

Samuel Gostomski
Bandera High School
Bandera, TX
Rwanda, Factor 6: Sustainable Agriculture

Rwanda: Implementing Nitrate Fertilizers via Methane Synthesis

Desperation to thrive born out of tragedy: this is the story of modern-day Rwanda. Despite the horrific genocide of 1994, Rwanda has shown the resilience and determination to rebound that is the perfect personification of the human spirit. The craving for progress after the appalling events of the 1994 genocide makes Rwanda a prime candidate for improvement, not just because of the presence of the necessary natural resources, but because the human factor has been primed for a love of progress. This year marks the twentieth anniversary of the genocide that shocked the world with its violence and intensity. Perhaps more importantly, this year marks the twentieth anniversary of the year that the world sat back and watched as this small, landlocked country in sub-Saharan Africa self-destructed. The West ignored the necessity of helping its fellow man during his time of crisis. As a result of the backlash against violence and hatred, which has been born out of the hearts of the witnesses to their atrocities, there is no better time than now to help spur the process of rebuilding this country.

With a population of 12,012,589 people living in an area of only 26,338sq km, approximately the size of Massachusetts, Rwanda is Africa's most densely populated country. (Africa, n.d., para. 6) Rwanda faces many challenges specifically because of its extremely dense population, the first and foremost being the overuse of its natural resources. As Feed the Future, the U.S. Government's global hunger and food security initiative explains:

Agriculture is the foundation of the Rwandan economy, accounting for one-third of GDP and employing nearly 80 percent of the labor force. However, agricultural productivity in Rwanda is extremely low. The vast majority of farmers practice subsistence farming on small, hilly plots. Due to erosion and poor soil fertility practices, up to half of the country's land is severely degraded. In addition, the use of improved seeds, pesticides and fertilizers remains limited. (Feed, 2013, para. 3)

Finding a means to improve sustainable farming in the region is, therefore, a primary concern if one intends to improve the long-term outlook for Rwanda's economy. With such a large percentage of the labor force engaged directly in the agricultural sector of the economy, increasing crop yields and quality in a sustainable manner will be absolutely crucial to the future growth of Rwanda.

In order to best understand how to help improve the economy on a large scale for Rwanda, one is going to have to understand the people and families that drive the economy at the local level. According to a recent estimate by the Sexuality Information and Education Council of the United States, the average size of a family in Rwanda is approximately eight people (SIECUS, n.d., para. 2). Due to the war and genocide of 1994, a significant portion of those households is assumed to be female-headed, putting them at additional risk of poverty (Koster, 2008, p.1-2). Only about 19% of the population lives in urban areas, and it is estimated by UNICEF that 36% of households are housing children that are not their own, posing an additional burden on the family (2013, para. 2). The strain caused by the large size of the average family, along with the low income of the average household – at approximately \$1,500 a year, Rwanda is ranked 204th in the world for per capita income (CIA, 2013, n.p.) – add up to create nearly unbearable living conditions. Children suffer especially under these conditions, with permanent physical and mental stunting as the result:

In Rwanda, more than 40 percent of children under the age of 5 suffer from malnutrition or stunting, according to 2010 Rwandan Demographic and Health Survey. The Ministry of Health

recently launched a 1,000-day campaign aimed at eradicating malnutrition. Because Rwanda is a landlocked country, improving agricultural practices is critical to achieving long-term nutrition gains. (Partners, 2013, para. 6)

Although efforts have been made to reduce the effects of poverty and malnutrition on children, the number of children born in Rwanda who don't have enough resources to grow and live healthy lives continues to increase daily. Furthermore, the majority of help has come in the form of direct foreign aid. What the people of Rwanda need is to be empowered to feed themselves through sustainable agriculture. By working towards self-sufficiency, the citizens of Rwanda will be able to improve more than just their short-term outlook. Additionally, they will also be able to expand and invest in social services and infrastructure.

Access to healthcare and education is extremely limited, due to the vast majority of the population living in rural areas where these services are not available. This problem is by no means unique to Rwanda, but unfortunately its prevalence doesn't make it any easier to solve. Hospitals in Rwanda have, on average, the ability to accommodate only 1.6 out of every 1,000 people; and the physician to civilian ratio is 0.06:1,000. (CIA, 2013, n.p.) Despite the lack, or poor quality, of formal education in most areas, 71.1% of the population - 74.8% male and 67.5% female - can read and write at least at a primary school level. This is actually quite an achievement given the history and challenges that so many of Rwanda's inhabitants have had to face. Although there is certainly ample room for improvement, Rwanda's moderately high literacy rate will serve as a definite advantage when educating the population about proper farming techniques and how to sustainably utilize their land.

Owing to the country's small size and hilly terrain, the average area of a family farm is well below global norms. As Daniel Ali and Klaus Deininger, researchers for the World Bank have explained: "(...) Rwandan farms are very small by global standards; maximum own cultivated area is about 2 hectares with mean value of 0.37 ha (or median value of 0.17 ha)." (Ali & Deininger, 2013, p.9) In addition to the fact that most families support themselves on such a small amount of land, it is common practice for several families to share a single plot. Most of these families have little to no education regarding the type or quality of their soil, how often they should let it lie fallow, or what crops they should rotate. Further, even if they did have such information, it would frequently be impossible for them to utilize it. Because they rely on their farms for their food on a season-to-season basis, it would be impossible for the majority of farmers to leave their fields fallow, or rotate crops that they don't need. As a result, the same crops tend to be grown over and over based purely on what is easiest to grow or easiest to sell. Typical crops include coffee, tea, bananas, beans, potatoes, and to a lesser extent chrysanthemums (typically used to make the insecticide pyrethrum). As has been shown by the Rwandan Government's 2008 survey of farming households, the amount of land farmed by the typical Rwandan family is not enough upon which to support themselves:

In Rwanda, Africa's most densely populated country, fragmentation and small farm sizes are considered a key issue by policy makers. The 2008 national agricultural household survey puts average holding size at 0.72 hectares per household (in four parcels with 0.18 hectares each on average) suggesting that the production to be generated from this will not allow the typical household to even meet their subsistence needs. (as cited in Ali & Deininger, 2013, p.2)

Implementing sustainable agriculture is the single biggest challenge facing Rwanda today. With 90% of the population employed in agriculture (CIA, 2013, Eco. section para. 1), it will be necessary for the citizens of Rwanda to either improve agricultural practices or shift Rwanda's economy to a secondary or tertiary economy. Due to Rwanda's lack of port access and the difficulty in transporting goods long distances, an economy based in services seems unlikely. Not to mention that it would be a waste of Rwanda's excellent natural resources, which are wholly able to support the country if utilized properly.

The question, then, is how to accomplish that goal. Ultimately, sustainable agriculture in Rwanda would look like this: Firstly, producing enough food for the population to survive on the land available, and secondly, eliminating the need for further deforestation. Throughout the world, one consistent trend in agriculture presents itself as a solution:

In every region of the world, the intensification of crop-based agriculture has been associated with a sharp increase in the use of chemical fertilizer. Given the generally low levels of fertilizer use in Africa, there can be little doubt that fertilizer use must increase in Africa if the region is to meet its agricultural growth targets, poverty reduction goals, and environmental sustainability objectives. For this reason, policies and programs are needed to encourage fertilizer use in ways that are technically efficient, economically rational, and market-friendly. (Morris, 2007)

It is this researcher's suggestion that the best way to create real change in the agricultural practices of Rwandans is to provide them with the tools they need to use the resources they already possess more effectively. Namely, providing a means of producing fertilizer to which most rural farmers would otherwise have no access. Nitrate fertilizers are the most commonly used fertilizers in the world, as well as the most widely available. Yet, they remain largely inaccessible throughout most of Africa. Nitrogen is the most regularly depleted nutrient in soil, and therefore nitrate-based fertilizers are the most effective in increasing crop yields. As was stated by Yara, one of the world's leading producers of industrial fertilizers, in their 2012 market report: "Among the major plant nutrients, nitrogen is most important for higher crop yields."(2012, p.6)

Another significant advantage nitrate fertilizers have to offer is the simplicity of their production. Requiring primarily air and natural gas as the main raw components, nitrogen fertilizer can be produced using nitrogen fixation, which is defined by the Encyclopedia Britannica as: "(...) any natural or industrial process that causes free nitrogen, which is a relatively inert gas plentiful in air, to combine chemically with other elements to form more reactive nitrogen compounds such as ammonia, nitrates, or nitrites." (2014, n.p.) The form of nitrogen fixation which would be most practical for this particular application is the Haber-Bosch process. This process is as simple as pressurizing methane and steam in the presence of a catalyst - typically iron - making it relatively inexpensive and easy to perform: "The Haber-Bosch process is the most economical for the fixation of nitrogen and with modifications continues in use as one of the basic processes of the chemical industry in the world." (Encyclopedia, 2014, n.p.) Aided by relatively simple and affordable production, the introduction of nitrate fertilizers into agricultural practices in Rwanda has the potential to be a game-changer for the entire industry. Most agricultural problems can be traced back in one way or another to a lack of basic fertilizer:

Low fertilizer use is one of the factors explaining lagging agricultural productivity growth in Africa. In 2002, the most recent year for which data are available, the average intensity of fertilizer use in Sub-Saharan Africa was only 8 kilograms per hectare of cultivated land, much lower than in other developing regions. Even when countries and crops in similar agroecological zones are compared, the rate of fertilizer use is much lower in Africa than in other developing regions, and crop yields are correspondingly lower. (Morris, 2007, n.p.)

If one is going to help the people of Rwanda achieve real progress in the field of food production, it is going to be necessary to give them the invaluable tool that is nitrate fertilizer. This poses the question: how can one get these fertilizers to the families who need them?

As was previously stated, nitrate fertilizer requires two main components for synthesis: natural gas and air. Rwanda is obviously in possession of plenty of the latter; it is the former that poses the only challenge. However, there have been numerous systems designed that can solve the problem of gas production. Furthermore, it can be done at a relatively low cost and be implemented with moderate ease.

Harvesting methane from organic compost is not a new idea, but the systems designed to do so have become increasingly more efficient as their popularity grows. There are several main components that one needs in order to build a methane production system: a digester, a storage tank, and a pump to pressurize the gas (Mother, 1970, p. 1-12). It is really that simple. A digester can be any tank, or gas-tight storage unit, and the same applies to the storage tank. In application, this could be recycled fifty-five gallon drums, or a simple concrete structure; they would be easily built, and relatively inexpensive. In addition to utilizing natural methane to create fertilizers, any excess gas could be stored and adapted to help provide affordable energy to homes and businesses. Local residents would provide all of the waste matter and the methane production facilities would be operated on a communal basis.

This solution would work to improve Rwanda's situation immediately, but it would also pave the way for future expansion and the growth of a new industry. Rwanda has proved 56.63 billion cubic meters of natural gas reserves, ranking them at 64th in the world for natural gas assets, according to a report by the Central Intelligence Agency. (2013, n.p.) These vast reserves have the potential to provide fuel to the entire nation of Rwanda in the future. Until the problem of food insecurity is addressed, however, it is unlikely that Rwanda will be able to build the infrastructure necessary for such an industry. Therefore, until it is economically feasible to tap these vast natural reserves, organic methane production can serve a dual purpose. Firstly, it would provide an immediate and, importantly, locally developed source of natural gas for fertilizer production. Secondly, organic methane production would pave the way for tapping the country's large natural gas reserves by providing a grassroots market for methane. Farmers will have both the incentive and, thanks to increased crop yields, extra income necessary to begin adapting their homes to run on methane. This solution allows Rwanda to make use of both organic methane production technologies, and the vast natural gas reserves that the country already has.

The most prohibitive part of a plan to provide nitrate fertilizers to Rwanda is the cost of an actual fertilizer production plant. The World Bank is already active in Rwanda (World Bank, 2013, n.p.), with multiple projects ranging from improving education to providing reliable electricity. It makes sense that all of these projects would benefit from improving the largest sector of Rwanda's economy. Obviously then, there is a strong incentive for the World Bank to help fund a project that would not only improve the lives of local farmers, but would allow them an opportunity to scale-up their existing projects. For instance, one way to expand upon existing projects would be to adapt generators to run off of any excess methane from the fertilizer plants, or to set up programs to educate local residents on the best way to utilize their new chemical fertilizers. It would be an excellent investment for the World Bank, because it would drastically improve the viability of their existing projects as well as the largest sector of Rwanda's economy.

There are already multiple Non-Governmental Organizations, such as the Forum for Agricultural Research in Africa [FARA] and the International Fertilizer Development Center [IFDC], working on fertilizer and sustainability based projects in Rwanda and the surrounding areas. However, these organizations are currently focusing primarily on fertilizer distribution and subsidy. Although these tactics have been marginally effective, it is absolutely critical that local farmers and residents be involved in the production and implementation of the fertilizers that they will be using. For instance, partnering with local residents to collect and store the organic matter necessary for compost in the methane generators provides community investment, which will be crucial for generating the kind of local support that will help to ensure the long-term success of the project. While the ultimate goal would be to train local residents to operate the plant independently, in the interim, jobs would be provided in the distribution and maintenance sectors. By partnering with the aforementioned organizations, it is this researcher's plan to use their already existing distribution and education networks to increase the effectiveness of locally produced fertilizer.

The economic feasibility of helping Rwanda build nitrate fertilizer plants is sound, and the benefits would

be immense. Improving agricultural output would not only be better for the environment, but it would greatly improve the lives of those who rely on farming for their livelihoods. The availability of fertilizers would make it possible to increase the yield of many farms to the point where they could export or sell some percentage of their goods. As the U.S. Department of Aid elaborates:

With more than 80% of Rwanda's population engaged in agriculture, an increase in the fertilizer penetration rate, currently less than 30%, can have a significant impact on farmer incomes and food security. This investment can help bolster Rwanda's food security in two ways: (1) by increasing the yield, and therefore the income, of smallholder farmers, and (2) by improving the sophistication of these farmers' farming practices. For example, correct fertilizer usage is expected to increase yields of a coffee farmer by approximately 20%, leading to a 22.5% increase in farmer profits. Additionally, armed with better access to (and knowledge of) credit and co - ops, and increased training in planting and harvesting best practices, smallholder farmers will be able to improve their purchasing choices and timing, which will have a positive impact not only on their immediate revenues but also on their long-term income sustainability. (Monitor, p. 7)

In a country where 57% of the population lives below the poverty line, (Feed, 2013. para. 1) any extra income could potentially be life changing. The extra revenue would allow the average family more access to basic healthcare, and perhaps even increase their income enough to make it possible to buy a means of transporting their goods, making it possible to further increase their income and the overall vitality of the Rwandan economy as a whole. Plus, by making goods from other regions commercially available, it would be easier for Rwandans to eat a more balanced diet and not be as directly dependent on what the local land can produce. Further, by increasing the ability of the land to yield productively, the need for deforestation is effectively reduced. Deforestation is often the only means of finding fertile land on which to farm, and, as has been summed up nicely by Dennis Avery, an expert on global food issues: "No one will starve to save a tree." (Chances, 2013, p.12) Rwanda is one of the most ecologically devastated countries in Africa, and is largely deforested due to this continual need for fresh farmland; therefore, any means by which deforestation can be halted is beneficial. (CIA, 2013, n.p)

Although there is no single solution to *all* of the problems faced by any one country, ultimately, Rwanda's future lies in sustainable agricultural practices. The first step towards this future lies in the implementation of modern nitrate fertilizers. Agriculture is the backbone of Rwanda. It is a country that has abundant natural resources, but that has been unable to care for and utilize them properly - until now. In a world where global connections are becoming increasingly more important, and where Africa is growing exponentially as an epicenter for investment and entrepreneurialism, taking the right steps towards helping our global partners find ecologically sound ways to live will be beneficial for all involved. The people of Rwanda don't need charity; they need to be empowered. Empowered to help themselves and their neighbors, they can begin to build a better future for themselves and future generations. Their example will not benefit Rwanda alone, but all of Africa. As has been summed up nicely by one of Africa's greatest humanitarians, Nelson Mandela: "Money won't create success, the freedom to make it will." (as cited by Khumalo, 2013)

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