Sam Schulte
Valley High School
West Des Moines, IA
Ethiopia, Factor 2
Reconciling Hydrological Resources in Ethiopia

Ethiopia has historically proven its ability to flourish. It was the sole nation in Africa to successfully fend off colonization and is, consequently, the oldest independent entity on the continent. Yet today, Ethiopia is facing its most challenging obstacle yet: poverty. Incomes rank in one of the lowest echelons in the world with an average income of less than one US dollar per day ("Ethiopia."). To earn this unfortunately paltry amount, 85% of Ethiopians work in the agricultural sector, an intrinsic portion of the Ethiopian economy ("Africa: Ethiopia."). Despite the fact that agriculture creates such a dominant allotment of jobs, agriculture represents only 50% of the country's overall GDP; while this percentage is still above average, the 35% discrepancy between the jobs agriculture creates and how much of the GDP agriculture constitutes illustrates the vast differential between how many jobs are created by the sector and the amount that the job pays ("Africa: Ethiopia."). Because agriculture represents an overbearing portion of jobs but pays little in comparison, a resultant poverty rate of 38.7% has developed ("Africa: Ethiopia."). In 1935, Ethiopia had a population of 15 million people. Now, the population stands at 90 million, an astounding 600% increase in just over 75 years (Carillet). Such a large population, which represents the second largest in Africa, renders the poverty rate even more alarming, as this indicates a substantial number of people enduring a life of poverty. In the coming years, this population is set to augment tremendously at 3.2% per year, representing the eighth fastest rate in the world ("Africa: Ethiopia.").

This expanding population exists in multifarious living situations. A multitude of villages define subsets of the Ethiopian population, and it is within these villages that most rural Ethiopians, who compose 83% of the population, live ("Africa: Ethiopia."). Because this village life represents such a dominant portion of the Ethiopian population and because it is these rural families which do the agricultural practices, they will serve as the main concentration for describing the population. Microcosms within these villages are represented by familial units which are usually formed from a modified nuclear and extended family model. After a marriage occurs, the husband and wife will typically live with the family of either side of the marriage for a few years. Then, after learning how to properly start a family, the husband and wife will ask the village in which they are living for a small piece of land on which they can build a home to house a family (Carillet). On this land, the newly formed nuclear family can take shape. The mother can expect to have an average of six children, contributing to the young population of Ethiopia ("Africa: Ethiopia."). The costs of raising so many children, however, are significantly defrayed by the extended family who is usually willing to help subsidize the raising of the children. In return for this assistance, children are expected to care for older members of the family when necessary. This symbiotic relationship represents what families and villages treasure most: connections between people. Ethiopians are caring and do not hesitate to extend support to fellow family or village members (Carillet).

After the family has been established, children are expected to fulfill an economic role. From a young age, Ethiopian children are usually involved in some kind of agricultural practice (Carillet). These children provide a substantial source of income for the families of Ethiopia. Consequently, children receive little and poor education. If Ethiopian children were legally required to remain in school until they were 16, as many countries do, about half of the nation's populace would be in school. This situation would not be feasible for families for whom the children provide a considerable amount of income. This lack of education has led to depleted literacy rates. Less than half the populace over age fifteen is able to read. Additionally, there is a stark contrast between male and female literacy rates with an approximately 50% male literacy rate and a mere 35% female literacy rate ("Africa: Ethiopia."). Such differences illustrate how women in Ethiopia remain in an inferior position within society. Within each family, the mother, while subordinate to the paternal unit, can still expect significantly better treatment than in other

countries in the area. Women in Ethiopia can own property, vote, and be represented in government. However, women still endure a difficult lifestyle (Carillet). Prostitution is alarmingly high, as many women find this to be the only avenue through which they can make enough money.

This intense reliance upon families to produce agricultural products is reflected in Ethiopia's main exports. A significant portion of these products lies in coffee production. Coffee essentially originated in Ethiopia, and it is still grown in substantial numbers in the Kaffa region, a region thought to provide an etymological basis for the word "coffee." Coffee exports continue to comprise the largest source of revenue for the nation, with 841.7 million US dollars earned in the first half of 2011 (Davison). In fact, the popularity of the coffee continues to be world renowned, as coffee exports jumped 38 percent during this same time period (Davison). Foods such as potatoes and cereals, which can help a family subsist, are overshadowed and vastly outnumbered by the production of coffee. However, these crops are still widely grown to help support families. Besides potatoes and cereals, both of which are staples of the Ethiopian diet, pulses and oil seeds are also widely consumed ("Nutrition Country Profiles: Ethiopia Summary."). Animal products are seldom used as nutrition, as many animals are utilized solely for the production of milk ("Nutrition Country Profiles: Ethiopia Summary.").

The production of these crops is contingent upon successful growing seasons. Seasons vary in different regions of Ethiopia, meaning that rain patterns also differ throughout the nation. Nevertheless, most of Ethiopia operates under a three season system. The dry Bega season (October-January), the mild rain Belg season (February-May) and the wet Kiremt season (June-September) constitute these three seasons (Reynolds). The period of time most critical to agricultural production is during the Kiremt season, in which parts of the country receive up to 90% of their annual rainfall (Reynolds). Consequently, even a moderate drought during this time period can have devastating effects. Because Ethiopia's climate is erratic, such droughts are common and somewhat expected. That, however, does little to prepare farmers for the impending consequences. Parts of the country affected by drought during the Kiremt season will find that crops have nary a chance of surviving. Famine rises exorbitantly, and this has been empirically proven (Tutton). During this past summer, the Horn of Africa has been subject to a drought of historic proportions. This drought, the worst in 60 years, has been unusual in that is has persisted for two seasons that normally see rain (Tutton). Droughts of this magnitude are unfortunately increasing in their rate of occurrence. The average temperature in Ethiopia is rising by approximately .25 degrees Celsius each decade (Demeke). Because there is typically a direct relationship between increased temperatures and drought, it is estimated that droughts will have the propensity to increase both in frequency and magnitude.

While the droughts are especially severe this year, the nation's hydrological variability is nothing new. Surprisingly, Ethiopia has numerous bodies of water from which water can be distributed. The problem lies in that the distribution of water has not been developed throughout the nation. Even if water was transported, Ethiopia is still deficient in water storage mechanisms. Consequently, farmers are solely reliant upon rainfall to help support successful crop growth. With the extreme variation in rainfall in Ethiopia, certain regions of the nation are bound to struggle. Western Ethiopia, which includes the highlands of the nation, is fortunate to have an average of 1,600-2,122 mm of rainfall per year (Reynolds). To the contrary, the eastern lowlands of the country see a mere 91-600 mm of annual rainfall (Reynolds). Lakes and rivers are also much less prevalent in the eastern lowlands, exacerbating the problem of the lack of rainfall. Studies have shown that this method of only using rainfall to provide water for crops leads to food insecurity. When a 10% decline in rainfall occurs, an average 4.4% of the country's food production is lost (Demeke). This illustrates the connection between water and food security in Ethiopia; there is a causal link between the two, and the former must be present before the latter can be achieved.

Fortunately, irrigation presents a vast reservoir of possibilities. Ethiopia has an estimated 3.7 million hectares of irrigable land, and a scant 4.3% of those hectares are currently being used for irrigation ("Ethiopia: Managing Water Resources…"). Unfortunately, the average number of hectares owned per person is shrinking as a direct result of Ethiopia's expanding population. The average farm size is currently 0.8 hectares, approximately half the size of a farm in 1980 (Awulachew). 87.4% of these smallholder farming families operate on farms consisting of fewer than two hectares (Gebreselassie). Additionally, the per capita irrigated area of the nation is approximately 30 square meters. This is despairingly low when compared to the global average of 450 square meters ("Africa: Ethiopia."). Having limited access to water impedes agricultural development, and most Ethiopian farmers can resultantly only grow one crop per year (Awulachew). Thus, if this one crop is decimated as a result of changes in temporal rainfall, the farmer is left with a severe economic burden. If these millions of hectares are utilized and if a well developed plan can be implemented, Ethiopia can increase its water supply and subsequently ensure its food security.

To do this, Ethiopia must expand beyond its current scheme of irrigation. Such irrigation can be supplied through two main sources. First, Ethiopia has 12 major river basins which, when combined, produce an annual runoff volume of 122 billion cubic meters (Awulachew). Secondarily, up to 6.5 billion cubic meters of groundwater are available. Combined, this produces an average of 1575 cubic meters of water per person per year (Awulachew). This amount is more than adequate for Ethiopia's needs, and an effective irrigation system could supply the nation with this water. Additionally, women in Ethiopia can be relieved of the immense burden of having to travel for hours just to acquire water ("Water, Environment and Sanitation."). This travel time is not merely an inconvenience; it also has economic and safety concerns. A woman could spend this valuable time working in a job that could bring in more money. A young woman could spend this time gaining an education. Not having this journey would also reduce her risk of being raped or abducted, as she would not have to travel these great lengths alone ("Water, Environment and Sanitation."). Thus, irrigation goes beyond watering plants; it provides both personal security.

There are several scales of irrigation that could be used in Ethiopia, including large-scale, medium-scale, and small-scale irrigation. According to Ethiopia's Ministry of Water Resources, large-scale irrigation irrigates an area greater than 3,000 hectares, medium scale irrigation irrigates land between 200 to 3,000 hectares, and small-scale irrigation covers less than 200 hectares (Carter). However, these definitions can be delineated differently. Generally, large-scale irrigation is perpetuated through a private corporation or through a public sector; small-scale irrigation, on the other hand, is any type of irrigation in which the farmer is in charge of his or her irrigation entities (Carter). A challenge in developing a feasible and suitable irrigation system for Ethiopia comes in the form of deciding which scale of irrigation to use. All three have had a significant presence, but not all three have had significant success.

Large scale irrigation has been used extensively in Ethiopia. Over the past few decades, the Ethiopian government has imposed new irrigation systems to help solve the water crisis (Rahmato). In the 1980s, four dams were constructed to help distribute water more evenly while simultaneously generating power ("Ethiopia: Managing Water Resources…"). Other irrigation schemes were developed and implemented, but after three decades, it has become apparent that these plans have failed (Carter). The dams eventually had to be shut down due to a lack of funds, and the irrigation schemes were poorly planned and had too much rigidity in their distribution of water. In 1995, the Ministry of Water Resources was created under the new constitution ("Ethiopia: Managing Water Resources…"). This legislation was critical as it was supposed to shift the management of water resources to more local levels of government. Unfortunately, this shift to local governments never propagated, as the relatively inexperienced local governments could not effectively handle the water ("Ethiopia: Managing Water Resources…").

Under this large-scale irrigation scheme, multiple beneficiaries were helped by a single iteration of the system. Such a setup has numerous opportunities for failure, as villages in Ethiopia have little contact with each other. While bonds within a village are strong within the familial units, bonds between villages are virtually nonexistent as a result of having no means of transportation to get from one village to the next (Carillet). Thus, expecting these incoherent villages to begin to cooperate is too ambitious and would disrupt the communicatory system that has been present in Ethiopia for centuries.

This connects to another flaw with a large-scale system, which is that it imposes new measures and standards onto agricultural practices that have been developed over centuries. Methods for growing crops have remained static in Ethiopia. Suddenly imposing a large-scale system automatically draws harsh resistance from Ethiopian farmers; they have been proceeding in a certain way for years and are unwilling to change, even if it is the government telling them to do so. Ethiopia, therefore, needs a non-invasive form of irrigation. Another problem with large-scale irrigation comes with the allocation of funds. Because it is members of the government setting up the irrigation and not the farmers themselves, a good deal of the profit that farmers make will have to be transferred back to the governmental agencies who set up the irrigation. These agencies have a tendency to be unscrupulous (Tucker). Irrigation chairmen have been known to distribute water preferentially in ways such that family and friends receive water first (Tucker). A final issue with this form of irrigation is environmental degradation. Though environmental degradation may seem nebulous in comparison to providing water to farmers, the long-term effects of this degradation can be devastating. Large-scale irrigation often involves flooding large areas or diverting streams to new places. Adding more water to more places results in increased erosion and a decrease in area for farming. This erosion could easily deplete soil of its nutrients, as the nutrients travel into the stream and out of the soil. Therefore, because of these obstacles, large-scale irrigation is not the most efficacious form of irrigation for Ethiopia.

A small-scale irrigation plan would be much more suited to the resources, geography, economy, and hydrological status of Ethiopia. Within the realm of small-scale irrigation, there are different options for the acquisition of water. Water can be harvested through rainfall and may subsequently be stored through different means, including a concrete pool, a pond that has been lined with a plastic material, or a hard plastic tank into which water could be funneled (Seleshi). These techniques, however, have fundamental flaws (Seleshi). Using concrete pools would be horrendously expensive, and acquiring materials to make it would be time consuming and arduous. Having an open-air pond brings with it a multitude of new problems. Flooding could easily occur if the plastic rips or if a hole develops in the pond, resulting in the nullification of the surrounding crops and possible damage to any form of shelter nearby. Open-air ponds also attract mosquitoes that could be carrying the West Nile Virus. A plastic container used to gather rainfall would, again, be outrageously expensive, and transporting these large tanks across the nation would be infeasible. Another form of small-scale irrigation would be the formation of new canals. This method, however, would be much too expensive, would take a great deal of time, and would be subject to abuse. Others who do not have permission could easily harvest the water from the canal, possibly sparring conflicts between villages. These canals are also highly susceptible to breaking, especially after a heavy rainfall, meaning that repairs would incur additional costs and time (Seleshi). Above all, these forms of rainwater harvesting are inherently flawed because they rely upon the erratic rainfall of Ethiopia, a practice that must be eliminated.

The form of small-scale irrigation that should be implemented is the use of groundwater resources. Groundwater is preferable to surface water irrigation for multiple reasons. Groundwater is much less susceptible to the effects of droughts, as evaporation and a lack of rainfall have a more direct effect on surface water levels. When this water dries up, the sole option left is groundwater, illustrating its imperative role in Ethiopia. Additionally, 80% of groundwater in Ethiopia has been deemed of a proper salinity and safety level, while surface water is more subject to the direct effects of pollution (Haile). Groundwater is plentiful in Ethiopia, and an expected 90% of the population are estimated to be able to be

supplied with groundwater (Dingamo). This great percentage of people can also benefit from a less demanding operating system, as acquiring water from groundwater resources is less intensive than maintaining a large pond or reservoir of water (Rahmato). While providing such a vast effect, groundwater irrigation can do so without adverse environmental ramifications. Further, water will not have to be transported through a canal, greatly reducing the effects of erosion and elemental degradation. Instead, water can be provided through manually drilled wells. These wells would access shallow groundwater through the use of a treadle pump, one not reliant upon electricity (Weight). Private sector well drilling could provide business opportunities for Ethiopians, as both the well drillers and suppliers of the parts could expect to see healthy incomes. As was empirically proven in Nigeria, where over 100,000 wells have been constructed, this task is feasible (Weight). One study estimates that 400,000 wells could be drilled in Ethiopia within ten years if just 200 drillers were hired (Weight).

However, the main hurdle to overcome with groundwater is locating it. Ethiopia's government is actively attempting to find these resources, but the process is a tedious one (Dingamo). Thus, an outside international source, such as The World Bank, could provide funding to locate these wells and get the businesses started. This is expected to cost 5 million US dollars, but after that, their influence can be relinquished to the private sector (Weight). Ethiopian farmers could be expected to pay some of the costs, as they will easily be able to rectify their losses through the production of more cash crops. The cost to drill the well for an Ethiopian farmer would be 156 US dollars, but in the next year alone, the farmer would be expected to generate an average additional 490 US dollars, immediately defraying the cost of the well (Weight). After the well has been implemented, the long term benefits will undoubtedly outweigh those of the more volatile and unreliable surface water resources. Groundwater is holistically accessible across the country, unlike the sporadic surface water in Ethiopia that only blesses a small segment of the nation. These attributes render groundwater much more effective. In fact, in a comparative analysis, water acquired from groundwater sources was found to require lower capital and produce higher monetary returns than its surface water counterpart ("Ethiopia: Managing Water Resource…").

The main benefit of this new form of irrigation will be reaped by the farmers whose hard work has not been able to sustain themselves or their nation. Their determination deserves rewarding. Using small-scale irrigation will provide these far-reaching, long-term benefits. Farmers will learn to do the work themselves, and through small-scale irrigation, an outside private or public entity will not be present to disrupt the work they are doing. The farmers will be allowed to practice their own technique and will be able to continue the agricultural practices that have been done for centuries with the added benefits of more crops and a higher income. This coincides directly with the MDGs, as the smallholder farmers will be the ones guiding and developing their own progressions. Such control will subsequently provide a direct pathway to the halving of poverty in Ethiopia by 2015 through a direct increase in water and, consequently, food. Allowing farmers to have this control and this success will provide a direct benefit to the 85% of the population involved in agricultural practices and an indirect benefit to the remaining 15% who rely upon this agriculture for a source of food. This one facet, water, will provide relief to the people of Ethiopia. It can allow Ethiopia to be lifted out of its cyclical and ubiquitous devastation, resulting in a better life for each person in this resilient nation.

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