exact needs of the people and environment it's producing for. Our system will have to be slightly modified to ensure that the system is running at maximum efficiency. For example we used a 250 gallon IBC container because it was readily available to us, that may not be the case in Malawi. We will also place banana leaves over the rock bed after the system is established. The oil coating on the banana leaves will keep water from being lost through evaporation. Banana leaves are easy to come by being as they are constantly falling off banana plants in the farms.

The leaves of a more prevalent plant could be used in place of banana leaves. Each system will be specifically built to its surroundings. For instance, if wood is not available we might use bamboo. Both of our systems at Stafford High School are made of entirely recycled parts. Some of the parts we used include a styrofoam cup, the lid from a gallon ice cream container, a pop bottle, and styrofoam insulation. The goal of this project is to provide food with what resources are present, rather than having to buy a product from a manufacturer.

The Borgen Project estimates that about \$30 billion each year is needed to end world hunger (1). Aquaponics systems are a one-time investment that can be made by any organization across the globe. Our systems are not bound by borders so they can travel anywhere and be effective for lifetimes rather than having to pay year after year to produce more food. This system relies only upon itself for its resources, it will be able to feed generations and improve the quality of life over time. Eventually not only will the system be able to produce enough food to be a subsistence farming operation, but the people will be able to expand their system to be able to produce enough to export produce as a cash crop. This will significantly increase the amount of income to the country and improve the quality of life for all Malawians.

Aquaponics food systems not only produce food but supplementary products as well. The solid waste from the fish can be used as a soil supplement. Recently (July 2016) started experimenting with adding fish waste to soil to replenish the nutrients that have been nearly used up due to over farming. This would save the country of Malawi from having to buy fertilizer at all. Early observations have shown the fish fecal material to improve the growth in plants, and to produce overall healthier plants. It has also been proven that the fecal material of mealworms can be used as a soil supplement. Due to the conditions of the experiment we are conducting with mealworms, we are unable to test this at the current time.

That's not the end of the mealworms' use either. Mealworms are 24% protein, and can live on almost any food source. We are currently conducting an experiment that specifically tests the boundaries of mealworms. We have found that mealworms are able to consume inorganic materials, such as styrofoam, cardboard, and plastic, and turn them back into organic material that can be used as a soil supplement. This would mean that if the people ate all the available food and there was nothing organic left to feed the mealworms, they could feed them trash. Our experiment was started in December and has since produced a second generation of mealworms. The second generation are more apt to eat the inorganic materials because they have never eaten anything else. They weren't raised on a farm like their parents. We hope to see, as we get into further generations, that plastic products become their preferred food. At that point we would know that the mealworms could provide a source of protein in the most starving regions. Mealworms could also eventually become an export product for Malawi, encouraging trade among other countries.

With all the benefits of aquaponics paired with the ability of the system to produce in nearly any environment, the final step is implementation. Our program at Stafford High School began with two students for the 2015-2016 school year. After our school pre-enrollment our numbers have tripled. Students realize that aquaponics works, even if they don't see its whole potential. This is what we plan to do in Malawi and other food insecure countries. In late June we had a visitor

from Uganda come and tour our facility. Educating one person empowers them with the knowledge to teach the rest of his village and eventually the rest of the country.

Aquaponics will provide a source of high volume food production with little to no capital investment by the Malawian Government or individuals. This will allow the people to produce food year round without having to work the land along with freeing up all the time that was spent tending to the crops to be used to sell surplus or work a job for more income. Not only would this increase the quality of life at the individual level, but aquaponics systems are able to benefit the entire Malawian economy.

Food scarcity is a bigger issue than any one solution. To solve the world's malnourishment and nutrient deficiency crises will take the world working together. In Malawi, people plant corn even though its nutrient value is low because that is the seed available and it is the staple crop of their culture. However, corn does not provide the micronutrients needed for optimum health. Through our studies at Stafford High School, we have found that aquaponics is capable of filling the micronutrient gap. Aquaponics can provide Malawi with quality nutrition utilizing local resources. These systems are simple enough to be built by anyone and effective enough to feed everyone.

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