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Guatemala, Factor 1: Plant Science

Samuel Johnson once said, “Agriculture not only gives riches to a nation, but the only riches she can call her own.” Agriculture is the most important commodity of every single country in the world. Without agriculture, people would have no food, no clothes, and no biofuels. Many people in developing countries rely on agriculture as their main source of income. Guatemala is one of these countries. In Guatemala, about 50% of the labor force is employed by some sort of agricultural field, and the agricultural sector accounts for 13.7% of the gross domestic product, or GDP (“Central America”).

Guatemala is located in Central America. It borders Mexico, Honduras, Belize, and El Salvador. It also borders the North Pacific Ocean and the Gulf of Honduras, which is located in the Caribbean Sea. Comparatively, it is slightly smaller than Tennessee. The climate is tropical, meaning it is traditionally hot and humid in the lowlands and cooler in the highlands. Guatemala’s terrain is mainly mountainous with narrow coastal plains. The official language is Spanish. It is spoken by 60% of the population. The remaining 40% speak Amerindian languages. In Central America, Guatemala is the most populous country. It also has the highest fertility rates and population growth. Additionally, Guatemala has the youngest population in Central America; almost half of the population is under age 19. The population as of July 2015 is 14,918,999 (“Central America”).

The average family size in Guatemala is five to six members. This generally includes a mother, a father, and three to four children (“Central America”). Basic grains, maize, sorghum, and beans are the staples of their diet. About 70% of the agricultural area under production in Guatemala is devoted to growing these crops (“Report and Recommendation”). A Guatemalan diet is often supplemented with eggs, squash, tomatoes, chiles, tropical fruit, and wild game. Rice has also become increasingly popular as a staple item. Many of the drinks ingested by Guatemalans are heavily sweetened with cane sugar. The cuisine has evolved from Maya, Latin America, and Western traditions (“Guatemala Adoption”). Some of the livestock raised include cattle, pigs, sheep, goats, and poultry. They are primarily raised for food or as a work animal on the farm (“Central America”).

In Guatemala, school is compulsory for nine years. However, in rural areas this is seldom enforced (Jugenitz et al.). On average, children attend school for eleven years (“Central America”). Guatemala’s health care system is split into three sections: public, private nonprofit, and private for profit. Access to health care is low, with slightly over 40% of the population receiving no access to health care. Guatemala does attempt to vaccinate children, and all routine vaccines are paid for by the government (“Guatemala - Health”). As of 2013, 6.5% of the GDP was used for health expenditures (“Central America”).

In Guatemala, 14.2% of the land is arable, or able to be utilized for agriculture. Unfortunately, this number is trending downwards (“Central America”). Guatemala is very reliant on agriculture, so having the arable land decrease will result in Guatemala having to face some very significant problems in the future. Land ownership in Guatemala is markedly skewed. Eighty-eight percent of farms in Guatemala have an average size of 3.7 acres (1.5 hectares). They occupy only 16% of arable land. Approximately 2.5% of the country’s farms control 65% of the arable land. About 40% of the economically active rural population does not own land (“Report and Recommendation”). The main crops grown for subsistence include corn, beans, rice, sorghum, wheat, fruit, and vegetables. The fundamental cash crops grown in Guatemala are coffee, sugarcane, bananas, and cotton (“Guatemala - Agriculture”).

A very large portion of Guatemala’s subsistence farmers have not actively adopted agricultural technologies. As a result, their farms often have low productivity. Due to various organizations trying to

educate farmers in Guatemala, some agricultural practices are being implemented. For example, some small farmers have abandoned the use of herbicides, pesticides, and chemical fertilizers. Even though these products may have improved yield, it was found they were polluting nearby water sources and leached the soil of valuable nutrients. Many educated farmers are now returning to agricultural practices used by their ancestors. An example of this is protecting native seeds. This helps keep plant biodiversity the same. It also allows time tested and proven crops to be saved and utilized for the future. In addition to old agricultural practices, farmers have also learned some new practices such as crop rotation, soil retention, and new harvesting techniques. Unfortunately, due to geographical barriers, it is often difficult to educate many of the farmers located in rural Guatemala (Gonzalez).

One of the main barriers small farmers in Guatemala face today is the unequal distribution of land. This problem has only worsened since the signing of the Central America Free Trade Agreement, or CAFTA, in 2006. As a result of CAFTA, many farmers have increasingly lost the right to produce crops on their own land. They are then resettled by the Guatemalan Land Fund. Many times, the land they are forced to relocate to is not suitable for growing crops and is also often priced at an amount far above what it is actually worth. This results in many small farmers having to migrate to urban areas in search of work (Abbott).

Many Guatemalans living in rural areas face the problem of accessing food markets. Most markets are located in cities and towns, and this creates a dilemma for many farming families. A large percentage of rural families cannot afford the travel expenses to access food markets. Also, roads in rural Guatemala can be very dangerous and difficult for travel. In some areas, roads do not even exist. Not being able to access food markets makes it difficult for farmers to sell their products. This results in the farmer having no monetary income. Also, since those living in rural areas cannot often access food markets, they may not be able to acquire the proper nutrients their bodies need. This can lead to chronic malnutrition (“Guatemala P4P”).

Plant science plays a very important role in the lives of small farmers in Guatemala. Plant science deals with how to increase crop yields and/or improve drought and disease resistance. This can be accomplished through research and breeding different varieties of plants to produce the most efficient plant possible. At this time, some public institutions, such as the Institute of Sciences and Technology of Agriculture, have developed plant breeding programs. These programs focus on the most important crops for Guatemalan people such as maize, beans, tomatoes, and potatoes. The government has provided some funding for these projects, but the economic support is very, very low. For cash crops, such as sugarcane, rice, corn, and chile peppers, plant breeding research is mainly conducted by private companies. This plant breeding research in Guatemala focuses on developing and evaluating genetic lines in specific plant species. Private companies have concentrated on improving yield and disease resistance in these crops (Osorio).

The amount of research dedicated to plant science in Guatemala is currently trending upward. However, there is still minimal research conducted in these areas. The most limiting aspect of this is the lack of financial resources. Also, there is a lack of laboratory technology and equipment needed to carry out field and laboratory experiments using plant breeding techniques. However, recently the Central American Bank for Economic Integration has endeavored to improve some of the facilities and the application of techniques used in the plant breeding process (Osorio).

Guatemala has the fourth highest rate of chronic malnutrition in the world (“Guatemala” *Guatemala*). Using plant science to improve yields could help to prevent chronic malnutrition in people living in rural areas. Also, the average farm size is only 3.7 acres. With such a small amount land, many farmers grow only enough to feed themselves and their families. They rarely generate a profit large enough to make a difference (“Report and Recommendation”). Plant science could help to maximize the

amount of crops grown on a small amount of land. This, in turn, would help the farmers generate revenue. Also, improving a crop's ability for drought or disease resistance could help provide stability during economically challenging times or natural disasters. Improving crops in Guatemala would help feed the country and also provide more revenue by increasing the amount of product available to sell.

Guatemala suffers from many different environmental issues that affect crops. These include drought, earthquakes, soil erosion, tropical storms along the Caribbean coast, and a variety of other problems ("Central America"). These environmental issues, along with a growing population, reinforce the importance of plant based biotechnology and the potential benefits for the citizens of Guatemala. Guatemala currently does not allow the production of genetically modified (GM) crops or animals, also known as genetically modified organisms, or GMOs, due to safety concerns. For example, there is speculation that GMOs infused with herbicides may cause birth defects ("Genetically Modified Organisms"). Also, another concern is the risk of biodiversity losses due to the introduction of GM crops. However, Guatemala does allow GM crops to be imported into Guatemala ("Guatemala Agricultural Biotechnology"). Despite these worries, the use of GMOs in Guatemala would be a very viable option for dealing with malnutrition and increasing yields.

In December 2010, the European Commission published a report summarizing the results of 50 research projects that dealt with the safety of GMOs for the environment and human and animal health. In one of the European Commission's statements, a spokesperson reported, "...there is, as of today, no scientific evidence associating GMOs with higher risks for the environment or for food and feed safety than conventional plants." There have also been several other studies conducted that indicate the safety of GMOs ("Commonly Asked Questions"). However, the concern of the loss of biodiversity is well-founded. To combat this, one option would be to set aside areas of land for the specific growing of GM crops. In order to avoid cross-pollination, a barren zone of land could be established between areas growing GM crops and areas growing traditional crops. This would help conserve biodiversity while still improving yields and overall production of crops in Guatemala.

In order to make this idea a reality, some support would be needed. Obviously, the Guatemalan government would need to legalize the production of GMOs. In addition, it would be beneficial for Guatemala to gain the support of the United Nations. The United Nations has created a code of conduct relating to GMOs called the Codex Alimentarius Commission. It is a collection of internationally adopted food standards, guidelines, codes of practice, and other recommendations ("Codex Alimentarius Commission"). The United Nations could help Guatemala establish an initial plan for how to deal with GMOs according to the Codex Alimentarius Commission. Guatemala would also need to contact companies such as Monsanto and DuPont to acquire GM seeds.

Even though GMOs are a viable option to reduce malnutrition, increase yields, and improve disease/drought resistance, there is the possibility that Guatemala will not allow the production of GM crops. If this is the case, Guatemala will still need to figure out a way to increase crop yields and improve disease/drought resistance in order to feed their growing population. Another idea would be to implement molecular breeding techniques such as molecular markers. Molecular markers are found on DNA and can include simple sequence repeats and single nucleotide polymorphisms (SNPs). Once markers for genes are identified, they can be used for genotyping. In this way, selection decisions can be made. This is a way to ensure plants receive desired traits faster than the traditional way of plant breeding ("Plant Breeding Research"). More research studies could be done utilizing this technology. This would help accelerate the improvement of plant varieties. This, in turn, could improve yields and also help to improve drought and disease resistance. As a result, this would also alleviate malnutrition without having to worry about health concerns or loss of biodiversity.

In order for this idea to be implemented, several organizations would have to provide sponsorship. For example, the Institute of Sciences and Technology of Agriculture (ICTA) in Guatemala currently carries out plant breeding in the main subsistence crops like maize, rice, potatoes, beans, wheat, and sesame (Osorio). Their programs could be expanded successfully. Also, new studies involving molecular markers could be added since ICTA already has the facilities for projects of this nature. Other organizations that could also offer opportunities for new studies are the Faculty of Agronomy at the University of San Carlos of Guatemala, the University of the Valley of Guatemala, and the Guatemala Rice Grower's Association (Osorio). However, one of the major hurdles would be the lack of finances to fund a project like this. The Guatemalan government could be urged to provide some economic support for projects that will have a positive impact on agriculture. Also, Guatemala could seek the aid of the World Bank. The World Bank provides low-interest loans, zero to low-interest credits, and grants to developing countries ("What We Do"). With a loan or grant from the World Bank, Guatemala could easily acquire enough finances to support this project.

Throughout the initial setup of both of these ideas, a smallholder farmer and his/her family would not necessarily be very involved. However, as the projects advanced, the farmers would be essential for the project's success. For example, if GMOs were legalized, many farmers who currently grow traditional crops would have to make the switch to GM crops. This would require educating the rural population on the best practices to use on GM crops. If the farmers actively tried to tailor their agricultural practices to support GM crops, an increased yield would be sure to follow. Also, if molecular markers were used to improve plant lines, smallholder farmers would need to be aware of these improved varieties of plants. They would also need to start buying the seeds that have improved drought and disease resistance, so their yields will increase. The acceptance and education of smallholder farmers and their families will be key for any project to successfully affect the status of food security in Guatemala.

In addition, keeping the public fully informed about the projects as they are happening would be essential. One way to achieve this would be to release an update informing the public about the progression of the projects each month. However, there are some rural areas that would not have access to the release. In cases such as this, a representative could be sent to these communities in order to deliver an oral report about the projects. This way, the local people would stay in tune to the research and would potentially be more accepting of it. Then, when the programs are completed, the farmers would be more willing to try the new products and techniques because they are already familiar with them.

Both GM crops and molecular breeding techniques would require a substantial amount of work to implement. Much of this work would happen out of the view of the public. This could cause dissatisfaction and tension in communities across Guatemala because the citizens might not feel like their immediate needs are being met. Also, these ideas may require a considerable amount of time to complete. As these projects are being conducted, other methods could be used to address the immediate needs of farmers in rural Guatemala. For example, there are several techniques and options to improve food security that could be introduced to the communities across Guatemala.

One of these options could involve educating women in rural areas. In Guatemala, there are 97 men to 100 women ("Central America"). This signifies that women outnumber men. As a result, women are a very valuable, and often underused, asset. Women can be trained to assist and/or manage farms. This could be achieved by having individuals put on a series of workshops. Each workshop would focus on an essential farming technique. These workshops could be held throughout Guatemala. Most women living in rural areas also have families to care for. In order to make the workshops more accessible for these women, it would be necessary to provide day care while the women attended the workshops.

Another option could be introducing *Cajanus cajan*, or pigeon pea. The pigeon pea is a bean specially bred to resist drought and can be grown simultaneously with other crops, such as corn. It is not a GM

variety of plant, as a result, it can be immediately implemented. The pigeon pea has quite a few advantages including, decreasing soil compaction, providing nutrient and protein rich food, and helping replace organic nitrogen, which cuts down fertilizer cost. In addition, pigeon peas are open-pollinating which means the farmers can then save their own seed (“Semilla Nueva”).

The pigeon pea could be implemented using the farmer to farmer method used by the non-government organization, Semilla Nueva. Semilla Nueva currently works in ten villages located in Southern Guatemala. They have had great success in this area. Their farmer to farmer method allows Guatemalans to be involved in every step. It starts with small experimentation. Farmers use a small amount of their land to try out a new idea, such as the pigeon peas. The next step is to analyze the data. Semilla Nueva workers teach the farmers how to analyze what they have learned through cost benefit analysis. This includes social, environmental, and economical factors. This allows farmers to weigh the pros and cons in their local context. After analyzing the data, Semilla Nueva places emphasis on sharing the new techniques the farmers have tried. Conferences and field visits conducted by the actual farmers allows other people in the surrounding area to see new technologies and strategies working in their very own community (“Semilla Nueva”).

Currently, Semilla Nueva does not reach the majority of Guatemala’s communities. This is an organization that could be successfully scaled up to reach almost, if not all, of rural Guatemala. Also, Semilla Nueva focuses mainly on adults. This organization could reach out to different age demographics very easily. For example, they could create a program focusing on research and experimentation for children. This would help children to develop a strong understanding of the scientific method. It would also help to promote leadership skills and an innovative nature in young individuals, which will be imperative for future generations.

John Muhaise-Bikalemesa once said, “You cannot have a happy, healthy, and peaceful continent without food.” Agriculture is the most important commodity of every country in the world. Some countries, such as Guatemala, struggle with food security and malnutrition. Advances in agricultural technology and in areas like plant science or biotechnology can help increase production and alleviate these problems. One example of how to improve food security in Guatemala using plant science would be the introduction of GM crops in production. Another example would be to increase research of plant genetics using technology such as molecular markers. Many different organizations and groups may be needed to help achieve these goals. However, with support and cooperation, countries such as Guatemala can improve processes which will help them to achieve food security.

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