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Ethiopia, Climate Volatility

Ethiopia: A Sustainable Plan for a Future

In this modern age, hunger and poverty remain interconnected, complex issues posing unique challenges on a global scale. One such issue is climate volatility, often marked by desert salinization, extreme weather, rising sea levels, and urban heat islands. A food crisis, induced by climate volatility, becomes especially propagated in economically weaker nations plagued with civil unrest, poverty, and inefficient leadership. However, through environmentally and economically sustainable solutions, individual nations can achieve stable food security, improving global food security in the long run.

One such nation, the Federal Democratic Republic of Ethiopia, highly suffers from climate volatility through unpredictable weather, rising sea levels, and drought. Landlocked at the center of the Horn of Africa, Ethiopia hosts Africa's second-highest domestic population: roughly 115 million people, with approximately 21.3% of people residing in urban areas and the remaining in 78.7% in rural settings ("Ethiopia Demographics"). Furthermore, Ethiopia's capital city, Addis Ababa, is rapidly growing at a rate of 4.43%. (Addis Ababa Population 2022). Under Prime Minister Abhiy Ahmed, Ethiopia hosts the fastest-growing African economy with primary exports of coffee ($837M), oily seeds ($347M), gold ($256M), cut flowers ($238M), and zinc ore ($199M) (OEC).

These exports are derived from Ethiopia's large agricultural industry, composing 46.6% of the nation's GDP. With 85% of the workforce employed in the agricultural industry, farming defines the nation's culture and practices. With only 20% of the nation being cultivated land (51.3 million arable hectares), the majority of Ethiopian farms are small, approximately 1 hectare. In comparison, the average American farm is roughly 180 acres. Effective rural Ethiopian farms produce meat and dairy for domestic subsistence purposes that offset the 67% of farms that live below the national poverty line (FAO). In line with the agricultural culture, 31% of urban households also own farm animals. However, in Addis Ababa, commerce and food access revolves around central city markets. Generally, Ethiopians use subsistence produce towards a diet involving stewed cereals, tubers, root crops, pulses, and oilseeds.

In rural areas, families pair their farms with traditional round thatched huts. Most families are patriarchal with an average size of 5 people. Populations are less dense in rural areas, while urban settings like Addis Ababa experience population densities as high as 5,165 individuals per km^2 ("Addis Ababa Population 2022"). This density is met with packed dilapidated homes with poor toilet conditions, including shared pit latrines and unattended solid waste. Socioeconomically, Ethiopian workers earn around 8,900 Ethiopian birr (ETB), or 178 USD, per year. As a developing nation, Ethiopia also has limited access to complete basic utilities, especially for rural populations. For example, 83% of urban Ethiopians have electricity access compared to 14% for rural populations. Access to safe drinking water is also limited to 49% countrywide. Mobile connection and road network access are both limited to approximately 40%.

Over the past decade, Ethiopia slowly approached their food insecurity and health issues. However, the nation's economic and agricultural development relies on deforestation for arable land, which has continuously increased greenhouse gas emissions. Natural phenomena such as La Niña and the El Niño, which are alternating five-year cycles of cooling and heating in the Pacific Ocean, have also propagated inland climate change (The New Humanitarian). As a whole, East Africa experiences drought and dry soil during the La Niña cycles, creating an expensive need for increased irrigation. In Ethiopian lowlands, increased temperatures and long droughts have limited the access to potable water needed for raising

livestock, while the highlands suffered from irregular rainfall, erosion, and decreased agricultural yields (Berhane, Bezabih). Perhaps most importantly, without serious change, Ethiopia's staple crop, injera, is expected to fall in production by 25.4% by 2050 (Solomon et al).

These climate issues are expected to impact rural Ethiopia the hardest, where childhood malnutrition is high at 38% and food insecurity is low due to a lack of an agricultural expansion legislature. The limited arable land mixed with climate change can cause failed growing seasons and food insecurity to be more year-round. Families without farms are also the most insecure. Finally, despite efforts to increase education for women, increased climate change reinforces a farming-first culture and forces women back into traditional gender roles of caregivers. This "psychological and emotional stress" on women translates to their dependents at home, including children and elders (The Global Citizen). Ethiopia's increasing greenhouse gas emissions, growing deforestation rates, and natural phenomena like El Niño clash with Ethiopia's socioeconomic issues and threaten forward progress.

Therefore, creating consistent and sustainable crop yields during growing seasons will become a priority for both the government and its citizens. Traditionally, Ethiopian farmers have relied on crop rotation, fallow land, and terracing methods, which hinge on predictable weather patterns allowing land to naturally replenish its moisture and nutrients. However, the unpredictable weather effects of climate change can only be combated with methods independent from consistent rainfall and weather.

One such method is hydroponic farming, which has been previously implemented in locations with inconsistent or little rainfall. Hydroponic farming involves growing crops in a controlled vertical setting without direct soil access. The method centers around three major components: water, nutrients, and an essential growing medium. The components act as substitutes to the soil by ensuring water is "integrated with the required oxygen and nutrients" to "supply the plants with the necessary hydration, nutrients, and the growth factors it needs" (American Promise). However, the growing mediums vary in pH, as some crops require more acidic or alkaline soils for optimal growth (American Promise). One potent growing medium is eutric nitosol, abundant in Ethiopia. Nitosols are weathered red soils composed typically of 30% clay, which allows for the medium to retain soil but is still permeable enough to drain excess water (NITISOLS (NT)) With a slightly acidic pH of 5.0 to 6.5, eutric nitosols have high potential for large hydroponic yields with proper management.

Hydroponic farming contains six different systems that vary with effectiveness, water requirements, and cost, where more expensive techniques require more water. In order to strike a balance between Ethiopian farmers' financial constraints and food requirements, the most cost-effective system is the Ebb and Flow systems. This system involves placing plants over a grow bed with a reservoir beneath it. The reservoir contains a timer-based underwater pump that circulates water to and from the crops in order to maximize nutrients. This solution has low water requirements, making it an ideal solution for Ethiopians (American Promise) Furthermore, ebb and flow systems can grow nearly any type of plant, providing both subsistence crops and those demanded in the global export market (American Promise).

Ebb and flow systems only have two potential downsides: water drainage and labor. After the reservoir water has been cycled many times, it is typically drained, which is inefficient in water contingent nations. Therefore, the ebb and flow system can be improved to drain that water into traditional lands for secondary crop sources. MIT, for example, has developed a cereal integral to Ethiopia's cuisine that doesn't require fertilizer or major nutrients (Modern Farmer). Secondly, while hydroponic farming is labor intensive, this is likely not a problem as Ethiopian labor is abundant and a cornerstone of the nation's work culture.

To develop this system, Ethiopia would require greenhouses adjacent to existing farms. Average Ethiopian farms can accommodate freestanding hoop greenhouses around 1000 square feet alongside ebb

and flow systems, which sum to less than $7500. While this system seems initially expensive, it provides two food sources independent of dry seasons or droughts. Ethiopia already suffered a large famine in 2011, and the Ethiopian government aims to not revert back into that crisis. The Bill and Melinda Gates Foundation has already been working to improve crop yields in Ethiopia. Through potential government subsidies, funding from the Foundation, and small economic inputs from farmers, this system can become feasible. The large crop yield would push small-holder farmers beyond subsistence levels and provide profit in the global export market, thus offsetting the initial costs. Beyond monetary input, the other government requirement is for education on these methods in order to enable farmers to earn high crop yields sooner. To be effective, Ethiopia should work with nations, especially those with similar climates, where hydroponics have been successfully implemented in order to develop their education program. This program would look for global funding partners with interests in Ethiopia's agriculture sector. Also, the program would be slowly introduced in test Ethiopian markets first in order to assess potential pushback. This method holds the potential to eliminate Ethiopian farmers' dependence on rainfall, reduce deforestation and CO2 emissions, and prevent malnourishment and hunger among people when traditional farming fails.

Another implementable solution for Ethiopian agricultural practices is an upcoming crop advancement: Kernza. Kernza is a perennial grain developed by the Land Institute in the United States. It is genetically similar to wheat, but comes with extended environmental benefits (The Land Institute). Traditional Ethiopian grains, including staple crop teff, are annuals, which are time-consuming to grow. In Ethiopia's ever changing and unpredictable climate, a new, stable, and reappearing crop is a necessity.

Kernza doesn't require tilling, which has been known to cause land erosion and release excess soil-stored carbon into the atmosphere. Tilling can also inhibit land reuse once plant cycles complete, which is a major problem in a nation already struggling to find arable land. Rather than cause land erosion, kernza builds deep roots into the soil and holds nutrients in place. Through these deep roots, carbon is trapped in the soil rather than escaping into the atmosphere. In terms of labor, kernza is also far more sustainable, as it requires fewer nutrients, herbicides, nitrogen fertilizer, and water inputs. Once planted, kernza can grow consecutively for 5 years without replanting.

Kernza's primary benefit to Ethiopian farmers is it easily integrates into a grain-heavy cuisine. Injera, a bread constructed from the native crop teff, defines Ethiopia's diet. As a more fiber-rich option than traditional grains, kernza serves as a healthier source that only slightly modifies Ethiopian cuisine. Kernza is also less labor intensive than kernza, so small-holder farmers can devote more effort towards developing other profitable crops without sacrificing subsistence. Kernza will enable farmers to farm consistently and feed families in drought or flooding seasons. Furthermore, kernza's ability to reduce carbon emissions due to soil erosion will allow the Ethiopian climate to slowly recover from the effects of climate volatility, thus improving farming productivity as a whole.

To introduce this crop, several steps must be taken. Firstly, kernza has been primarily developed for Eurasian climates, so slight research may be required to adjust the crop's genetics. The Land Institute has already partnered with the Jimma University in Ethiopia, so expanding these partnerships will allow for kernza improvements (The Land Institute). Secondly, the Ethiopian government must provide aid to small farmers shifting to this method, primarily through education programs and subsidy policies to kernza-friendly farmers. Ethiopia could also adopt India's policy of ensuring small farmers will have their yields bought and distributed at a fixed price. Such policies would encourage farmers to plant kernza and devote more time towards growing other globally demanded crops. Finally, the government must obtain grain seeds from overseas. Through existing partnerships, such as with the Bill and Melinda Gates Foundation, kernza can safely be introduced into Ethiopia. By not only being a proactive climate change measure in an ever-changing environment, but also an economically feasible option, kernza can become extremely desirable for farmers.

Poverty and food insecurity are intertwined issues that are ever growing across the globe. Ethiopia suffers from food insecurity and the possibility of an unstable economy as a result of climate volatility. While agribusiness has been growing, climate change threatens to create large economic loss and poverty. With proper management, Ethiopia can become a primary African exporter and move into a higher global standing. Through solutions like adjusted hydroponics and the introduction of the kernza crop, Ethiopia's farmers can move beyond subsistence farming and produce high crop yields. By improving food security, Ethiopian families can accelerate their forward progress and erase the effects of climate volatility.

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