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Nigeria: Biochar Implementation to Combat Famine, Soil Erosion, and Carbon Emissions

Emmanuel, weakened by his already growling stomach, hobbles out of his hut. He is instantly engulfed in a moist, hot towel of humidity, which is fueled by the rising sun over the horizon. He realizes his family is in trouble, but he is unsure as to where to turn. He thinks of the many other farmers in his area who have already migrated away from the farm (Ajaero 13). As a subsistence farmer, Emmanuel strives to feed his family, but it becomes increasingly difficult every year to grow enough food. Thoughts and hopes of having enough crops to sell are but distant dreams. His land is under siege, he cannot plant what he once planted, he is unable to harvest what he once harvested, and he cannot stop the culprit - not alone anyway. It takes a lot of help to defeat Mother Nature.

Emmanuel's family like many other subsistence farm families in Nigeria faces many barriers. Feeding a Nigerian family is often difficult as the average family size is five persons ("Household" 12). A typical Nigerian family eats a base of starchy foods. They dry maize, yams, plantains, and grind them into flour to use for dough. Another popular dish is porridge ("Food" 1). Unfortunately, there is a lack of protein in the diet of many Nigerian children, which has led to a large population of children having Protein Energy Malnutrition (PEM). In Nigeria, 60% of children's deaths are caused by PEM (Yetunde 2). This malnutrition issue is compounded by a lack of formal education by 31% of males and 46% of females. Even children that do attend school do not get the proper amount of education. In fact, females on average only stay at secondary school for an average of 0.2 years, and males stay only an average of 3.6 years ("Household" 13). Emmanuel's family is not one of the lucky 33% who have internet access ("At a Glance" 5). Additionally, when a family member gets sick, it is hard to find affordable treatment due to a lack of supplies and the poor development of the Nigerian healthcare system (Osain 7). The healthcare system in Nigeria remains insufficient.

With a population of approximately 175 million people, Nigeria has the largest population in Africa ("Nigeria Facts" 1). Despite rapid levels of migration from rural to urban areas, about half of the Nigerian population still remains rural dwellers and engage in smallholder semi-subsistence agriculture (Liverpool-Tasie 8). It is estimated that there are around 250 unique ethnic groups in Nigeria, which speak different languages, and practice different religions and customs. However, the Hausa-Fulani, Yoruba, and Igbo makeup 68% of the population ("Living" 1). Within the largest groups, Nigeria is a male dominated society, but women are gaining rights, gaining more professional employment opportunities, and taking more dominant roles in Southern Nigeria. This process is still slow, as Nigerian women are still having on average of 5-6 kids each ("Nigeria-World Fact Book" 3).

Poverty has become a huge issue in Nigeria. The average person in Nigeria only makes $900 a year. Further, 70% of Nigerians live on less than $1.25 a day and 80% of Nigerians live on less than $2.00 per day ("Nigeria Facts" 1; Liverpool-Tasie 8). This increasing poverty is caused by a myriad of factors including lack of economic diversity, unemployment, and a very young population. Life expectancy in Nigeria is the lowest among West African countries, with a life expectancy of fifty-two years ("At a Glance" 2). Interestingly, 43% of Nigeria's population is fourteen years of age and younger, and the median age of Nigeria is merely 18.2 years of age ("Nigeria-World Fact Book" 3). In a country with such a young population base, it can be difficult to instill immediate change; however, Nigeria's population base that has just entered adulthood should help the country improve its world standing and provide a strong population base to carry forth change if it is understood.

Despite all of these barriers, perhaps the largest factor contributing to mass poverty in Nigeria is the soil quality or lack thereof. Soil quality is important for growing crops for subsistence or for commercial sale, which makes up 30.9% of the Nigeria's GDP ("Nigeria-World Fact Book" 5). Total agriculture accounts for about 40% of GDP, but its growth has lagged behind other sectors (Liverpool-Tasie 8, 10). Before oil became Nigeria's dominant economic sector, the agricultural sector contributed over 60 % of GDP and 90% of exports. Cocoa beans, a soil based crop, are also the largest agricultural export from the country ("Nigeria-Agriculture" 1). Yet, over 70 % of the Nigerian labor force works in an agricultural related field. Because of this shift, Nigeria moved from a food sufficient country in the 1960s to a food importer in the 1980s (Liverpool-Tasie 10-11). Poor agricultural outputs and widespread poverty has led to extensive food insecurity, with some studies identifying as many as 70% of household being food insecure. Other studies have shown seasonal changes in food insecurity with 42 % of households being food insecure during the harvest season, but as many as 78% of the households being food insecure during the planting seasons (Liverpool-Tasie 8, 10-11, 29). Without the ability to produce sufficient food within the country, food would become very expensive even for the wealthiest people in Nigeria. Women, men, and children would all be equally affected by this issue.

Unfortunately, severe soil erosion has taken place in Nigeria, especially in the southeastern part of the country. This erosion is likely a major factor contributing to the extensive food insecurity of Nigeria. Soil erosion generally is the removal of the topsoil or fertile soil through rain, wind, and even man-made activities. Erosion in Nigeria is primarily of three types: sheet erosion, rill erosion and gully erosion. Sheet erosion is a gradual uniform removal of topsoil in thin layers or particles on gently sloping lands leaving only coarse infertile materials behind; rill erosion results when topsoil is removed by water from small streams that run through or over the land with poor surface drainage; and gully erosion occurs when the rills deepen and the topsoil and small rocks are removed by concentrated runoff that forms deep channels or gullies. Gully types of erosion are the more obvious types of erosion in Nigeria due to the remarkable impression they leave on the land. Some examples of this type of erosion occur in Agulu-Nanka, Obioma, Nsuka, Alo, Nnobi, Nnewi, and other areas of southeastern Nigeria (Oseni 5). It is currently estimated that the gully erosion has a mean advance rate of 150 meters every three to five years (Menace 1). The gully erosion in this area has led to an estimated loss of agricultural and residential lands in excess of 500,000 hectares of land (Ajaero 3). In addition, the soils in the South are often low in nutrients which is caused by long exposure to the sun and rain and often leads to further erosion. In the South-South region, petroleum exploration and mining have depleted the quality of soil and water. Finally, in the Northern region, farmers must contend with the threat of desert encroachment (Liverpool-Tasie 13). Sheet erosion, however, is probably the most widespread type of erosion in Nigeria, and almost all of Nigeria is impacted by one form of erosion or another (Oseni 5). This overall erosion is causing devastation of homes, schools, and businesses, and a lack of fertile soil for crops, and as a result, less food and money ("Nigeria: Erosion" 1). As a result of this soil degradation, only 35% of the land of the country is able to be farmed ("Nigeria-Agriculture" 1).

Soil degradation and erosion in Nigeria negatively affect agricultural productivity. Due to the soil's erosion, less fertile soil is available for crop production. As a result, the more soil that is lost or made infertile, the less food and cash crops Nigerian farmers can produce. Not only does the lessening of food cause hunger issues in Nigeria, it reduces the household income of the country as less crops can be sold. Additionally, the food that is grown on the degraded soil will most likely contain fewer nutrients and will not be as satisfying for starving Nigerians.

The trends for soil loss are getting worse every year. Federal and state governments understand this trend and the harmful impact it has on agricultural productivity and the lives of rural and urban dwellers and have tried to give attention to the issue. In the Niger Delta region of Nigeria, this issue is exemplified and research of erosion has been done. Over twenty-eight million people who are predominantly farmers reside in the Niger Delta Region, and this region consists of approximately eighty thousand square

kilometers, which represents about 8% of Nigeria's land mass. Soil erosion is measured by using historical maps along with aerial and satellite imagery, in additional to GPS and total station instruments for watershed, flood basins and erosion gullies sites to determine their spatial hill slopes. Further, some remote sensing technology provides a synoptic view of the spatial distribution and dynamics of flooding and erosion on the land and provide land use and land cover images to review (Ehiorobo 3-6).

Beginning around 150 years ago, Nigeria's lush rainforests started to be destroyed as Europeans began to demand palm oil. The newly planted palm trees generated soil salinity which also hurt the soil. This along with loose soil, hills, and a lot of heavy rain create the ideal situation for soil erosion in parts of Nigeria. In addition, many Nigerian farmers burn off brush, which destroys roots and shrubs that would provide cover for the soil (Nigeria: Erosion" 1). As Emmanuel burns his shrubs after his crop, he doesn't even realize he is essentially burning his next year's profits.

Soil erosion in Nigeria is becoming a very severe problem and will only continue to worsen unless something is done to stop it. If current trends continue, according to the United Nations University's (UNU) Ghana-based Institute for Natural Resources in Africa, by 2025 the continent might be able to feed just 25% of its population (Oseni 6). If global temperatures rise and less rainfall comes to Nigeria, wind erosion will be more prevalent and the soil will continue to erode. As it erodes, more soil becomes exposed to the air creating a positive feedback loop for the loss of soil. Until the problem is addressed, more soil, more crops, and more lives will be devastated, and once the soil is gone, there is little hope of bringing it back.

An increase in soil quality would bring great benefits to the Nigerian people. If soil quality is better, more land will be able to be farmed. As a result, this would allow for more crops to be grown and consumed by the families. In addition, more nutrients in the soil would allow for healthier and better quality crops, which can be sold for more money in the market. This would also allow for continual growth and continual gain by farmers. This consistent increase in crop production would lead to economic growth for farmers as they could begin to focus their business on profits instead of just survival. Finally, if more food was grown, there would be less hunger and poverty as a whole in Nigeria. Women, men, and children would all benefit from better soil as more food would be available for them to consume. Urban dwellers would also have more food available to them, and better soil would reduce the prices of food for them. Additionally, better soil would benefit farmers as they would have a more consistent income and a consistent crop.

Climate volatility causes greater erosion problems. As droughts and floods become more common, soil is more likely to erode. With climate change, it is expected that heavy and damaging storms will increase in frequency and have greater erosive effects. In addition, increases in wind and temperature are hurting the soil in Nigeria. Population growth will also be a problem as more people will not have enough to eat. More urbanization caused by population growth reduces further the amount of land that is available to be farmed. Rapid population growth creates extra pressures on the land use as agricultural lands give way to housing developments, roads and other urban structures, often without adequate drainage systems in place (Ehiorobo 2). With water being fairly scarce during many months of the year, it is hard to irrigate much of the crops, and during the flooding seasons, the soil is not able to absorb the water leaving it more vulnerable to erosion. Pollution is also becoming a bigger issue as many farmers are beginning to use fertilizers to help increase crop production. Unfortunately, due to the lack of good soil, these fertilizers are washing away and polluting clean water or evaporating into the air (Pearson 1).

While soil degradation is a massive problem in Nigeria, a new scientific study gives hope to the abysmal situation. A new additive of farming, the use and implementation of Biochar, may be the answer. Biochar is a carbon-rich product that is created by slow thermochemical pyrolysis of biomass materials (Jien 1). Scientifically, Biochar is a compound of six carbon rings without an attached oxygen of hydrogen. Its

production mirrors that of charcoal, and is created by heating wood, manure, leaves, or any other biomass in an airless container at temperatures around 700°C. This process is sustainable as the Biochar added to the soil will help grow more primary products which can be turned into food which can, in turn, be turned back into Biochar. Biochar takes organic waste, like manure, sludge, crop residue, and compost, and converts them to Biochar, which is then added to the soil. Simply put, Biochar is any charred organic matter that can be applied to the soil in a deliberate manner in order to improve overall soil quality. In addition to lessening soil erosion, Biochar would bring improvements in multiple areas; soil fertility, water quality, waste management, energy production, and climate control. In addition to the removal of carbon, Biochar is useful to poor farmers for the reduction of nutrient loss, and agricultural chemicals in runoff. It also improves the water-holding capacity of soils that would help to limit flooding in Nigeria ("Biochar-Environmental Management" 1-9). If more water is held by the Biochar, less fertilizer will be needed and thereby less fertilizer runoff will flow into surface water. This result will cause clean water to be more prevalent in Africa ("Building" 1).

Another significant benefit of Biochar is that in addition to improving soil in Nigeria, implementing Biochar would help the world as a whole. As the inevitable climate change is occurring and the issue of greenhouse gases continues to grow, Biochar provides a safe solution to slowing down its progress. The presence of greenhouse gases is increasing around 3% every year (Amonette 1). To stop our world from meeting an ecological tipping point from greenhouse gases, Biochar has the ability to sequester excess carbon from the environment. When Biochar is produced, carbon is taken from the atmosphere, helping to limit air pollution, and the spread of greenhouse gases. Further, much of the climate mitigation from Biochar comes after Biochar is added to the soil.

Biochar would improve Millennium Development Goals 1, 4, 5, 7, and 8. More specifically, because Biochar increases both the soil nutrients and the soil quality, in addition to water quality, the introduction of Biochar to Nigerian farmers will be a step forward in efforts to eradicate extreme poverty and hunger in Nigeria. Farmers will be better able to provide food for their families and will also increase the likelihood of more plentiful harvests which would allow them to sell some of the harvest to make money and decrease their wealth. Similarly, by improving the nutrient level of food and the quality of water, the Biochar will help reduce child mortality in Nigeria. Additionally, the impact will improve maternal health as a result of the improvement in nutrients and water quality by reducing fertilizer runoff, and absorbing more water into the soil. In addition, Biochar, because of its cycle of creation and use, will ensure the environment's sustainability. Moreover, the positive impact on the greenhouse gases will further enhance global environmental stability. Finally, as the news on the positive impact of Biochar spreads and governments, Non-Governmental Organizations (NGOs), private companies, and end users such as the farmers work together to utilize Biochar, it will continue the growth and development of a global partnership for its continued development and utilization around the world ("Millennium" 1).

Biochar projects and field studies have been on-going throughout the world. Some of these projects have occurred in the United States, Kenya, Colombia, Brazil, and Zambia. In Zambia, field studies were conducted in conjunction with the Community Markets for Conservation (COMACO) and Wildlife Conservation Society (WCS) in efforts to evaluate the effect of rainfall and soil types on the benefits of Biochar. Field experiments concerning Biochar were conducted around 2005 and 2006 in Kenya to determine at what stage of soil degradation Biochar was most effective, and the results indicated that applications of Biochar to the most degraded soils increased yields the most ("Biochar Soil Management" 1-5). In a more extensive on-going study in Peru's Kosnipata Valley, Biochar has been introduced to determine its potential to increase the soil health of the area, which was previously depleted by slash and burn agricultural practices which stripped the soils of nutrients and contaminated it with potentially heavy metals. This project provides the framework for a Nigerian solution. The project utilizes a slow pyrolysis batch kiln designed in Australia and fabricated in Peru (Kosnipata 1). This kiln structure consists of a stationary steel cart with a kiln made of stainless steel and ceramic insulation. Ducting captures and

combusts the gas and vapor byproducts, and a fan provides high pressure air for the fire box. The unit is fitted with a water pump and nozzles to regulate the pyrolysis reaction. This unit has a chamber volume of 4.5 cubic meters and produces approximately 200 – 400 kilograms of Biochar per burn. A burn takes four to six hours to complete the full cycle. The area would then need a grinder to help grind the Biochar to process it for application to the fields ("Kosnipata" 1). A potential obstacle would whether the area had dependable electricity and water supply for the process. Further, farmers and those involved in the Biochar process may have concerns about the char dust and other small particles that arise from a Biochar production facility and whether they would be adverse health effects. However, this threat can be avoided by implementing standards and safeguards during production. Education concerning proper use and production of Biochar would also be important to obtain the support of the Nigerian Farmers (Sholz 48-54). In addition, the rural population would need to understand and be educated on the process so as to garner support for their assistance but most importantly their willingness to apply the Biochar to their fields. This education can be brought about through seminars and workshops for farmers much like the ones already being conducted in Kenya by the Re-Char initiative group (Rechar). Biochar kilns can be purchased for between 7,500 to 75,000 Swiss Francs or approximately $7,500 to $75,000 ("Medium" 1). The more expensive kilns can process a much wider variety of feedstocks to create the Biochar. As Biochar efficiency grows and research continues, the idea of having a "cooperative" kiln or a community kiln that would be accessible to all farmers in the community, or having much smaller kilns on individual farms will be more fully vetted to know what is the most efficient and cost-effective process.

While the mass production of Biochar is expensive and adds to the overall cost of production, there is a practical way of paying for the implementation of this Biochar. First, Nigeria should seek the cooperation of the Millennium Project. The United Nations Millennium Award for 2011/2012 went to the Biochar Millennium Project in Australia. This project was originally sponsored by the United Nations University, Smithsonian Institution, Futures Group International and the American Council for the UNU. This project provides in an on-going capacity, a geographically and institutionally dispersed think tank to help promote Biochar usage throughout the world and attempts to connect individuals and institutions around the world to collaborate on this effort ("United Nations-Millennium Award" 1). Other countries, including the United States, could extend and broaden the use of the carbon point systems to promote the production of Biochar in countries like Nigeria. Private companies in the United States could obtain these Carbon Credits in return for their financial support of Biochar projects in Nigeria. These funds could be used to fund the Biochar structures. Further, the government in Nigeria has attempted to minimize some of the problems plaguing its country. Unfortunately, to date, there appears to be no law or government action in Nigeria that is targeted specifically to the management of soil erosion or soil degradation. However, awareness of this issue is now prevalent in the government. To make this effort truly successful, participatory management strategies should be developed by the government of Nigeria and the population at risk, the government should continue to develop programs to limit soil erosion, and the government should work to educate the population especially (the young) farmers, on the sustainable use of their land (Ajaero 10, 19).

Farmers in Nigeria would play a huge role in the implementation of Biochar as they would be the ones applying the Biochar to their soil. In this application, farmers would have to simply mix the Biochar with water and soil five to seven days before planting their crops. Biochar should make about 10% of this mixture ("Wakefield" 2). In addition, rural and urban Nigerians alike need to do all they can to help solve this soil quality problem. Reducing surface runoff, planting of grasses and other vegetation to reduce the amount of bare soil exposed to erosion, planting of cover crops, and other common sense small acts, can cumulatively have a large impact. Further, increasing the education of farmers will enhance and likely lead farmers to adopt progressive farming practices and utilize new technologies (Liverpool-Tasie 16). Biochar is the new technology that can change Nigeria and the world.

A recent Biochar project in western Kenya showed that this sort of implementation is possible. A company named Re-Char invented a Biochar producing oven called the Climate Kiln, which is called a Rutuba (fertility in Swahili) Kiln by the natives (Rechar 1). This kiln is a small pyrolysis system that is capable of creating Biochar. On average, every kiln can produce 3 to 5 tons of Biochar every year. This kiln costs around $25, and is expensive on its own. However, because Biochar can replace the need for many expensive fertilizers that are now being used in Nigeria, farmers will have more money to put towards the kiln. In addition, Nigeria could institute a micro loan system that farmers pay back when the increased crop is yielded the next year. Rechar has hosted educational seminars for farmers in Kenya, and have already been able to reach 750 farmers in a short time. Programs like Rechar show that the implementation of Biochar into African countries is not only possible, but also sustainable and beneficial.

Emmanuel, and the whole country of Nigeria, are running out of options in stopping the fleeting escape of their most important ally, Mother Nature. The soil of Nigeria is being depleted, and as a result, poverty has stricken the nation. There is hope, however, in the production and implementation of Biochar which would improve the countries soil, food production, waste management, water quality, and the overall climate of the world.

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