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New Approaches to the Green Revolution: Successes, Failures and New Rice for Africa

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Abstract

The nature of worldwide food insecurity is staggering, with thirteen percent of the world's population currently malnourished. The situation is particularly dire in Sub-Saharan Africa, where 265 million people face hunger daily, with 30 to 50 million dying yearly. Solutions to the problem are often unsustainable, save a select few. One such attempt, coined the Green Revolution, garnered both praise and notoriety through its relatively successful transformation of Southeast Asia in the 1960's. Aimed at increasing food production, the project focused on small-holder farmers and their acquisition of more productive inputs such as high-yield seeds, fertilizers and pesticides. African nations remained unsuccessful in their implementation of this 'revolution' as poor domestic conditions rendered them unable to compete effectively. Now fifty years later, organizations like AfricaRice, Food and Agriculture Organization of the United Nations (FAO) and Alliance for a Green Revolution in Africa (AGRA) attempt to refurbish the endeavor for a new generation of self-sufficient and technologically advanced Africans. This paper is a study of the efficacy of this project and its potential to reduce and reverse the high incidences of poverty and hunger in Africa. Through a combination of interviews and an extensive literature review, this study attempts to determine the extent to which AGRA's new interpretation of the Green Revolution is in line with the successes and failures of the previous endeavors. In conclusion, this paper in defense of the capacity of rural farmers to propel food sovereignty, and upholds bottom-up intervention and its new interpretations as an effective method of improving food production and reducing poverty and hunger.

Keywords: Green Revolution, agriculture, NERICA, rice, imports

1. Introduction

The spread of malnutrition and hunger is a fairly unyielding global trend, spanning a multitude of complications across a variety of disciplines, areas and conditions. This multi-faceted global problem has been manifested in several generations of extreme hunger and destitution, often exacerbating pre-existing conditions of poor health, education or poor domestic market conditions and complicating development policies. According to the Food and Agriculture Organization's "The State of Food Insecurity in the World", 850 million people are currently malnourished, meaning 13% of the world's population lacks appropriate access to nutritious food, and in many cases, cannot access food at all (Food and Agriculture Organization of the United Nations [FAO], 2011). Furthermore, these incidences of hunger and malnutrition are deadly, killing 30 to 50 million people each year, at least 30 times more than HIV/AIDS kills yearly. The problem is most acute in Sub-Saharan Africa, where 265 million face hunger on a daily basis. While academics and policymakers attest that both malnutrition and hunger could result from a multitude of political, economic, and structural faults, both are direct consequences of food insecurity, a far more dire global condition.

As defined by the World Food Summit in 1996, food security is "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life" (World Health Organization, 2012). Built upon the three pillars of food availability, access, and use, the issue is multi-faceted and interdisciplinary. Through carefully directed food aid, food programs and agricultural support, Western nations have been supporting the impoverished and the hungry in many of the world's most affected nations. Complicating the situation with potential reliance on Western support, this imbalance of self-sufficiency and dependency has come to underscore the food security issues facing the developing world today. Furthermore, high worldwide food prices and lack of intervention sustainability have exacerbated the already urgent prevalence of hunger and malnutrition in many of the poorest nations.

In recent years, there has been a transition to scaling-up methods of food production projects that sheds some light upon the possibility of sustainable agricultural reform. Currently, the agricultural sector receives just below 5 percent of total

development aid to Africa (FAO Regional Office for Africa, 2010). However, this 5 percent has spurred immense improvements that highlight agriculture as an effective means to reduce poverty and generate incomes that could sustain households and their food supplies. Many of these current models of reform used in Africa are based upon the past models of the Asian successes from the mid-20th century. First initiated by the Rockefeller Foundation in the 1950's, agricultural interventions based on training local seed breeders and planters on more effective ways of planting and fertilizing were spread throughout India and Southeast Asia to rural farmers and their families (Daño, 2007). Intended to exercise import substitution, the programs aimed to increase yields in key crops, thereby reducing dependence on foreign interference and increasing the availability of cheap domestically produced food. Over the course of twenty years, increased yields of wheat, corn, rice and other staple foods immensely and significantly increased access to available food, leading to what USAID has coined a "Green Revolution".

However successful the endeavors in Asia, Africa's dry and rainy seasons encourage both drought and flooding and thus the conditions are far more specific and difficult to predict. Failures in infrastructure also exacerbate these problems, as a general lack of access to markets is also a large struggle for these populations. Despite all of these potential downfalls, this model of Green Revolution has been adapted for a new generation, implementing improvements in technology to generate genetically modified seeds and fertilizers, and thereby increasing yields exponentially between generations. Again, results are varied, as conditions for success are dependent on a multitude of external factors. Despite these varied results, these innovations have demonstrated the ability of small-scale farmers to propel development, and in some areas, has led to some sustainable improvements.

This study of this new "Green Revolution" and the cases that have subscribed to these methods is an analysis of the effectiveness and feasibility of such an approach for development. While this method has been extremely successful in some areas, it has often brought about significant problems in implementation and efficiency in others. Successes and backlash go hand in hand, as well as inspiration for new avenues of agricultural intervention. One of Sub-Saharan Africa's most potentially successful

endeavors is the New Rice for Africa (NERICA) seeds, which has led to some significant gains amongst countries implementing these seeds. A child of the Green Revolution and its school of thought, this study uses the example of NERICA to demonstrate the change, the potentiality, and the effect that small-scale farmers can have on their own food security, and how they can help to secure food sovereignty in future generations.

2. Methodology

As the field of food security is well researched, a literature review was necessary to approach a firm understanding of the basic crises of food insecurity.

2.1 Literature Review

The yearly reports published by the Food and Agriculture Organization of the United Nations were instrumental in providing a base of knowledge about the nature of worldwide food security and the changes exhibited over the past decade. A review of the publications from the most recent years created a framework of the general issues and conflicts in food security, instrumental for the additional complexity of the question. Regarding the history of the Green Revolution and its evolution towards today's generation of agricultural interventions, the most instrumental sources were in fact the publications from the organizations that themselves work in the field of agricultural development and public policy research. Included among these organizations are The Oakland Institute, CIRAD Research Center, and publications from United Nations Conferences on the topic of food security. Additional peer-reviewed articles were utilized to complete the literature search.

New Rice for Africa (NERICA) is a well-documented endeavor of the past decade and thus, several recent studies on its efficacy in Sub-Saharan Africa have been conducted.

Information was collected using the aforementioned empirical studies as well as briefs from organizations implementing its usage.

2.2 Interviews

Because each country's problems come with an entirely different set of conditions, it was imperative to collect information from experts from the field to clarify the overarching themes that bind each case. Contacts were chosen for their varied perspective on the issues of food insecurity or their varied perspective on the positions within the implementation of food security policies. Contacts were attempted with Global Alliance for Improved Nutrition (GAIN), Food and Agriculture Organization (FAO), Aga Khan Agency for Microfinance (AKAM), Roger Zürcher of Food for the Hungry as well as Drs. Ronald Jaubert, Christophe Golay, and Christophe Gironde from the University of Geneva and Kiah Smith of the United Nations Research and Development Group. Of this target group, Roger Zürcher, Dr. Christophe Gironde of the University of Geneva, and Dr. Suffyan Koroma of FAO responded for an interview. Each set of questions was catered to the interviewee's specialty, with the main body of questions involving the general nature of food security and the impact that the Green Revolution has upon it, expected and unexpected. As the research paper evolved, questions became more catered towards the implementation of NERICA in Sub-Saharan Africa, given that both Mr. Zürcher and Dr. Koroma had worked extensively with its usage in the area.

The interviews were conducted in English, as it was the shared language between interviewer and interviewee and added clarity to the research.

2.3 Limitations

One of the limitations in this method is that much of the information regarding the NERICA implementation was taken from scholarly articles and peer-reviewed papers. While Mr. Zürcher's organization has been using NERICA in Uganda with great success and Dr. Koroma's experience is indicative of scenarios often seen in its usage, the results are varied from country to country and the success of NERICA in certain

areas is not necessary indicative of the entire region. It makes it therefore difficult to extrapolate the findings to the entire experience of the Green Revolution. This study recognizes these limitations and remains as specific as possible with scope.

Results

3.1 Roots of the Production Problem

According to the Food and Agriculture Organization of the United Nations (FAO), worldwide prevalence of hunger is staggering, even with interventions on the rise. Even if the Millennium Development Goals are met, it is estimated that some 600 million people will still suffer from undernourishment and hunger (Food and Agriculture Organization of the United Nations [FAO], 2011). Despite the severity of the problem, academics agree that it is not the lack of food that plagues the world, yet the poor distribution of food. According to the FAO, the world produces 17 more calories per person than thirty years ago, sufficient to provide each person with 2,720 kilocalories daily. However, even with the worldwide level of food production at its current state, it is estimated that about one billion people still remain undernourished, with 30% of Sub-Saharan African remaining in that category. As food insecurity does not hit each region equally, particularly vulnerable social groups such as female-headed households, the elderly, rural poor without access to land, labor, capital or income are especially susceptible to insecurity and hunger (Boussard 2005). Future prospects for this current situation are dire. Recent data projects that by the year 2050, worldwide food production will need to grow by 70 percent to remain sufficient for the increased demand of the estimated 9.1 billion world inhabitants (Food and Agriculture Organization of the United Nations [FAO], 2009). Further data shows that even at that level, about four percent of the world's population will remain food insecure. Among this future four percent lie the world's most vulnerable developing nations and most especially, the rural poor in such nations.

With figures so staggering, many experts claim that the most proactive angle to approach food security is to increase food production, specifically in the areas that are

lacking a sufficient agricultural sector. The idea stems from the fact that Africa remains a net food importer, and has been since the 1970's (Rakotoarisoa, 2011). The same data shows that the vast majority of these food imports have been for staples like dairy, meats, sugar and cereals, demonstrating the importance of this international trade for domestic food security. The goal of input-substitution stems the dependency on foreign interference in addition to increases income from increased opportunity for market share. By increasing yields, the surplus can be sold at the market for more disposable income, which in turn helps to build the economy as well as increase availability of food. For Sub-Saharan Africa, this entails increasing opportunity for the rural farmers, and therefore the 61.1 percent of the population living in rural areas. According to the current patterns of worldwide agricultural growth, it is estimated that seventy-five percent of the projected necessary growth in production will stem from yield increases and sixteen percent from increased crop intensity (Boussard 2005).

Increases in agricultural production as noted above are often multi-faceted and often multi-staged interventions. In regards to naturally existing land and inputs, lack of natural resources is often the primary source of agricultural strife and also in turn the primary focus of agricultural change. Therefore, increasing production makes this an entirely imperative priority, especially in the variable region of Sub-Saharan Africa. Rural farmers in Sub-Saharan Africa are typically susceptible to a wide-range of unpredictable environmental follies because many of them are planting on semi-arid or arid lands (Daño, 2007) According to Dr. Christophe Girarde of the University of Geneva, it is precisely why access to natural resources, land and water most specifically, remain a focus of scholars and policymakers (C. Girarde, personal communication, April 16, 2012). As the production capabilities are dependent on the ability of these inputs to grow in tandem, they must remain imperative. Furthermore, the environmental shocks of droughts, floods and other such natural disaster make this priority even more necessary. For many, this means increasing investment in infrastructure, including more irrigation lines and improving pasture management (Boussard 2005). Additionally, expansion of arable land is also imperative, particularly in Sub-Saharan Africa and Latin America, where arable land is particularly vulnerable to fluctuations in climate and soil degradation.

Economic conditions in Sub-Saharan Africa remain such that the agricultural sector is still the main proponent of growth and a large portion of GDP in many of these nations, with food exports responsible for about \$16 billion in revenue (Rakotoarisoa, 2011). Complicated by the schism between rural and urban markets, food security issues are particularly arduous for populations of rural villages. In relation to the aforementioned necessities for food production, rural farmers fall far behind the large-scale farmers. Often lacking sufficient infrastructure in the form of irrigation and land management capabilities, the small amount of arable land cannot be farmed to its full potential. This problem is amplified by the common lack of capital and available funds to finance additional capital acquisition. An inconsistent form of financing can manifest in several ways, often equating to lack of dependable farm inputs, such as inconsistent seeds or inconsistent fertilizers, or cheap low-yield varieties of otherwise successful crops (Food and Agriculture Organization of the United Nations, 2009). On the rare chance that rural farmers secure access to secure irrigation lines, consistent financing, technologically relevant capital and consistent inputs, it is often lack of market access that leads to production and economic failure. Without proper market access, there is no feasible way to trade or to sell final goods, leading many farmers to depend on their subsistence agriculture for their livelihood. Ultimately, this is not sustainable as with no way to generate income from trade, there is no financial backing to support further agricultural endeavors.

3.2 Small-Holder Capacity

With further analysis, capacity for growth of small-holder farms in these areas becomes more apparent. While many international actions cater to solving the grand issues of food insecurity, it is the traditional peasants, as Dr. Christophe Gironde attests, that show great capacity for large production improvements. “They have the capacity to shift from one production system to another and they have the capacity to modernize” (C. Gironde, personal communication, April 16, 2012). Economic literature generally supports this claim, with the capital intensity remaining a major factor in this argument. As large farms are typically capital intense, they are an entirely inappropriate

model for some rural areas of Sub-Saharan Africa that lack access to enough capital to support large-scale endeavors (Boussard, 2005). Furthermore, given the size of large-holder agriculture, individual workers are much less accountable for their work, leading them to lack proper incentives for hard work.

As it is rarely the lack of work ethic as it is lack of technology or sustainable inputs, it is evident that with proper support, these groups can also improve production themselves. Given that many of these small-holder farms are for subsistence and have difficulties with market access, often farmers organizations or associations band together to collectively reach markets by collecting production, storage, transport, etc, also increasing the capability for improvement. With these conditions in mind, it is apparent that small-holder farms have the propensity for change, and such propensity has been revisited and demonstrated through several large agricultural interventions, not least of which being the “Green Revolution”.

3.3 Green Revolution Implementation and Results

As previously discussed, the initiative was inspired by the actions of the Rockefeller Foundation in 1940's Mexico, where poverty and hunger were addressed by increasing yields of beans and corn (Daño, 2007). Training local scientists on new breeding and farming technologies utilized the new high-yield varieties of local staples effectively, stimulating production and reducing the incidences of local hunger. Extrapolating this model to the expel the high incidences of hunger and poverty in Asia, the endeavor was initiated in the early 1960's for Southeastern Asia, targeting countries like Japan, Indonesia, Vietnam and Taiwan (International Food Policy Research Institute, 2002). The Rockefeller Institute together with Ford Foundations propelled an initiative focused on improving production in rice, a widely used staple crop for Asian nations. These groups led a research team to develop a semi-dwarf high-yield variety with fast maturation and the potentiality to grow year round. Similarly, research teams throughout the area began work on a high-yield hybrid of Mexican and Japanese wheat, bearing similar effects and strong resilience to variant conditions. These high-yield varieties quickly gained popularity, moving from twenty percent coverage of wheat fields

and thirty percent coverage of rice fields in 1970 to seventy percent coverage for both crops twenty years later (Boussard 2005). In combination with increased use of fertilizers, pesticides and new agricultural technologies like irrigation and improved water management, the positive changes came in droves. Asian cereal production doubled between 1970 and 1995, increasing the calorie availability per person by nearly thirty percent (International Food Policy Research Institute, 2002). The dissemination of the high yield varieties to rural small-scale farmers allowed rural poor to increase production, thereby providing opportunities to increase income. By selling the increased supply on the market, income for both farm and nonfarm economy increased. In Asia, real per capita income saw an increase of 100 percent between 1970 and 1995, with the absolute number of poor falling from just over 1.15 billion to 825 million, despite a sixty percent growth in population. Hand in hand with these improvements came the price reduction in the crops due to increased supply. With the combination of increased income and reduced prices, both wheat and rice became more affordable for the masses, allowing previously marginal populations access to more calories and diversification of diet.

Despite the popularity and success, failures were numerous. The overuse of inorganic fertilizers and pesticides caused immense environmental degradation over time. Often used in excess, these chemicals have since polluted waterways, reduced biodiversity by killing beneficial insects and other forms of wildlife, and poisoned field workers (International Food Policy Research Institute, 2002). The chemicals have often damaged potentially useful food by rendering it unsafe to consume. Despite immense amounts of product, the inedibility of the rice or wheat undercuts the potentiality of the high yield to solve problems (C. Gironde, personal communication, April 16, 2012). Additionally, irrigation lines have been racked with salt build-up that had led to the salinization of many previously arable plots of land. Furthermore, the reliance of a few varieties of high-yield substitutes have led to potential dependency that in some cases, has led to a depletion of biodiversity.

3.4 Green Revolution Failures in Sub-Saharan Africa

Given the success of the endeavors in Asia, the initiatives were thought to be applicable to the poorest regions of Sub-Saharan Africa, where the conditions were seemingly similar. Policymakers sought similar success without the downfalls from the last generation of endeavors. However, the factors contributing to agricultural failures of the rural poor in Africa far eclipsed the previously attempted Asian nations and make implementation of the changes nearly inconceivable.

Most of Africa's most destitute farmers reside in arid and semi-arid regions, where access to water is rare and infrastructure is sparse (Daño, 2007). Due to failed irrigation lines, access to water is, in some areas, limited to rainfall or sparse influxes of water, leaving land particularly susceptible to drought. Infrastructural failures like poor roads and railways leave many left without market access, restricting access to seeds, fertilizers, and other inputs necessary for production. The abject poverty is a contributing factor, as it has been shown that the consumption of improved seeds, fertilizers and pesticides has been nearly stagnant over the same amount of time that it has quadrupled in Southeast Asia. In Africa, 8 kilograms per hectare of improved seeds grew to a timid 9 kilograms per hectare between 1980 and 2000. In that same time, use of fertilizer increased from 20 kilograms per hectare to 22 kilograms per hectare. These often expensive inputs, rendered out of reach by poor market access and lack of sustainable income complicate the already diverse and arduous agricultural conditions.

For some, the access to natural resources is a large constraining factor upon productivity as well. Land rights, as Dr. Christophe Gironde claims, are an essential part of the scenario as well. Access to sufficient amount of land and water remains a focus of scholars and policymakers attempting to circumvent these issues that make agricultural growth nearly impossible (C. Gironde, personal communication, April 16, 2012). Limiting the propensity for growth, often times small plots of land can be easily exhausted by overuse of fertilizers and pesticides, and consistent planting of the same crops that strip the land of important nutrients (R. Zürcher, personal communication, April 23, 2012). While the constraint on land does increase the necessity for high-yield seeds, in turn it runs the risk of soil depletion.

Market conditions also lead to distortions that cause failures. As the poor infrastructure restricts market access, international trade competes with locally grown produce, wiping out competition at the final stage. The current international trade regime restricts the amount of import barriers and trade restrictions nations may place on one another and thus, cheap imports are freely shipped into countries at a production cost much lower than those of the rural farmers (Daño, 2007). These low prices drive domestic varieties and domestic vendors out of business, as the rural poor often cannot afford the fruits of their own labor. Further complicating the scenario is the low quality of the cheap imports. Often times, products arrived broken or cracked, especially in terms of rice, a key import for many of these areas (S. Koroma, personal communication, April 22, 2012). While the quality of the food may be sub-par, the low price makes it infinitely more affordable for populations and thus, remains a challenge for domestic producers and their families.

3.5 New Approaches to the Green Revolution: African Ownership and NERICA

Given the failures of the past attempts to spur the Green Revolution on the African sub-continent, Africans have now taken ownership over the initiatives, aiming to incite an “African-led Green Revolution to transform African agriculture” (Mittal 2009). Led by Alliance for a Green Revolution in Africa (AGRA), head itself by former Secretary-General of the United Nations Kofi Annan, the goal is to promote a market-based agricultural agenda to circumvent the aforementioned challenges (Alliance for a Green Revolution [AGRA], 2009).

In an attempt to take ownership of the production and dissemination of high-yield seeds, Dr. Monty Jones, then of WARDA (West Africa Rice Development Association), pioneered the development of what is now known as New Rice for Africa (NERICA), a hybrid of an Asian and native African seed (Diagne 2010). The rice blends the favorability of both strains of seed, creating a high-yield rice resistant to the variable growing conditions often found in West Africa. Dependency on rice in West Africa becomes more important yearly, with per capita rice consumption growing by 8 kg per person per year between 1970 and 1980. By 2005, that consumption grew to 32 kg per

person per year. As rice remains the most important source of calories in Western Africa, the implementation of the product has reduced the need for some yearly 40 percent of rice market imports. Generally, it is considered to be highly successful, for both upland and lowland agricultural systems. It has been adopted for some 700,000 hectares of land in Sub-Saharan Africa. Within the five to ten years immediately following its implementation, significantly positive yields were observed in many of the first countries to embrace it. For example, adoption rates of NERICA reach 87 percent in Gambia and 61 percent in Guinea, with 51,000 hectares planted in Guinea alone. Nigeria was observed to have 186,000 hectares of NERICA cultivated by 2007. NERICA is now supported by both AGRA and AfricaRice as a potential solution to local food insecurity and a small step towards large-scale results.

4. Discussion

4.1 Successes of the Green Revolution

As has been evidenced by generations of failed attempts to combat large-scale food insecurity, issues of this magnitude are wildly multi-faceted and multi-dimensional, leading to often complicated and often sub-par solutions. Given the dynamic nature of this problem, the Green Revolution and its sub-revolutions seem to be a relatively stable solution to the crisis.

Market-Based Solution

At the time when the Green Revolution first began to take prominence, it was in an age of in-kind food aid flowing from developed nations to underdeveloped villages in third-world countries. However helpful for short-term availability of food, the system was less of a system than a thinly-veiled attempt at foreign influence. In the wake of such realizations, international organizations and domestic governments alike hail a market solution as the most efficient way to circumventing potential dependencies and promoting self-sufficiency. By strengthening local avenues for selling and buying goods, the change can be self-propelling, with consistent demand encouraging consistent supply.

With so much of the developing world reliant on foreign imports, international conditions can have a long-lasting affect on local food security. Most specifically, this is often in terms of price volatility and its ability to affect both imports and exports. Because these nations are so dependent on imports, the price shocks echoing that of the international financial crisis caused domestic staple foods prices to rise exponentially. (FAO, 2011). This price volatility is one of the main downfalls of the current system, underlining exactly why this foreign dependence risks undermining development of the agricultural sector. Capitalizing upon this problem, the recognition of this problem as a key to the solution is exactly why the Green Revolution has been as successful as it has. While food aid has been helpful in preventing potential disasters and saving millions of lives in emergency situations, increasing capacity for self-sufficiency and eventual autonomy grants potential food sovereignty, a situation that could vastly improve domestic conditions for much of the developing world. Moving forward, this creates an appropriate window of opportunity for the Green Revolution to fill. Import-substitution is a feasible way to circumvent the issue, as it grants relative autonomy to nations previously lacking. While it has been established as an appropriate method, it is also preferred for the following reasons:

Increases Food Availability for Domestic Use and for Export

Unlike the in-kind food aid, vouchers and other government programs for food accessibility, increasing production is a direct attack on the issues affecting the majority of the population, which are low levels of production and consequently low income. Although the details of the plan are debatable, the Green Revolution's acceptance of this mechanism as one that can successfully and simultaneously increase both, is one reason why it is so hailed. As is evidenced, these high-yield seeds, when successful, have been shown to generally increase yields dramatically.

For some this has been a blessing while for others, the gains have yet to be seen. In many countries, extra yields have been stored in stockpiles, rotting before being able to reach the market. As discussed by Mr. Roger Zürcher from Food for the Hungry, community support can facilitate the market access necessary to export or to reach markets. For example, Food for the Hungry works with farmers in Uganda to

building 'houses' for the stock, essentially a place to store surplus (R. Zürcher, personal communication, April 23, 2012). With surplus storage, communication between the market and the rural community is facilitated to determine the most profitable time to bring the surplus to market. In fact, this organization is credited for the circumvention of potential infrastructure failures as community effort can avoid unnecessary and potentially costly travel on poor roads and for long distances. Dr. Christophe Girondé feels similarly, stating the government support was a defining factor in the success in the Asian Revolution and as evidenced, is necessary to facilitate the appropriate amount of dissemination and organization today. It can be safely established that community organization and government support is imperative for a secure manifestation of this yield increase and thereby improve the possibility of effective use domestically and for export.

Increased control over domestic markets

By producing for import-substitution, the Green Revolution has been shown to be impressive in reducing the amount of dependence on the quality of foreign imports, particularly important in this current environment of price volatility. Dr. Koroma of the FAO claims this may be one of the most important pieces affecting the quality of the crop bought and sold at market, as well. Cheap imports often mean low quality, and thus the quality of the locally grown food allows possibility for greater nutrition. Domestic markets can now have greater exposure to homegrown food, and less of the less familiar and less-nutritive variety.

Unfortunately, the propensity for import-substitution has plateaued over time, as international agreements have decreased the opportunity for protection. In the first phase of the Green Revolution, international agreements allowed for more possibility for trade restrictions. Therefore government protection for domestic farmers in the form of tariffs and import barriers was a far more common occurrence, allowing developing countries to successfully protect fragile rural agriculture and allow it to flourish. In today's post-Uruguay Round climate, international trade agreements have caused a reduction in the amount of tariffs for both developed and developing countries, effectively reducing them by 24% over 10 years for developing nations (World Trade

Organization, 2012). As a result, in the time necessary for these rural agribusinesses to develop, cheap imports are still allowed to creep into markets. This will remain a struggle for future generations as domestic crops become a larger portion of the local markets.

Increased Incomes

The propensity for increased income is one of the more concrete reasons for support of the Green Revolution, and has been well documented among groups with successfully increased yields.

By increasing yields, rural farmers have the ability to save supply beyond subsistence to sell at market, thereby increasing their ability to gain income. If in an area where infrastructural components are sound and market access is fairly possible to attain, this is a reality that has been one of the greatest achievements of the revolution to date. As was previously noted, Asian incomes have increased by over 100 percent over the past fifty years, with a grand number of rural poor gaining the ability to support themselves more securely. This is especially important for these marginal groups most affected by food insecurity—female-led households, elderly and the poor.

In regards to the NERICA implementation, this is particularly true. An empirical study in Benin found that the increased incomes affected these marginal groups particularly well, allowing for some female farmers to garner more economic freedom, a potentially substantial social gain. This effect is one of the most staggering, as evidenced by international organizations, domestic governments and rural poor alike that the potential for improvement is certainly there. Underscoring the possibilities available with a market-based solution, the increased incomes illustrate the propensity of the Green Revolution, and why its tenants are relevant for our new generation of policymakers.

4.2 Downfalls

Despite the various positive effects the Green Revolution has seen throughout its usage, the world has witnessed the imminent plateau of some of its most prominent

archetypes of success, and thus the endeavor in its entirety remains questionable. Some of the direst of these consequences lie in the environmental hazards, input dependency and new movement towards genetically modified inputs, which threaten to undermine the validity of the effects.

Environmental Standards

As the Green Revolution pushes towards a new interpretation and a new generation of implementation, policymakers, governments and farmers remain concerned about the downfalls of the last series of interventions, particularly the environmental components. Because the revolution hailed the use of fertilizers and pesticides due to their ability to improve growth capabilities, land has been overwrought with chemicals, often growing hazardous to worker and consumer alike.

For example, Punjabi farmers who once benefited from the Green Revolution in their high-yielding crops and consequent incomes, are now buying three times the amount of fertilizer they did thirty years ago (Zwerdling, 2009, April 13). The overuse of pesticides has also caused resistance among the insects typically exterminated by the process, leading to large-scale destruction of crops as well.

This situation is not entirely uncommon, as the double-edged sword of the old phases of the Green Revolution have rendered several areas dependent on chemical processes that deplete the land of resources and reduce the arability of previously fertile plots. For many opponents of the endeavor, this remains a primary reason for refusal, and one of the many that AGRA uses to promote African-led agricultural endeavors and new interpretations of the old model. While these initiatives were enacted often in cooperation with the farmers who now implement these inputs, it still remains a downfall for future suggestions of the Green Revolution as the consequences in some cases have far exceeded the benefits.

Genetically-Modified Inputs

In turn with the rejection of chemical components comes the refusal to accept genetically modified crops, which remain a widely accepted factor of today's approaches to agricultural interventions. Often considered to be the hallmark of the

current high-yield movement, genetically modified seeds such as “The Terminator” and other such products of biotech companies have in fact remained more harmful than helpful (Yusuf, 2010). Companies focusing much of their energy on creating industrial solutions rather than food crops often market single-generation crops, which once planted and sowed, cannot be used to produce another generation of seeds. Essentially, the seeds need continual repurchase each planting season, rendering rural farmers dependent on a secure supply from only a few companies, leading to near monopolies. It remains a similar situation to that of fertilizer and pesticide dependence, often found in areas hailing a similar agricultural reform.

In regards to fertilizer and pesticide dependence, often times the entire package will be presented in one kit of genetically modified fertilizer, pesticide and seed, tying high-production to a certain company. According to Mr. Zürcher of Food for the Hungry, this is not an uncommon occurrence. He lends the example of a particular type of maize, supposedly sold with a certain type of Round-Up, a common weed killer (R. Zürcher, personal communication, April 23, 2012). The use of Round-Up does not impede the maize from growing successfully, yet does kill everything else in the vicinity and thus, the maize must be purchased with the Round-Up, and vice versa. It is such cases that exhibit the degree of the danger in genetically-modified inputs, as both the crop as well as the inputs have been genetically modified to grow, yet remain wrought with harmful and potentially toxic chemicals. Additionally, it is a prime demonstration of business interests marring a potentially beneficial revolution with environmental, health, and ethical implications to their actions.

Eventual Plateau

In some areas around the world, an eventual plateau has been documented, lending some doubt to the infallibility of these high-yield inputs. For example, India’s cereal production is said to have stagnated at 150 million tons per year and it is not an uncommon trend. According to Dr. Gironde, it is a tendency of much of the Asian nations formerly experiencing high increasing in yields in the 1960’s. The improvements are no longer increasing yields more than or proportional to the change in population

rate for many countries and thus, the long-term effects of the Green Revolution leave much to be debated.

4.3 New Rice for Africa

Moving forward, domestic governments and rural societies are looking to create a more sustainable vision for agricultural reform, without the risk of industrial interests and the environmental hazards while maintaining an agricultural program catering towards approaching food sovereignty. Born from this school of thought have been the NERICA varieties of rice seeds, quickly making their way through Sub-Saharan Africa and quickly spreading across thirty-one countries on the continent. While some consider it a rebirth of the revolution, complete with unpleasant side effects, evidence hails this as one of the most valid reinterpretations of the tenants of the Green Revolution and the propensity for real change is certainly evident. NERICA has been defended as a departure from the Green Revolution as it remains a hybrid seed and not genetically modified and the implementation of the seed is an homage to the successful endeavors of the past. In fact, some may say it is one of the most successful byproducts of the revolution to date.

Production

As NERICA is a hybrid of two particularly advantageous types of seeds, it does not qualify as a genetically modified seed, lending itself to a category of products particularly appropriate for agricultural reform. Developed by Sierra Leonean Dr. Monty Jones, the seed itself is a prime candidate for domestic production and as such, remains true to the AGRA tenant of African-led development, from the ground up. Roger Zürcher of Food for the Hungry upholds this detail, stating that domestic companies in Uganda have now begun to take over production for domestic use, and thus its ability to integrate into local production is evidenced and upholds the primary tenant of domestically-propelled development.

Income Effects

NERICA's high-yield capabilities have been spread throughout Sub-Saharan Africa and the results have been heterogeneous, albeit mostly successful. As has been stated before, the implementation across Africa is staggering, with testing in thirty-one African countries, with 700,000 hectares combined (Diagne 2010). Despite concentrated success, the seed has performed well in terms improving yields in those areas, with demonstrable increases in the tons of rice. The extent to which these yields are utilized effectively is entirely variable, with government and community support remaining a defining factor. For the areas that have responded well to the seed implementation, increased incomes have been reported, specifically among impoverished marginal groups like female-led households. As such, the usage has indeed illustrated the propensity for change, both in increases in food sovereignty and reducing poverty.

Environmental Hazards

NERICA is shown to perform incredibly well in both the highland and lowland regions, and is typically rain-fed. As this eliminates the need for intensive irrigation lines and water management, this can substantially stem the potentiality for environmental downfalls in this area like salinization and poor management. While fertilizers help to increase the yields, it has been shown that even without fertilizer, the increase in yield is substantial enough to leave surplus for sale at market. As the target audience throughout the entire conception of the seed has remained rural poor farmers, who often cannot afford fertilizer, the product is created with this in mind, and therefore does not require the heavy inputs necessary of other types of high-yielding crops.

In addition, the seed's status as a non-genetically modified crop does lessen the risk of the potential health effects due to unknown processes and chemicals utilized in its growth and development.

5. Conclusion

Among one of the primary goals of this project is the defense of propensity of small-scale farmers for large-scale change. Often when considering issues of food security and food sovereignty, the international arena tends to think in terms of famine, price hikes and emergency relief. However, these issues are often large-scale secondary effects to the underlying and pervasive food insecurity.

In moving forward in the fight against these serious disasters, development agencies, international organizations and domestic governments should look towards capacity building, and therefore the Green Revolution's aims are not misguided. In attempting to reach the poorest of the poor, nations increased the availability of food to marginal groups while simultaneously improving income for these groups as well. While the environmental hazards were often severe, many academics believe that in this case, the gains outweigh the losses. In terms of loss of human life due to malnourishment and general issues of poverty, the interventions have certainly succeeded in reducing suffering. In that breath, the Green Revolution was entirely successful in its aims, and in terms of a type of agricultural reform, should remain hailed as one of the most successful of our generation.

This paper recognizes the imminent downfalls of the new generations of Green Revolutions, as the attempt to circumvent the environmental hazards of the last round has driven many nations into the evils of industrialism and dependency. The release of agricultural packages and genetically modified seeds, while useful for increasing yields, undercuts the potentiality for economic growth and undermines the propensity for domestically led market strengthening. As such, this study recognizes the potential of NERICA as a seed that can potentially and very positively change the face of agricultural reform.

New Rice for Africa's status as a home-conceived, homegrown, and home-sold product has entirely upheld the propensity for domestically led agricultural growth, and with very positive results. The wide acceptance and growth of rice crops continent-wide demonstrates the success of the endeavor as one in line with AGRA's goals of African-led initiatives.

Looking forward, AGRA and other such organizations should look to diversify and expand this endeavor to other key crops such as maize, sorghum and cassava to amplify their yields throughout the continent while simultaneously improving the potential for food sovereignty, an entirely imperative part of the development of Sub-Saharan Africa and other such food insecure places.

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Annex – ISP Work Journal

January 28– ISP Proposal

- Identified hunger and malnutrition as areas of interest
- Write-up concludes that I want to research “food security”
- Current thoughts: Maybe research bureaucracy of food aid? Why food aid hasn’t fixed anything?

January 31 - Meeting with Dr. Fehlmann:

- Dr. Fehlmann: Food insecurity is too large of an area to focus on. There a lots of different types of food aid
- Thoughts: Back to the drawing board for more research and clarification
- Future Plans: Research the scope of food security. What it is? What are the differences between the different types of food aid? Is food aid the only avenue to fix these problems?

Weeks before the ISP Justification:

- Two areas of interest defined: Small-scale agriculture and bureaucratic failure in food aid
- Relevant visit: Centrale Sanitaire Suisse Romande
 - Key observation - More often than not, development projects fail
 - Maybe a good ISP would focus on what they do that fails
- Relevant visit: Jardin de Cocagne
 - Key observation - Small-scale development can be effective. Essentially scaling-up agriculture can solve bigger issues.

February 17 - ISP Proposal

- Current proposal: Touches on both bureaucratic failures and small-holder agriculture
 - Really focusing on small-scale agriculture
- Discovered lots of info about “Green Revolution”

- Decide to focus upon this and its effect on long-term food security
- Decide on case study: Benin and Malawi comparison
- Breakthroughs: Narrowing of scope, focusing on Green Revolution and other bottom-up approaches to food security.

February 20 – Meeting with Dr. Fehlmann

- Very confused but supposedly a good start
- Refers me to Global Alliance for Nutrition (GAIN) as a potential source

February 20 – Lecture from Aliyah Esmail, Aga Khan Agency for Microfinance

- Discover microfinance is a huge part of agricultural interventions, especially scaling-up interventions
- Receive contact information for potential interview

February 21 - Rebecca Spohrer from GAIN)

- Relevance to topic isn't apparent anymore
- Collected contact information for potential interview

Week of February 24 – Week of Lit Review

- Thoughts: Maybe Green Revolution is too specific?
- Changes: Now including microfinancing as a bottom-up approach to food security
- Current ISP topic: Analysis of scaling-up approaches to food security in relation to one another

March 5 – Morocco

- E-mail Dr. Viladent my Lit Review as I've now had a change of advisor

Making Contacts – March 15th-April 5th

- Contacts attempted with:
 - Aliyah Esmail – Aga Khan Microfinance Agency

- Food and Agriculture Organization of the United Nations, Rome and Geneva
- Global Alliance for Nutrition (GAIN)
- Dr. Christophe Gironde, University of Geneva and Dr. Christophe Golay, University of Geneva
 - Co-teach class on food security issues at The Graduate Institute
- Dr. Kiah Smith, UN Agency for Research and Development
 - Research interests include food security in developing nations
- Roger Zürcher, Food for the Hungry
 - Food for the Hungry is a non-profit group based in Geneva that initiates agriculture interventions and other development in developing nations to spur agricultural improvements
- All potential contacts received an e-mail regarding the nature of my research and asking for an interview.

April 3 – Contact Update

- No response from FAO, Dr. Kiah Smith, GAIN,
- Aliyah Esmail refers me to Mr. Olivier Massart, a fellow employee at AKAM
 - Begin e-mail correspondence
- Dr. Christophe Golay refers me to his colleague
- Send e-mail to Dr. Suffyan Koroma of FAO, Rome
 - Previously stated openness for interview

April 7th, 2012

- Scheduled meetings with Dr. Christophe Gironde, Olivier Massart of AKAM, Dr. Suffyan Koroma and Roger Zürcher by e-mail

April 16 – Meeting with Dr. Viladent at SIT Study Room

- Meet with Dr. Viladent to clarify some questions:
 - Would it be better to do a study of bottom-up interventions or the Green Revolution?

- General overview of bottom-up interventions is too broad
- Would this paper work better as a study of the driving forces behind bottom-up interventions? Or as a study of the failures of the Green Revolution?
- Viladent recommends:
 - Focus on downfalls
 - Case study is still a good idea
- Current ISP: Analysis of Green Revolution's potential in Africa
- Changes: Interview with Olivier Massart from AKAM is no longer relevant

Meeting with Dr. Gironde:

I e-mail Dr. Gironde the following questions, as I assume they are general enough to give a good background, yet also specific to my question of choice.

- How does one define food security? In doing so, is it the nutritional value of the existing food or the mere existence of food that is most important?
- In general, what are the main objectives in solving food security? Is it the balanced market, a fair price level or the amount of food available that is most important?
- Is subsistence farming typically considered a secure option for rural communities of little means? In attempting to improve food security, could intervention in subsistence agricultural communities be considered an appropriate mechanism for change? In short, is approaching from the bottom-up a valid approach?
- Who does the 'Green Revolution' cater towards? Is the goal to increase food availability for farmers and local communities or to increase food availability for export and thereby improve country-wide income?
- As a model for development, how effective are market-based solutions to food security? Given the volatility of local and global markets, can this be considered a sustainable and effective method?
- Couldn't the Green Revolution be considered an unwanted market distortion? Wouldn't the availability/necessity of certain agricultural products create dependency on the companies providing them?
- Why not just invest in the infrastructure of the domestic country? Why give them the means without increasing their capacity to do so?

April 17th - Case Study Change

- Decide to omit the studies of Benin and Malawi and instead study New Rice for Africa and its efficacy in Sub-Saharan Africa

- Extensive literature review on the implementation and the empirical data related

April 22 – Meeting with Dr. Suffyan Koroma

- Unstructured interview in which we talk about general issues in food sovereignty in Sub-Saharan Africa
- Provides extensive background on NERICA and its implementation

April 24th, 2012 – Meeting with Mr. Zürcher

- Changed my questions due to subject's standpoint as an NGO
- Semi-structured interview based on the following:
 - How are these new seeds being accepted locally? Is there any resistance amongst small-scale farmers? If so, what are the roots of the resistance?
 - What are the avenues that allow the products to reach the market? Is there infrastructure available to allow trade for goods? Does production ever eclipse demand?
 - How does the interaction with FH and the farmers associations work? Does the large number of groups involved make organization difficult?
 - Do these seeds ever drive other native crops out of production? And beyond that, does this seed intervention cause these new products to flood the market since they are produced in mass quantities?
 - Does FH ever receive competition from other groups like FAO or WFP giving in-kind food aid? How does one orchestrate the various organizations on the ground?
 - Targeted Areas of Development: Why invest in agricultural inputs instead of investing in infrastructure? Is there some component of government agreement that is necessary for this endeavor?

End of April – ISP Complete!