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Libya, Sustainable Agriculture

**Libya: Making a Desert Sustainable**

The world has had the same amount of water since the beginning of time, but why does Libya suffer from clean water deficiency and thus the lack of food? Libya has poor soil and little water to naturally help crops grow. These circumstances make it hard for Libya to be a dependent country, due to the fact that they rely on other countries for majority of their food. These less than ideal circumstances will not change overnight, and certainly will not change without the will and the money to make a change to Libya's national crisis.

Libya is a country at high risk for food insecurity due to a highly concentrated population, challenging terrain, and a high vulnerability to future climate change. Libya has over 6 million people (1). The terrain of Libya is barren, and over 90% of the land is desert, concentrating the population at the coast. The cities are so densely populated that 90% of the population is along the coast in major cities, including the capital, Tripoli (12). This population density limits the space to grow crops. The amount of cultivated land is only 1.2% of the 1,759,540 $km^2$ total land (12). The amount of arable land is 1% and only 0.2% of the crops grown are permanent, meaning they stay year round like orchards (12). Libya produces only 15% of the food required to feed its people, relying on food imports to keep the population fed (8). The geographic aspect of Libya makes it hard to transport goods inland. Since most of the cities are on the coast, so are most of the roadways, making transportation of food imports inland difficult. There is little access to crops in areas where the population is malnourished. The country is not without natural resources, however, their natural resources include fossil fuels (such as petroleum, petrochemicals, and crude oil), natural gas, aluminum, iron and steel, cement, and chemicals (9). This reliance on fossil fuel production increases the vulnerability to climate change and raises the difficulty in keeping a healthy environment for animals, plants, and humans. Libya's food security situation is complicated even more due to an unstable government.

Libya not only have a shortage on water that is safe for human consumption, but also a shortage of water for crops. Although Libya lies on the Mediterranean Sea, they continue to have a shortage of water. The Mediterranean Sea is a saltwater body of water so drinking water from the sea would be unsafe and most plants that grow in that type of climate are not able to grow in saline. From March 2010 to 2015, it rained twice in Libya. The water shortage Libya annually experiences is around 500 $m^3$ (3). A groundwater expert, Saad al-Din al-Gharyani, claimed that the lack of water will cause a lack of food due to the domino effect and the essential role water has in any organism (3). Following al-Gharyani's domino effect, the lack of water not only makes it impossible to grow plants, but also to keep any livestock healthy. The animals have nothing to eat or drink because there is no water to spare for the plants use. In turn, the livestock is not able be used for human consumption, due to lack of water and food. Libya gets roughly 95% of their water from the ground and only .66% of the countries water is wastewater treated.

The typical diet for a family in Libya is normally one-pot dishes. The average household size is around 5 people with 2-3 kids and an older relative, but the country as a whole has a population density of 3 people per $m^2$ (5). The women were treated as property, but during the 20th century men had to get permission from a wife for a divorce before taking another helping expand women's rights. Marriage in Libya is a civil act more than it is a religious related tradition (4).

As stated, Libya has to ship in food from other countries. Their imports come from self-sustainable

countries such as Italy, China, Germany, Turkey, etc. (9). Libya has to import so much food, because there is no way to feed the whole country with the lack of arable land and transportation. The OEC shows that Libya produces mostly petroleum products, but almost nothing else. Families, due to the low income, have to make a choice to eat healthy or have a substantial quantity of food. Tom Price, former United States secretary of Health and Human services, states the following, "health is affected by the quality and quantity of food." For example, a family of five with minimum wage jobs will be able to pay for a substantial quantity of food, but fail to achieve a good quality of food. Most families, if not all, make the choice to have enough food to fill stomachs instead of healthy food, thus risking starvation. The amount of water also helps keep a person healthy since the human body is mostly water.

Libya faces further ongoing threats to its already limited soil in the forms of nutrient depletion, desertification, and salinization further threating food security. Farmers have to have land to grow crops on, but if the land lacks soil nutrients, crops cannot grow and help with the amount of food produced. In addition, due to inhospitable environmental conditions, farmers have a smaller variety of crops that they are able to grow. This leads to nutrient deficiency in the crops. There is a trend in the relationship between conditions of soil and room to grow crops among people in that area and surrounding areas that are low or out of food.

A scientific solution to the food deprivation in Libya would be to genetically modify genes from plants that work well in saline and transfer that specific gene into other plants that Libya can use to grow that work with the nutrients that the soil has to offer in that land. We would need a plant to thrive in saline and to get the water from the Mediterranean Sea inland and then plant saline successful GMO crops. GMOs are useful to make certain plants adapt to an unnatural environment for that specific plant. GMOs can help can help with nutrition, because families will not have to rely on processed food, which is substantially cheaper, but also bad for human health. Studies claim that GMOs can cause cancer and other diseases. GMOs are controversial, but they would be able to feed the population where there is food deprivation, like rural Libya.

Golden rice was made for farmers in poor countries to keep up with the growing population. Journal of the Royal Society of Medicine claims, "From the beginning, the aim of the scientists was to provide the technology free of charge." The point of genetically modified organisms, GMOs, was not to flaunt the idea of technology around, but to help the world issue of hunger and famine. GMOs also help produce healthy crops in mass quantities, in turn making prices for that food cheaper. In Libya's case, the people who need food tend to be poor which causes them to buy processed food, which is not as healthy as locally grown food. People in rural Libya can only feed themselves and potentially others within walking distance. However, people in urban Libya have easy transport to get food, even if producing is hard due to the dense population along the coastline.

Due to little crop rotation, the soil lacks nutrients to make the crops grow. The lack of crops that can grow in the conditions Libya provides, make the soil lose nutrients essential to the plants growing. When a plant grows, the plant takes specific nutrients from the soil; if the same crop is planted year after year, the soil will become worn and will not be able to help grow the crop to its full potential. To farmers in the Midwest, the tools are available to replenish nutrients to the soil to some degree or use crop rotation, which people in rural Libya cannot practice. Libya produces non-ecofriendly products which worsens their environment for crops to grow. GMOs can reduce the carbon footprint humans leave. There is a dead zone in the Gulf of Mexico due to the fertilizer runoff. A dead zone is an area of water that is so polluted that no life can live there or life will perish; it would be the equivalent of a human being in a secluded room with only carbon dioxide to breathe. Potentially, Libya could turn a small part of the coastline on the Mediterranean Sea into a dead zone. Libya already has a bad ecosystem due to the exports, so the chance of a dead zone is high. Libya also has low water resources so they cannot afford to lose their water resource from the Mediterranean Sea. The climate change is projected to lead a noticeable increase in

desertification and saline rich soil (10). It would make more sense to use water with saline in than purified water, because they have access to saline, but not purified water.

The solution may be complicated, but perhaps the easiest way for this particular part of the world is to use saline GMO crops. The salt water from the Mediterranean Sea is a natural resource and there are ways to manipulate certain crops to grow in saline. Libya is fortunate enough to have direct access to the Mediterranean Sea which provides saline. The Genetic Literacy Project says that it is inevitable that sea levels will rise so it is worthwhile to work with plants to strive in the saline (3). There was a project done by Dutch researches in 2014 on saline and growth in crops. They divided a section of land into 8 with irrigation pipes distributed, with different ratios of saline to water to see which crops grew the best. They tested potatoes, carrots, white cabbage, red onions, and broccoli. The amount of solution put into each eighth of the land was controlled by a programmed computer system. Their conclusion was that certain crops tolerate the saline solution better than others, but only with the correct irrigation system used. They believe the test was successful because the solution went through the roots, unlike fertilizer, which just goes on the top of the land and has lees of a chance of reaching the roots. The study found that the vegetable that strived the most was the potato; the other vegetables were smaller in size, but had a better taste, believed to be because the natural salt in the water that was carried to the vegetable (11). Through this process the Dutch researchers were able to determine which saline solution worked best with which crop, and due to the variety of crops they were able to find the common gene that thrived in saline.

ISAAA is an organization based in India and they claim, “Salt stress effectively decreases the availability of water in the soil to plants.” They used halophytes, which thrive in high salt concentration levels, to find the gene of the plant that is responsible for the high salt tolerance. Arabidopsis, more commonly known as Thale Cress, is a small plant that has a short life cycle and has an abundance of genes able for manipulation (10). The ISAAA used the Arabidopsis as the test subject and tested the response to different stresses including salinity, drought, extreme heat and extreme cold and recorded data on the stress the plant endured. The purpose of using GMOs in this particular case is to create crops that succeed in saline since predictions show that the sea levels will rise making the soil carry more salt. There are specific proteins that move across the cell membrane that also help potassium ions into the plant. The gene found in Arabidopsis is also found in other plants like tomatoes and canola. The specific gene helps the plant when under heavy saltwater levels. If scientists use the gene found in the plants that make plants successful in saltwater, they can use test the gene in other plants. The research done would help provide an easier way to grow food, especially food or herbs that are important in Libya’s diet.

In an ideal world, it would be easy to get water inland to Libya and use the Mediterranean Sea, which is saltwater. Then the water would be transported to the water reclamation plant, through the pipeline system, and eventually to the farms which can grow crops with a gene that continues to grow, even when stressed by salt. To get the water inland the potential idea would be to use a water reclamation plant and dilute the saline with water. The water reclamation plant would also hire people and create a good example of agriculture and all it has to offer. Ideally, the plant would be feeding water to the pipes 24/7. Once the idea is not foreign and the funds come in, each secondary pipeline would be able to dilute the water accordingly so the primary pipeline coming from the water reclamation plant isn’t the only solution, thus expanding crop options. To transport the water inland, use a pipeline system that goes from the reclamation plant to the desired area. Potentially the pipeline would be able to help transport safe drinking water to those who do not have any. With the pipeline system communities would be able to feed themselves and potentially neighbors. If a community is within close capacity, households should be assigned to grow a crop for a year and the community as a whole will practice crop rotation so the nutrients in the soil does not become exhausted. Along with this the community will also have different crops to include in their diet to live a healthier lifestyle.

To finance this project would be the United Nations International Fund for Agriculture Development (7).

IFAD helps with water scarcity in developing countries so everyone can have access to clean water and the Agriculture Development from the Bill and Melinda Gates Foundation would help finance to research GMOs. The Gates Foundation has already spent $306 million dollars on the development of agriculture in developing countries (1). Libya may be used as a field test subject, because they have the saline nearby and the lack of food in rural area, and even the quantity of food imported from other countries. Engineers and scientists from around the world may collaborate to figure out the large-scale model of what the Dutch researchers and scientists did. If the Dutch help, they may be able to warn of any kids done on their small-scale experiment so the likelihood of an error reoccurring between the Dutch and Libyan soil trials would not be as likely. Along with this the scientists and engineers behind this large-scale experiment would have the distributing systems as well as the irrigation systems set up already, so Libya would not have to pay for the set up; Libya would only have to pay for the upkeep and for someone to organize how it is run and by whom. Along with this the country of Libya could potentially receive money for their cooperation and agreement to be used as a countrywide field test. If the field test was not as successful as planned, Libya may be reimbursed for their efforts and use of citizen and government time, planning, and perhaps money.

The logistics for this project seem to be more complicated than expected, as most things are. The government would potentially have to be granted access by neighboring countries to use the Mediterranean Sea as a resource. The other countries may be able to overrule Libya's chance to use the water for their own benefit. Water is a liquid so international boundary lines would not help determine Libya's fair share amount of saline water, thus needing to consult countries that boarder the Mediterranean Sea as well as areas that get water from a river coming from the Mediterranean Sea. Along with this, the inland and more rural communities may be more willing to adapt because of the lack of roadways and waterways to receive food from other countries. Along with the saline issue, Libyans would have to accept GMOs and if it is like the United States, some people may not buy the food if it is a GMO, which then eliminates the cash crop option, so a family would only be growing for themselves and maybe to trade if the trade partner accepts GMOs. The project should be sustainable due to the use of nearby resources and modern day technology to help the continuously growing population. The hardest part would seem to be getting the community to agree upon this idea due to the fact that GMOs and saline crops are still developing ideas. Each community will have different needs, so the project with saline and GMOs needs to be easily adaptable. Given this, each community may need different vegetables or have a harder time making the appropriate saline solution. Hopefully, if the Dutch and Indians can combine their knowledge and resources they can help feed more than just their country and Africa, but the whole world.

The saline crops are an appropriate solution, due to the knowledge of the science behind the GMOs and already being discovered and developed with saline and other plant growth stressors. Both experiments have worked successfully separate. Both the saline and GMOs have been proven to work together so hopefully there would not be as much push back as there would be if saline or GMOs were never field tested as a single object. Using the scientific method and results from the Dutch scientists, the saline and GMO kinks may also be able to be worked out before the GMOs in saline idea is worldwide, using Libya as a test subject, or a small portion of it. As far as irrigation goes, science and technology continues to develop and work to adapt to stressors. The pipeline system would work like the oil pipelines while being more environmentally friendly. Once the water is diluted and moved inland, the way to distribute the water may change based on the communities needs such as a water pump, high tech irrigation system, the percent of saline in the solution etc.

Although Libya has bad land for farming and as well as a lack of water, science has now advanced to the point of making land that seems useless, into food for the community and sometimes their country. The biggest issue with the saline crop idea would be that Libya is a conservative country, which may have a hard time accepting foreign technology, although Libya is slowly breaking out of their shell. Libya may be more willing to let science and technology from a foreign country help them because of how they are

encouraging women empowerment. The typical family will need to get a healthy quality and quantity of food to make their lifestyle healthy. Libya has the potential to be a more self-sustaining country if they could increase their amount of food produced by using GMOs and using Mediterranean Sea to their advantage.

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