

Katherine Taylor, Student Participant
Hoover High School
Des Moines, IA

Ethiopia: Global Warming and the Threat to Food Security

Introduction

According to Chinese Proverb, “Give a man a fish and you feed him for a day. Teach a man to fish and you feed him for a lifetime” (Bartelby). But what good is fishing if there is no water? This is an apt metaphor for imperiled agricultural sustainability in sub-Saharan Africa due to the impact of adverse environmental changes. In many developing countries of the world, high producing genetically modified crops supplemented by improved fertilizers and pesticides have been key weapons in the war against hunger. However, the effectiveness of these agricultural breakthroughs is contingent on stable climate and adequate hydration. Consequently, climate instability caused by global warming threatens their continued effectiveness as water is depleted.

The international scientific community has reached general consensus that “the warming trend in the global mean surface temperature observations during the past 20 years is undoubtedly real and is substantially greater than the average rate of warming in the 20th century” (2 National Academy of Sciences). According to a study by the National Academy of Science, measurements of surface temperature recorded consistently for over 100 years show the Earth’s surface has warmed by about 1 degree (Fahrenheit) in the past century with the 20th century's 10 warmest years all occurring in the last 15 years. If global warming is unabated, scientists expect that the average global surface temperature could rise 1-4.5°F (0.6-2.5°C) in the next fifty years, and 2.2-10°F (1.4-5.8°C) in the next century (2 US EPA).

Sub-Saharan African countries such as Ethiopia are especially vulnerable to the agricultural upheaval global warming will induce. Recent assessments show that 46 percent of Ethiopians are undernourished (Rural Poverty Portal). Although there would be room for regional variation, the resulting climate change would directly impact human nutrition, especially in Africa as this report states:

“Peoples most at risk of famine live in agriculturally isolated, arid or semi-arid regions, such as sub-Saharan Africa African agriculture was already unable to keep pace with population growth during the last decades of the 20th century. And climate models generally predict that mid-continental summer soil moisture will tend to be lower with greenhouse warming” (2 National Academy of Sciences).

Ultimately, the war against hunger in Ethiopia will be lost unless global warming, and accompanying soil and water resource degradation, is reversed.

Challenges

The typical family in Ethiopia already struggles for survival. Consisting of 6 people (USAID), as many as eleven families crowd into each square kilometer. They, like eighty-three percent of the population, live in a rural area. Like eighty percent of employed Ethiopians, both parents work in agriculture. The average farm size is .79 hectares, or, approximately two acres. Grains, pulses, and coffee make up the products of Ethiopian agriculture; wheat, maize (corn), barley, teff, sorghum, and millet are the major grains grown. High protein, carbohydrate, and

fiber content make pulses an essential dietary supplement (Vegetarian Society). Chances are low that either parent can read or write, since only 43 of every 100 can. Like the overwhelming majority of Ethiopians, family members must survive on less than two dollars each day. Health is negatively impacted by lack of medical care (physicians are virtually nonexistent) and lack of proper sanitation (only 4% of the population has access to toilets). Additionally, clean water is scarce; this family would be very lucky to drink water without health risk, as only eleven percent of Ethiopians have access to an “improved water source” (Rural Poverty Portal). The Green Revolution has not yet reached Ethiopia. According to Workneh Negatu of the Addis Ababa University only about 3% of crop land is grown with improved crop seeds (Negatu).

To fully understand the problem of climate change and water degradation in Ethiopia one must first understand global warming dynamics. It is also and aptly known as “the greenhouse effect” because CO₂ and other gases (always present in the atmosphere) create a natural warming effect similar to the warming inside a greenhouse. This process has accelerated greatly in recent years as higher concentrations of CO₂ and greenhouse gases are added to the atmosphere at a rate faster than any time over the past several thousand years. The underlying cause is, primarily, fossil fuels combustion accompanying industrialization. (Carbon is the “fuel in fossil fuels. Industrialized countries like the United States run on carbon; CO₂ is a byproduct of burning carbon-based coal, oil, and natural gas.)

Global warming triggers a global environmental chain reaction. Atmospheric warming produces surface warming, which in turn impacts the environment. As temperatures rise, ice turns to water. Glaciers in the Arctic, Antarctica, and atop mountains dwindle. Melting glaciers contribute to the rise in sea levels. Ocean temperatures also rise, causing more severe weather events such as typhoons, tornadoes, and hurricanes; fish migrate to cooler areas in higher latitudes away from fisheries along universal coasts. On land animals are affected by changing habitat, while vegetation is affected by changing growing conditions.

Many scientists currently argue that the increase in atmospheric carbon dioxide (CO₂) will benefit crop production. True, CO₂ is considered a “gaseous fertilizer” (Pickrell) by ecologist Peter S. Curtis at Ohio State University. This promotes photosynthesis in plants, the process that converts CO₂ and water into glucose and oxygen. By speeding up the photosynthetic rate, plants will grow, mature, and produce fruit more quickly than normal (Wolfe). While this seems like good news, a broader viewpoint reveals a foreboding truth. Crop yields may rise initially, but only within a narrow range of optimal temperatures. The forecasted bumps in crop yields have scientist jumping to conclusions that CO₂ escalation will be a supplement to food production; this is a false presumption. Plants are growing faster, therefore shortening the life cycle of the plant, and, consequently, the harvest period. Even though plants are producing more fruits, it occurs within a shorter time period. In this case, speed does not compensate quantity. The acceleration in production is simultaneously lengthening the time period between harvests. Poor farmers in Ethiopia will not be able to store any excess food in such a short time span and be able to rely on that amount until the next harvest arrives a year later. This trend will spiral down over decades into lower quantities of food. This is bad news for a global population expected to reach 8 billion people by 2030 (1 FAO).

Rising temperatures may move too quickly for staple crops to adapt. When temperatures are too high for a plant, its vital enzymes run the risk of denaturing (the breakage of its polypeptide bonds). This process has the potential to kill the plant (Abrol and Ingram). Plants that do adapt and survive may be nutritionally impaired. One adaptation to atmospheric CO₂ increase is reduction of protein content. In a study by Peter Curtis, nitrogen, an element most often found in proteins, is decreasing (Pickrell). This poses a new and decidedly worse dilemma:

how is the nutritional value affected? Curtis found that nitrate levels dropped 15-20% in tested plants. The adverse impact is obvious considering that these plants will be consumed by Africans already struggling with undernourishment. Additionally, some staple crops that are especially vulnerable to the CO₂ proliferation are grains. These plants produce seeds once in their lifetime (Wolfe), creating untenable uncertainty for millions of farmers whose livelihoods depend on these foods, and raising further the specter of regional famine. For example: "A projected 2 to 3% reduction in African cereal production for 2020 is enough to put 10 million people at risk." (2 FAO).

Also important to Ethiopia's water problem: rising temperatures render arable land arid because soil evaporation is accelerated. The impact will be especially keen to a population so predominantly tied to the land. According to Andrew Simms, spokesperson for World Development Movement:

"Africa is more exposed to the impacts of climate change than any other region in the world. Climate change is happening and it is affecting livelihoods that depend on the natural environment, which, in Africa, means nearly everyone" (Vidal).

The arable/arid land dichotomy highlights one of the first agricultural consequences of global warming: land resources. Globally, arable land per capita is shrinking. In 1970, .38 hectares of land per capita were arable; in 2000, only .28 hectares remained (1 FAO). Agriculture constitutes forty-seven percent of Ethiopia's GNP, yet only seventeen percent of the country's land area is cultivated (U.S Department of State). People are struggling to keep food production stable as crop production decreases due to decreased soil quality. They resort to expanding crop area, thus forested land is converted to farmland. By converting forests to seasonal crops, the regional climate system is altered because, for example, clear-cut hillsides are significantly warmer than forests. Thus deforestation exacerbates global warming.

Changing land use is associated with changes in the usage and availability of water, as well. The present state of water in Ethiopia is already a major barrier to food security due to soil over-cultivation, which affects the quality and availability of water in two key areas: 1) crop production, and 2) direct human consumption.

Regarding the first area, crop production, according to the National Sustainable Agriculture Information Service, soil holds water due to a rich mix of components. Soil is defined not only as mix of minerals and water, but includes fungi, bacteria, other microorganisms, earthworms, decaying plant parts, roots, and other organic materials that are responsible for making the soil hold water (Sustainable Table). Use of synthetic fertilizers weakens organic matter, damaging water retention in the soil.

Synthetic fertilizer use also affects the second area, human consumption. Not only is water capacity in soil affected, but the ground cannot absorb the nutrients the man-made fertilizer forces into it. Subsequently, the unabsorbed chemicals gradually transfer into the nearest bodies of water. These waters are sometimes the main source of water for an entire area of people. One of the most frequent nutrient pollutants is nitrogen. Nitrogen contamination is especially hazardous to small children and infants. Babies who drink nitrate-polluted water often obtain methemoglobinemia, or blue baby syndrome, causing brain damage and even death (Sustainable Table). For millions of Ethiopians with weakened immune systems due to undernourishment, exposure to nitrate-infested water is especially damaging. Moreover, the water supply is infested with harmful microbacterial organisms. Water-borne diseases and conditions such as cholera and diarrhea are prevalent killers. Only 22 - 34 percent of sub-Saharan Africa has access the

contaminant-free or “safe” water (Tatlock). The lack of financing for development and distribution of water also hinders the population’s access. The health of millions depends on the availability of clean water. Of all deaths in the developing countries of the world, 80% of diseases are traced to contaminated water; 30% of deaths are water-related (Tatlock).

Other barriers to food security in Ethiopia involve lack of education and lack of a common language. Of the 77 million people that live in Ethiopia, 43% can read or write. Only 57% of Ethiopian children attend elementary school (U.S. Department of State). Without basic education, hopes for future prosperity are dim. The Ethiopian government needs to emphasize the importance of education by requiring children to attend a certain number of years of school. Currently none is required. Communication challenges nationwide are another challenge. Ethiopia has an abundance of ethnic diversity: seventy-seven different ethnic groups exist, some numbering as few as 10,000 people (U.S. Department of State). Though Amharic is considered Ethiopia’s official language, it has been replaced in many primary schools by Tigrinya or Oromifa, local languages in areas. Establishing communication in a developing country is integral to its recovery; this move militates against that. However, it should be noted that in spite of low education and overwhelming diversity, recent history shows that Ethiopians united to overthrow an oppressive Communist regime in 1989, adopting a new constitution and implementing a democratic form of government in 1994.

Solutions

Kyoto Accords Thanks to global warming vulnerable countries like Ethiopia are placed in enviro-nutritional risk by more prosperous industrialized countries. Therefore, the first solution lies with the United States, a major contributor to global warming. U.S. emissions account for about 20 – 30 percent of global greenhouse gases according to a 1997 report. Fossil fuels burned to run cars and trucks, heat homes and businesses, and power factories produce about 98% of U.S. carbon dioxide emissions, 24% of methane emissions, and 18% of nitrous oxide emissions (1 US EPA). Therefore, it is imperative that our government take immediate action to reduce emissions. We must join the rest of the industrialized world in taking responsibility for cleaning up our environmental messes and sign the Kyoto Accords. This treaty was ratified by 140 nations and went into effect in 2005. It is an international agreement to fight global warming. Signatories are legally committed to meeting emissions targets by 2012.

Green Revolution Genetic engineering is more important than ever in Ethiopia. Temperatures may rise faster than plant species can adapt. Science must help crops “catch up” to climate change and water degradation until global warming is under control. Genetically modified crops are the most direct and “natural” way to achieve sustainability. By extracting the nuclei of plant cells with a desired trait, scientists can separate species of plants with a preferred quality in plant hardiness, such as drought resistance or higher fruit production. Scientists then extract the nuclei of a staple crop plant, and in its place, put the better nuclei. One promising area involves manipulating plants’ natural line of defense against high temperatures: heat shock proteins (HSPs), proteins synthesized when plants encounter heat stress through high leaf temperatures (Abrol and Ingram). Plants genetically engineered to produce HSPs are far more resistant to heat injury. This and other promising areas have yet to be realized due to insufficient financial resources which constantly constrain lab studies and other efforts toward food security. The Green Revolution has yet to flourish in Africa, giving infinite room to increase crop production in Ethiopia. Providentially, now a benefactor, Microsoft founder Bill Gates along with the Rockefeller Foundation has recently announced plans to give \$250 million over five years (\$30 million/year from the Bill and Melinda Gates Foundation, \$20 million/year from Rockefeller) to replicating the Green Revolution in Africa (Brasher). Help is on the way!

Halt Deforestation and Soil Erosion Bringing the Green Revolution to Africa will also halt deforestation and soil erosion. For example, when the Green Revolution was applied to India from the 1960s to the 1980s, over 100 million acres of India's natural environment was saved from deforestation (Rauch). This reduces global warming as forested land is cooler than agricultural land. Since overgrazing is an enormous contributor to soil erosion, repopulating Ethiopia's mountains with trees and contoured crops in place of inefficient cattle is important. Contoured crops would hold topsoil in place by growing plants to take root in the ground, and preserve the landforms' natural shape by shaping crop rows to fit Ethiopia's rolling hills. Other small, but mighty, weapons in the battle to prevent soil erosion are worms. Worms reduce the need to plow or till the soil. They enhance plant growth by tilling the earth without exposing the precious topsoil to powerful dry winds from the Sahara. As they travel, they break down organic compounds in the soil, making nutrients more usable by plants (Sustainable Table).

Water Quality Water treatment would greatly restore vitality to the Ethiopian people. Wells on small Ethiopian farms are one example of "small-scale" improvements farmers can make for themselves. Reducing or discontinuing use of synthetic fertilizers and pesticides is especially important here. Carefully introducing natural predators of crop-devouring pests can cut down the need of harmful chemicals and thus reduce the damage done by chemical pollution that runs off into water sources for Ethiopians. Without the danger of chemical water contamination, susceptibility to disease will be reduced.

Water Supply Many forms of irrigation exist. Pedro Sanchez, a scientist at the Earth Institute at Columbia University stresses the importance of "green water;" not found in lakes/river/streams, green water is the moisture already present in the ground that constitutes 2/3 of water supply as a whole (Tatlock). The utilization of drip irrigation is an effective and sustainable strategy to reduce the issue of water scarcity. Treadle pumps are tremendously beneficial to farmers without access to ample irrigation means. They are human-operated, eliminate CO2 emissions, and have improved water supply for other African countries like Niger, Kenya, Zimbabwe, and Zambia (Kay and Brabben). As of yet, no initiative has been taken toward extending access to Ethiopia. The costs of treadle pumps are an obvious setback. Prices range from 28 to 160 American dollars (Kay and Brabben). For the average Ethiopian who earns \$116 in a year (U.S. Department of State), this is an impossible luxury. International aid should be provided to foster treadle pump usage.

Micro-biodiversity Reducing reliance on synthetic pesticides, herbicides, or fertilizers will create a more hospitable environment for manipulating microorganisms to utilize mycorrhizas. This promotes biodiversity that uses mutual symbiosis benefiting both species. Mycorrhizas are the relationships between different species of fungi and plants that help to obtain nutrients more easily and efficiently. Arbuscular mycorrhizal fungi are certain species that interact particularly with crop plants. In exchange for a home, these fungi grow extremely fine hairs that extend into a tree-like formation. These hairs are important because they increase the surface area for absorption, therefore increasing the amount nutrients otherwise obtained by plants. The fungi then transport these nutrients to the plant roots, where mycorrhizae make their home. (Using synthetic pesticides, herbicides, or fertilizers suppress this naturally occurring benefit.) This also increases water potential, enabling plants to adapt to climate variability.

Conclusion

The threat of global warming is real and imminent; food security in Ethiopia is already fragile. Ethiopians could be the first nutritional casualties of this environmental crisis. This is

not a phenomenon which will stop in Sub-Sahara Africa. If they are affected tomorrow, it will affect the rest of the world in a tomorrow to come.

Fortunately, we have the knowledge and means to solve this problem. Thanks to initiatives like the Kyoto Accord the international community has mapped out the plan for global reduction of greenhouse gas emissions. Scientists already know how to genetically alter crops to adapt to various environmental factors for maximum yield. Even the financial resources necessary to support crop research are coming into place with the generous support of the Gates and Rockefeller Foundations. Literally and figuratively this is seed money. Hopefully, more financial resources from other entities will follow.

Unfortunately, we don't have, or have not yet demonstrated, the resolve to tackle global warming. It is imperative that the United States sign the Kyoto Accord and begin a coordinated national campaign to reduce greenhouse emissions. We have to live green at home in order to launch the Green Revolution into Africa and Ethiopia. It's fair to say that the first Green Revolution was a U.S. export, spearheaded by a great American, Norman Borlaug. But the toxic emissions of our industrialized nation are another export. A lethal export that threatens the gains of the first Green Revolution and the promise of the revolution so desperately needed in Africa.

The time to act is now.

Bibliography

Abrol, Yash P. and Ingram, Keith T. "Effects of Higher Day and Night Temperatures on Growth and Yields of Some Crop Plants." <http://www.fao.org/docrep/W5183E/w5183e08.htm>. August 23, 2006.

Brasher, Philip. "Bill Gates Takes up Borlaug's Ag Cause in Africa." September 24, 2006. Des Moines Register.

Environmental Bamboo Foundation. "More about CO2 and Global Warming." Updated 2000. <http://bamboocentral.org/shareinrepair/globalwarming.htm>. September 24, 2006.

1 Food and Agriculture Organization of the United Nations. "Food Security and the Environment." 2000. <http://www.fao.org/worldfoodsummit/english/fsheets/environment.pdf>. August 20, 2006.

2 Food and Agriculture Organization of the United Nations. "Impact of Climate Change on Food Security and Implications for Sustainable Food Production." Committee on World Food Security, 29th Session, May 12-16, 2003. <http://www.fao.org/DOCREP/MEETING/006Y9151e.HTM>. September 1, 2006.

Henze, Paul. "Ethiopia: Major Staple Crops." The United States Library of Congress Country Studies. As of 1991. [http://lcweb2.loc.gov/cgi-bin/query/r?frd/cstdy:@field\(DOCID+et0105\)](http://lcweb2.loc.gov/cgi-bin/query/r?frd/cstdy:@field(DOCID+et0105)). September 23, 2006.

Kay, Melvyn and Brabben, Tom. "Treadle Pumps for Irrigation in Africa." International Programme for Technology and Research in Irrigation and Drainage, Knowledge Synthesis Report No.1, October 2000. Powered by The United Nations Food and Agriculture Organization.

- 1 National Academy of Sciences. "The Evidence for Warming." 2005.
<http://www4.nationalacademies.org/onpi.webextra.nsf/44bf87db309.html>. September 2, 2006.
- 2 The National Academy of Sciences. "Global Warming Facts and Our Future." 2005.
<http://www.koshland-science-museum.org/exhibitgcc/impacts09.jsp>. September 2, 2006.
- Negatu, Workneh. "Land Tenure and Technological Improvement in Smallholder Agriculture of Ethiopia." Addis Ababa University. August 2005.
<http://www.eaecon.org/EEA/conferences/Land5Aug2005/FSS%20technology%20paper.doc>. August 7, 2006.
- Pickrell, John. "Global Warming May Boost Crop Yields, Study Says." National Geographic News. November 25, 2002.
http://news.nationalgeographic.com/news/2002/11/1122_021125_CropYields.html.
 September 11, 2006.
- Rauch, Jonathan. "Will Frankenfood Save the Planet?" *Atlantic Monthly*, October 2003.
- "Respectfully Quoted: A Dictionary of Quotations," requested from the Congressional Research Service. Washington D.C.: Library of Congress, 1989; Bartleby.com, 2003.
www.bartleby.com/73/. September 12, 2006.
- Rural Poverty Portal. "Ethiopia Statistics." Powered by IFAD. Updated June 14, 2006.
<http://www.ruralpovertyportal.org/english/regions/africa/eth/statistics.htm>. August 7, 2006.
- Sustainable Table. "The Issues: Soil." 2004. <http://www.sustainabletable.org/issues/soil>. August 13, 2006.
- Tatlock, Christopher W. "Water Stress in Sub-Saharan Africa." August 7, 2006. Council on Foreign Relations. http://www.cfr.org/11240/water_stress_in_subsaharan_africa.html.
 September 8, 2006.
- United States Department of State. "Background Note: Ethiopia." September 2006. Bureau of African Affairs. <http://www.state.gov/r/pa/ei/bgu/2859.htm>. September 10, 2006.
- Vidal, John, and Radford, Tim. "One in Six Countries Facing Food Shortage." *The Guardian*, June 30, 2005.
- United States Agency for International Development. "Family Planning: Ethiopia." Last updated February 25, 2005.
http://www.usaid.gov/our_work/global_health/pop/countries/ethiopia.html. August 17, 2006.
- 1 United States Environmental Protection Agency. "Science FAQ."
<http://yosemite.epa.gov/OAR/globalwarming.nsf/content/ClimateScienceFAQ.html>.
 August 16, 2006.

2 United States Environmental Protection Agency. "Global Warming: Climate." January 7, 2000. <http://yosemite.epa.gov/oar/globalwarming.nsf/content/Climate.html>. August 15, 2006.

Vegetarian Society, The. "Information Sheet: Pulses." <http://www.vegsoc.org/info/pulses.html>. August 19 2006.

Wolfe, David W. "Potential Impact of Climate Change on Agriculture and Food Supply." Cornell University. <http://www.gcrio.org/USGCRP/sustain/wolfe.html>. August 19, 2006.