PROSPECTS FOR RICE PRODUCTION IN EQUATORIAL GUINEA:
OPPORTUNITIES AND CHALLENGES

A Thesis

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ABSTRACT

Equatorial Guinea, a small country located on the west coast of Africa, is rich in oil resources. However, due to the uneven distribution of wealth, nearly 75% of the population lives in poverty. Among other challenges, food shortages are a main constraint facing the 1.3 million people living in Equatorial Guinea. In fact, one in five children under 5 years of age suffers from malnutrition and stunting (moderate or severe) (United Nations Development Program, 2018). Therefore, solving Equatorial Guinea's food scarcity requires immediate attention and if this action is successful, it will substantially increase the quality of life of many Equatorial Guineans. Rice is the most widely consumed staple food for a large portion of the world's population. Ideally, the climate and natural resources in Equatorial Guinea are favorable for the production of rice. An abundant and sustainable supply of rice will greatly alleviative the nutritional status of the undernourished population. Although significant progress has been made in selecting and growing rice varieties adapted for the country, rice production in Equatorial Guinea is still limited by several key factors. In this paper, I present and evaluate the growing conditions for rice production in Equatorial Guinea as well as the major constraints to increased production of this staple crop. Specifically, the growing environments for rice production I am referring to include geography, climate, soil conditions, and agricultural history. Constraints on rice production are due to several factors including environmental conditions, pest problems (e.g., weeds, insects, and diseases), human resource limitations, and socio-economic and policy constraints. I also propose suggestions for overcoming these constraints, such as promoting effective irrigation methods, using organic waste to address the poor fertility of soils, biological control of pests, training farmers so they can effectively address these challenges, and enacting policies that support and promote agricultural development in Equatorial Guinea.

BIOGRAPHICAL SKETCH

I was born in Jiangxi, China on November 24th, 1996. Both my parents have a career-long engagement in agriculture. Thus, I developed a great deal of interest in agricultural related subjects. This led me to pursue a biochemistry degree at Old Dominion University (ODU) in 2015. During my undergraduate studies, I invested much time and effort in my academic studies and feel I gained a solid background in biochemistry and related subjects. In 2017, I was recipient of an *Undergraduate Award in Analytical Chemistry* from the American Chemical Society. I was also an Outstanding Graduate (Top 5%) at ODU. In summer 2018, I participated in research in Professor Xie Huaan's lab focusing on the selection and breeding of multiple ratooning rice varieties. After graduation, I traveled to Africa to assist my parents in providing agricultural services to the farmers of Equatorial Guinea. This experience inspired my enthusiasm and interest in further developing my knowledge and practical skills in sustainable agriculture and equitable food systems and food security. Subsequently, I entered the Master of Professional Studies degree program in the field of Soil and Crop Sciences at Cornell University, under the guidance of Prof. Antonio DiTommaso, a weed scientist. At Cornell, my research focused on cropping systems in Niefang, China, and Equatorial Guinea, Africa. My experience within the Cornell MPS program and research has been very beneficial to my future career in helping to build sustainable and resilient agricultural systems in underdeveloped regions of Africa.

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LIST OF ABBREVIATIONS

UNDP, United Nations Development Programme

DNAP Farm, Dumasi-Niefang Agricultural Pilot Farm

OM, Organic Matter

GDP, Gross domestic product

IPM, Integrated pest management

HDI, Human Development Index

IMF, International Monetary Fund

P, phosphorus

K, potassium

Introduction

1.1. Background information and statement of problem

Equatorial Guinea is a small oil-rich country located on the west coast of Africa. However, because the country is plagued by vast income inequality, most of the population lives in poverty ("Equatorial Guinea Country Review," 2020). According to the Human Development Report published by United Nations Development Programme (UNDP) in 2018, 26.2 percent of children under 5 suffer from malnutrition and stunting (moderate or severe) (Food and Agriculture Organization). The large number of children with stunted heights suggests that the population in Equatorial Guinea has suffered from inadequate nutrition during an extended period of time. Therefore, there is urgency in solving the food scarcity situation in Equatorial Guinea.

Rice (*Oryza* spp.) is an important staple food in the world. It is productive, sustainable, and essential for human nutrition and caloric intake (Balasubramanian et al., 2007). From 1990 to 2018, rice consumption and production in Sub-Saharan Africa (SSA) tripled from 9.2 Mt to 31.5 Mt (USDA, 2018), and this trend is expected to continue given the high rate of population growth and rapid urbanization in this region of Africa (Tsujimoto et al., 2019). There is significant potential for growth in the rice sector in Equatorial Guinea. In 2018, the first regionally adapted rice cultivars in Equatorial Guinea's history were successfully developed and grown (Economic and Commercial Counselor's Office of the Chinese Embassy in Equatorial Guinea, 2018). It is hoped that the introduction of this new staple grain crop to the region will substantially alleviate the nutritional status of a large portion of the population that is malnourished. Although significant progress was made in selecting and growing rice varieties adapted for the region, significant rice production constraints and challenges remain.

1.2 Objective

The objective of this study is to evaluate the growing environments and production constraints of rice in Equatorial Guinea. Suggestions for overcoming these constraints based on the data obtained are also presented.

2. Rice-growing environments

2.1 Geography

Equatorial Guinea is located on the west coast of Africa along the Atlantic Ocean between Cameroon and Gabon ("Equatorial Guinea Country Review.," 2020). It lies between longitude 8^{o} $25^{'}$ ~11^{o} $20^{'}$ E and latitude 1^{o} $0^{'}$ ~3^{o} $48^{'}$ 30" N ("Equatorial Guinea Country Review.," 2020). The land area is 28,050 km^2, of which 17,520 km^2 was estimated to be a forested area in 2000 (World Bank, 2020). The country consists of a mainland area (Río Muni) and five islands (Bioko, Corisco, Great Elobey, Little Elobey, and Annobón) (De Castro & De la Calle 1985). According to the 2018 census, the population of the country is 1.3 million people.

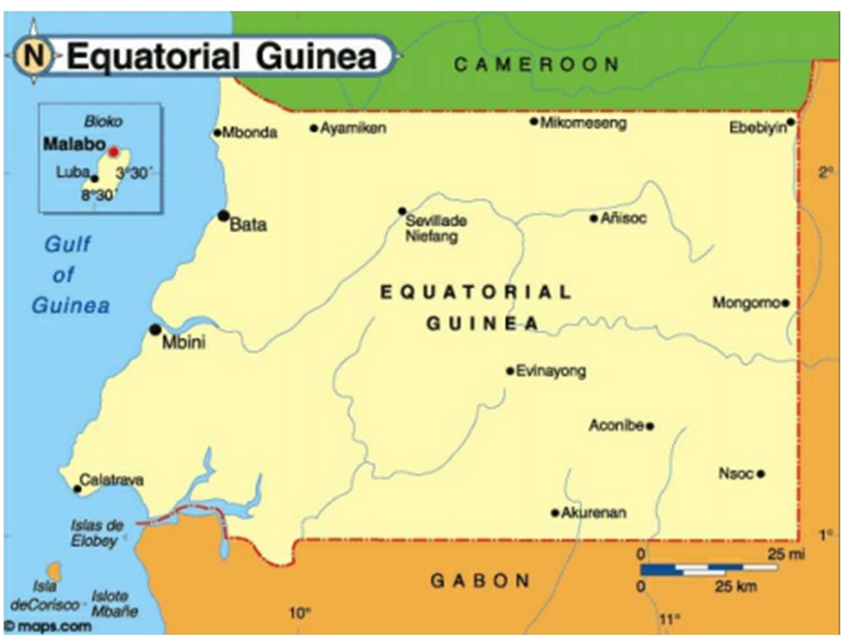

Figure 1. Map of Equatorial Guinea ("Equatorial Guinea Country Review.," 2020).

2.2 Climate

Equatorial Guinea has a typical tropical climate, which is hot and humid (Teke & Atanga 2011). The average annual temperature of Equatorial Guinea is between 24° C and 26° C; the annual rainfall varies from 2100 to 3100 mm (Figure 2) (World Bank, 2020). Equatorial Guinea features distinct wet and dry seasons. The wet season lasts from March to May and September to November in the mainland and from May to October in Bioko (Kümpel, 2006).

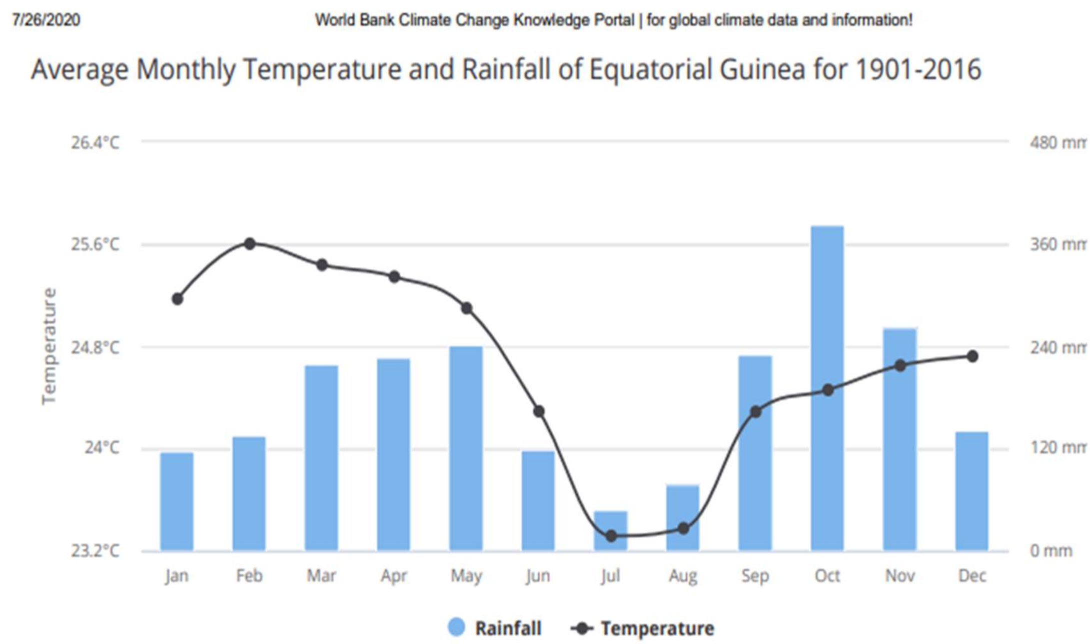

Figure 2. Monthly-mean variations of temperature (dark line) and rainfall (blue bars) in Equatorial Guinea for data from 1901-2016 (World Bank, 2020).

2.3 Soil Conditions

In Equatorial Guinea, the total arable land area is about 850,000 hectares, but only 20,000 hectares have been cultivated (African Development Bank Group, 2020). Most soil parent materials are volcanic sedimentary rocks. Thus, the soil is rich in minerals. In 2015, Chinese agriculture experts collected and analyzed five soil samples from five sites In Equatorial Guinea. Three sites are from the Dumasi-Niefang Agricultural Pilot Farm (DNAP Farm) and two sites are from BOME (a town near the DNAP Farm). The DNAP Farm grew a rice crop successfully in 2018 for the first time in the history of the country. Based on the soil data collected, the soil is acidic and the organic matter (OM) content is low. Moreover, the soils had low fertility and poor water retention ability (Table 1).

Table 1. Soil test results averaged from five soil samples collected at five different sites in 2015. Data include pH, organic matter (g/kg), total nitrogen (g/kg), available phosphorus (mg/kg), and available potassium (mg/kg).

Soil Sample	pH value	Organic Matter (g/kg)	Total Nitrogen (g/kg)	Available Phosphorus (P) (mg/kg)	Available Potassium (K) (mg/kg)
cultivated land at BOME	5.13	51.6	1.67	3.45	8.10
river sediment at BOME	5.56	28.6	1.71	2.25	3.60
vegetable greenhouse at DNAP Farm	4.50	24.4	1.49	17.0	189
cropland at DNAP Farm	4.96	34.2	1.60	20.8	93.9
land beside reservoir at DNAP Farm	4.46	32.8	1.60	12.2	49.9

2.4 Agricultural History of the Region

Cassava is the major staple crop grown in Equatorial Guinea (Kümpel, 2006). Local farmers also grow other agricultural crops, such as sweet potato, peanut, taro, corn, banana, vegetables, and fruits ("Equatorial Guinea Country Review.," 2020). During the colonial period, Equatorial Guinea's economy was based on agriculture, with cocoa, coffee, and timber as major export products ("Equatorial Guinea Country Review.," 2020). Equatorial Guinea gained independence from Spain in 1968. At that time, the main economic activity was cocoa production, which provided 75 percent of gross domestic product (GDP) of the country (Frynas, 2004). To expand cocoa production, local people cut down most of the lowland rainforest (Zafra-Calvo et al., 2010). However, from 1968 to 1979, the country turned into a pro-Soviet one-party state, causing cocoa production to plummet from approximately 28,000 tons in 1969-70 to only 4,000 tons a decade later (Frynas, 2004). Today, Equatorial Guinea's cocoa sector has yet to recover from this severe decline in production (Frynas, 2004).

In 1995, significant reserves of offshore oil were discovered in Equatorial Guinea and the country became a significant producer and exporter of oil ("Equatorial Guinea Country Review.," 2020), with more than 80% of its GDP dependent on petroleum and natural gas exports (Equatorial Guinea 2020). Today, the economy of Equatorial Guinea is one of the fastest-growing economies in the world (Frynas, 2004). Despite this rapid economic growth, the majority of the population in the country is still engaged in agriculture. In 2004, agriculture accounted for 3% of the total GDP, although 70% of the population was engaged in agriculture. In Equatorial Guinea, over 99% of the farms are family or privately owned (Teke & Atanga 2011). Smallholder farms generally have high labor inputs, poor crop management practices, and low crop yields. Thus, most food in Equatorial Guinea is imported.

In 2018, the DNAP Farm successfully grew rice for the first time in the country's history (Economic and Commercial Counselor's Office of the Chinese Embassy in Equatorial Guinea, 2018). Theoretically, the abundant natural resources found in Equatorial Guinea can support a substantial increase in rice production. Hence, the introduction of this new staple grain crop into the region is of great significance. However, rice production in this region still faces numerous constraints and challenges.

3. Production Constraints and Management

3.1 Environmental Constraints and Management

Equatorial Guinea experiences both a wet and dry season annually. During the rainy season, crops may be affected by storms, strong winds, and brief heavy rainfall, causing significant yield loss. During the dry season, the rice crop may be subjected to drought and inadequate fertility because of the low moisture holding capacity of soils in the region. However, because of the abundance of sunshine in Equatorial Guinea which is highly favorable to rice production, local governments should prioritize the construction of water reservoirs and/or promote more effective irrigation methods so that a constant supply of water is available especially during droughts.

In general, local farmers could use synthetic fertilizers to increase the fertility of their soils. However, for most farmers in the region, fertilizers are too expensive to purchase. Therefore, farmers have been encouraged to apply a mixture of well composted organic waste, such as human/animal excrement and urine as a fertility and organic matter source. This method is relatively cheap and environmentally friendly.

3.2 Weed, Pest, and Disease Constraints and their Management

Weeds, like insect pests and diseases, are one of the major biotic constraints to rice production in both lowland and upland ecosystems (Saito, 2010). The detrimental impact of weeds on crops results in reduced crop yields through competition for water, light, space, and nutrients (Renton & Chauhan, 2017). It is estimated that the total damage and control costs caused by weeds in the United States totals approximately $33 billion USD (Pimentel, 2005). In Sub-Saharan Africa, total crop yield losses due to weeds surpass 25% (Balasubramanian et al., 2007). In Equatorial Guinea, the major weeds found in rice cropping systems include *Spermacoce alata*, *Ipomoea hederacea*, *Digitaria sanguinalis*, *Galinsoga parviflora, Eleusine indica, and Echinochloa crus-galli*. Not surprisingly, most of these weeds are summer annuals. Generally, summer annual weeds can survive the warm and humid winters. These plant species are often difficult to manage because most are better adapted to summer growing conditions than rice. For instance, weeds often have taller canopies than rice plants, which can enhance their light-foraging capacity. Thus, weeds tend to have more extreme shade avoidance responses than rice. Generally, for these weeds, pests, and diseases, the use of pesticides is the most effective control strategy. However, as mentioned, many farmers in the region are very poor and cannot afford the purchase of synthetic pesticides. Moreover, the improper use of pesticides can negatively impact wildlife and the environment. Manual weeding and the use of insect traps are the most common methods to manage weeds and insect pests, although they are time-consuming and laborious. Based on Integrated Pest Management (IPM) principles, establishing a density-dependence relationship between pests and their predators (biological control) is an effective pest management strategy. Although it may take a long time to implement and reduce pest populations, this approach may provide a permanent solution over a wide geographic area. However, this strategy may have negative impacts on non-target species. Nonetheless, taking into account economics, environment, and efficiency, the appropriate and safe use of chemical control methods is still the most effective approach to managing weeds, pests, and diseases in the region.

Table 2. Common weeds found in rice cropping systems in Equatorial Guinea.

Common Name	Scientific Name	Family	Habit
Winged false buttonweed	*Spermacoce alata*	Rubiaceae	Perennial
Ivyleaf morningglory	*Ipomoea hederacea*	Convolvulaceae	Summer annual
Large crabgrass	*Digitaria sanguinalis*	Poaceae	Summer annual
Potato weed	*Galinsoga parviflora*	Asteraceae	Summer annual
Goosegrass	*Eleusine Indica*	Poaceae	Summer Annual
Barnyardgrass	*Echinochloa crus-galli*	Poaceae	Summer Annual

3.3 Human Resource Constraints

Smallholder farmers account for more than ninety percent of the total agricultural production in Equatorial Guinea (Teke & Atanga, 2011). Smallholder farmers typically use simple agricultural production techniques that are often not very efficient including manual irrigation, manual weeding, and using cattle to pull tillage implements. However, there are two main reasons why modern, high-technology agricultural equipment cannot be promoted in Equatorial Guinea. First, poverty! The price of most farm machinery is beyond the reach of most poor farmers in the region. Second, the lack of education. In the ranking of 169 countries and regions, the Human

Development Index (HDI) ranks Equatorial Guinea in the 141st place (Human Development Index, 2020). The HDI is a comprehensive index of several indicators that measures a country's achievements in the three main areas of human development: longevity, knowledge, and education, as well as the economic standard of living. In Equatorial Guinea, only 28.7% of farmers have secondary level education, with over 26% of the population being illiterate (Teke & Atanga, 2011). This low level of formal education is a major obstacle to introducing new technologies to the region and training farmers to be highly skilled. This makes it difficult for farmers to understand and adapt to new agricultural technologies. In 2018, because of the implementation of many of the benchmarking program measures signed with the International Monetary Fund (IMF), public finances improved, and education funds were increased (African Development Bank Group, 2020). Certainly, this is a positive step forward for the people of Equatorial Guinea but likely requires some time before societal benefits in terms of increased literacy and education level in the population is observed.

3.4. Socioeconomic and Policy Constraints

Infrastructure is also crucial to supporting agricultural endeavors. Over the past two decades, oil production has modernized the country's infrastructure (African Development Bank Group, 2020). Ambitious programs are being carried out on various infrastructures, including roads, shipping ports, airports, water supply, and electricity production, transmission, and distribution (African Development Bank Group, 2020). Most infrastructures are new and in good condition, which will be beneficial for the agricultural sector of the country.

Between 2014 and 2018, the contribution of the agricultural sector to the national economy was less than 2% of GDP (African Development Bank Group, 2020). The National Agricultural and Food and Nutrition Security Investment Plan 2015–20 stressed training farmers and creating small and medium agricultural enterprises (African Development Bank Group, 2020). The government should expand this type of policy support to promote the development and modernization of agricultural systems. This policy action will promote the introduction of advanced agronomic techniques, development and promotion of genetically modified seeds, and the training of more farmers.

Conclusions

Growing rice in Equatorial Guinea can potentially alleviate food shortages and child malnutrition. Certainly, the climate of Equatorial Guinea is most favorable for the production of rice although the fertility of soils and other soil parameters are important limitations. Thus, enhancing rice production in this region of Africa remains challenging from an agronomic, labor, and policy perspective. These limitations are not insurmountable, however, but will require a concerted effort of collaboration from all involved including farmers, scientists, policymakers, and government leaders, and the international community.

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