Czech University of Life Sciences Prague

Faculty of Economics and Management

Department of Economics

Bachelor Thesis

Agriculture in selected West African countries

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CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

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BACHELOR THESIS ASSIGNMENT

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Economics and Management

Thesis title

Agricultre in selected West African Countries

Objectives of thesis

The main aim of the bachelor thesis is to analyze situation of agriculture in selected countries West African countries with regards to their economic growth and evaluation of factors that influence its situation.

Methodology

This thesis will be divided into three parts.

The first part is a theoretical one and will be based on literature search. It will define the current state of knowledge in the field of African agriculture with the overlap to its history and development.

The second part will rely on the theoretical part and it is the key component of the thesis. The author will use method of quantitative research such as statistical and mathematical methods. The researcher will use secondary sources of information (UN, UNCTAF, FAOSTAT, African Development Bank, etc.).

The final part will conclude the results of the previous parts and discuss it with another author. The most important part will consist of partial conclusions outcome and finding

The proposed extent of the thesis

30 – 40 pages

Keywords

West Africa, agriculture, development, crop production, trade

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Recommended information sources

Agricultural Growth in West Africa: Market and Policy drivers (2015): Rome: African Development Bank with the Food and Africulture Organization of the United Nations, ISBN 978-92-5-108700-8.

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Declaration

I declare that I have worked on my bachelor thesis titled "Agricultural in selected West African countries" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break copyrights of any person.

In Prague on 14.3.2017 Pešková

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I would like to thank Ing. Benešová Irena Ph.D, than my mother Gabriela Pechrová and my sister Ing. Marie Pechrová Ph.D. for their help and support in writing this thesis.

Situace v zemědělství ve vybraných zemích Západní Afriky

Souhrn

Cílem bakalářské práce je analyzovat situaci v zemědělství ve vybraných zemích Západní Afriky. Teoretická část nejprve popisuje geografické podmínky a ekonomickou situaci v Nigerii, Ghaně a Togu. Poté se věnuje problematice zemědělství v těchto státech a prezentuje výsledky výzkumů v této oblasti. Praktická část se zaměřuje na rostlinnou výrobu a zjišťuje pomocí lineárních vícenásobných regresních modelů, jaké faktory ji ovlivňují. Výsledky odhadnutých modelů jsou ekonomicky verifikovány a statisticky testovány. Provedeným výzkumem se zjistilo, že nejvíce mají na rostlinnou produkci vliv výměra, na které je plodina pěstována, a výše výnosu. Na základě zjištěných údajů lze doporučit oblasti, na které by se Nigerie, Ghana a Togo měly zaměřit pro zlepšení situace v zemědělství. Jedná se především o zvyšování výnosů, kterého je možné dosáhnout jednak zlepšením obhospodařování půdy, hnojením atd. a rovněž zvýšením investic do zemědělské techniky, do nových technologií a zaváděním inovací v zemědělství.

Klíčová slova: Ghana, Nigerie, rostlinná výroba, Togo, Západní Afrika, zemědělství

Agriculture in selected West African Countries

Summary

The aim of the thesis is to analyse the situation in agriculture in selected West African countries. The theoretical part describes the geographical conditions and economic situation in Nigeria, Ghana and Togo. Then it deals with the problems of agriculture in these countries and presents the results of research in this area. The practical part focuses on crop production and detects, using multiple linear regression models, what factors affect it. The results of the estimated models are verified economically and statistically tested. Carried out the research found that most influence on crop production have area harvested and yield. Based on the data we can recommend areas which Nigeria, Ghana and Togo should focus on for improving the situation in agriculture. This is primarily to raise yield. That can be achieved both by improving land management, fertilization etc., as well as increasing investment in agricultural technology and introducing innovations in agriculture.

Keywords: agriculture, crop production, Ghana, Nigeria, Togo, West Africa

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1 Introduction

West Africa is geographical region extending from Atlantic Ocean on the west to the Chad Lake on the east. Geographically, it is mostly a plateau with several highlands areas exceeding 1000 meters above see. Five mayor rivers systems flow through region - Senegal, Gambia, and Volta rivers, rivers around Chad lake and river Niger.

The biggest problem in African is a production of food. Partly it is governmental fault as their control and bans discouraged many businessmen. Government hold the price for the private products low, transport network wane and industrial goods less available and more expensive. Therefore, agriculture is an important issue in African Countries.

Agriculture still holds a dominant position in terms of job and wealth creation. Apart from oil producing countries like Nigeria, Cote d´Ivoire more than half of population works in agricultural business. In Burkina Faso 85% of labours worked in agriculture. Number of new workers coming into agribusiness in is still growing in comparison to rest of the world. National economy of West African countries is strongly related to agriculture.

Therefore, the thesis analyses the situation in agriculture in those countries with focus on Ghana, Nigeria, and Togo. Theoretical defines the current state of knowledge in the field of African agriculture with the overlap to its history and development. Practical part searches for the factors that influence the crop production the most using linear regression models. The recommendations are formulated based on the findings.

2 Objectives and Methodology

2.1 Objectives

The main aim of the bachelor thesis is to analyse the situation of agriculture in selected West African countries with regards to their economic growth and evaluation of factors that influence its situation. To achieve this main aim of the thesis, there are several sub-objectives:

1. To describe, compare and analyse the agriculture of selected countries in West Africa. Particularly are chosen Nigeria, Ghana, and Togo. The reason why they were selected is that despite each country have different economic situation the position of agriculture in their national economy is similar and very important.

2. To find the determinants that affect agricultural crop production in particular country.

2.2 Methodology

This thesis is divided into three parts. The first part is a theoretical one and is based on literature review. It defines the current state of knowledge in the field of African agriculture with the overlap to its history and development. From various publicly available resources and databases are taken data about the agriculture in the West African countries. The research uses secondary sources of information (UN, UNCTAF, FAOSTAT, The World Bank etc.).

The second part rely on the theoretical part and it is the key component of the thesis. The practical part uses theoretical information from literature review and tries to find the determinants that affect agricultural production in Nigeria, Ghana, and Togo.

Mainly are used quantitative methods, particularly linear regression models for each country and crop. Explained variable is particular type of agricultural production (in tonnes) and explanatory variables (the determinants) are average year temperature (in °C), average year rainfall (in mm), total annual usage of fertilizers (in tonnes), area harvested (in ha), total annual usage of pesticides (in tonnes), total usage of machinery (in pieces), yield of a crop (in tonnes/ha).

Firstly, is determined agricultural production as a whole than production of particular crops. Selected crops are rice, cereals (sorghum, millet, maize), cassava, cocoa, palm fruit, yams, and plantains because they are the most frequented in West Africa.

For estimation of linear regression model is used least squares method. This method tries to minimize the sum of the errors made in the result to obtain equation. This method gives the best, unbiased and consistent estimates of parameters of the model, when following requirements are met:

1. Specification requirements:
   - not neglecting the essential explanatory variables;
   - not including irrelevant explanatory variables;
   - selecting the correct functional form of the model;
   - stable estimated parameters, time invariant;
   - respecting the simultaneity of relationships between variables.
2. assumptions about the random component:
   - zero mean of residues;
   - homoscedasticity (variance is constant and finite);
   - absence of autocorrelation of residues;
   - independent variables are non-random and fixed in repeating files;
   - no perfect multicollinearity;
   - normal distribution of the random component.

Essence of the method is to find the parameters that minimize the sum of squared deviations of theoretical values ($\hat{y}$) of the response variables from their actual values (y): $\min \sum_{t=1}^{n} (y_t - \hat{y}_t)^2$, where *t* represents time.

Statistical significance of the structural parameters is tested by t-test. Test criterion is calculated as the division of the value of parameter in absolute terms (γ) by standard error (S_{bi}): $t - value = \frac{|\gamma_{it}|}{S_{bi}}$. Calculating the parameter and then comparing the *t*-value with a tabulated value at the selected significance level (0.05) with regard to the degrees of freedom it can be determined if the parameter is statistically significant. (Čechura, 2013)

Significance of the model as a whole is determined by F-test. If compared significance of F with significant level it can be determined if the parameter is significant. Calculating the parameter and then compare it with a tabulated value at the selected significance level (0.05) with regard to the degrees of freedom it can be determined if the model is statistically significant. Also for determining significance of model can be used p-value and compare it to the significance level.

R^2 is coefficient of determinacy. Explains how much variability in explained variable is explained by the variability in explanatory variables, i.e. how good is the fit of the model. It can be expressed in percentage on the scale from 0 to 100%. The higher it is the better is the fit of the model. It is calculated as the division of the variance of theoretical values ($s_{\hat{y}}^2$) by total variance (s_y^2): $R^2 = \frac{s_{\hat{y}}^2}{S_y^2}$. (Čechura, 2013)

Correlation analysis is also conducted. Correlation coefficient express the strength and direction of the dependency between gross value of agriculture and total gross domestic product in Nigeria, Ghana, and Togo.

Correlation is mutual linear relation between variables *x* and *y*. Degree of correlation express the correlation coefficient which has values from -1 to 1. Value of correlation coefficient -1 denotes fully indirect dependency. Correlation coefficient +1 indicates direct relationship. If it is 0 there is no correlation between variables. (Čechura,2013)

Final part concludes based on the synthesis of the results of previous parts. And results of the thesis are compared and discussed with the studies of other authors.

3 Literature Review

Theoretical part firstly describes the geographical and economic situation in West African countries. Then is describe the situation in agriculture and its challenges. At the end, there are presented the results of researches in agriculture of West African countries.

3.1 Geographic description

West Africa is geographical region extending from Atlantic Ocean on the west to the Chad Lake on the east. It lies between latitudes 4°N and 28°N and longitudes 15°E and 16°W. According to Encyclopaedia Britannica region comprise of countries Benin, Burkina Faso, Cameroon, Cabo Verde, Chad, Côte d'Ivoire, Equatorial Guinea, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra Leone, and Togo (Encyclopædia Britannica, 2016). United Nations' definition of West Africa does not contain Chad and it adds Island of Saint Helena and British oversees territory. (United Nations, 2016)

Figure 1 – Map of West Africa

Source: United Nations, 2016

Geographically, Western Africa is mostly a plateau with several highlands areas exceeding 1000 meters above see. It is mainly Guinea Highlands, Sierra Leone Mountains, Nimba Mountains, Mandara Mountains, Adamawa Highlands, and Plateau of Djado in Niger. The highest point in the region is Dimlang in Nigeria. It is 2042 meters above see. Five mayor rivers systems flow through region. The first group of rivers stems in the Fouta Mountains and flow into Atlantic Ocean. The second is longer river system that flow southward into Gulf of Guinea. The third system forms Senegal, Gambia, and Volta rivers. (Školní atlas světa, 2007)

In human geography, Africa is distinctive but not so differentiated. Almost all countries are ethnically diverse. According to Collier (2006) results of ethnic diversity is that democracy is more important for economic performance and the domain of the public sector should be kept small and decentralized.

3.2 Historical development

Original West Africa was sparsely populated. When people discover agriculture and iron, the population started to grow. Tribes from North Africa moved to the South with desiccation of Sahara. They choose places with good and sustainable conditions for agriculture. For example settlement in Middle Niger or in the mountains above flood area south of Chad Lake.

Main problem was famine. Every seventy years there was a huge famine that killed third to half of population. The cause could be a locust, torrential rains or war. The most frequent cause was a drought. The hardest crisis was in 17th century. Many people sell themselves into slavery to have something to eat. (Iliffe, 2001)

Spread of agriculture throughout the region can be explained by a climate-culture mechanism. Study by Ozainne S et al. (2014) that first agro-pastoralists adapted to conditions in southern Sahara and developed new ways for exploiting resources. Both herding and pearl mille cultivation led to a rapid expansion of agriculture in savannahs.

3.2.1 Economic changes 1918-1950

Main invention that drove economy was car. With growing infrastructure and growing numbers of Lorries the transport of products was easier and cheaper. With this donkey and camels could be replaced and peanuts could be transport from remoter villages.

Farmers could expend their fields especially when the price for their crops were high. Initiative businessmen created new areas for crops for export: Cocoa in Gabon, cocoa and coffee in Cote d´Ivoire. (Illife et al., 2001)

3.2.2 Independent Africa

Three main power cause change in African history. First was population growth which was caused by progress in medicine with high birth-rate. Second power was nationalism and independent movement. Third was wish for political harmony, economic growth or just survivor in discomfort.

After 1960 most of the colonies gained independence and that raised hope for better future. Unfortunately, new leader did not image higher wages but development plans and bureaucracy like in socialist world. (Illife et al., 2001)

Economic growth could be divided into three branches before the decline in 1970s. First was continuation of production traditional crops like cocoa in Cote d´Ivoire or coffee in Ghana. Second was mining mineral resources. Bauxite was mined in Ghana, iron ore in Liberia, and phosphates in Togo, and petroleum in Nigeria. Third branch was industry.
After the 1970 these small accomplishments reversed into crisis. One was rapid population growth. Money that other way went to industry now went food and housing for new citizens. Other was change in global economy. Many countries borrowed money that now they were not able to pay. The African debt went up four times.

The saddest story has Nigeria. In 1958 Nigeria started mining the petroleum, which brought money and investments. However, this overvalue Nigerian currency so export collapsed and cheap products from outside destroyed domestic industry. When the price for petroleum went down the economy in Nigeria was in disastrous condition which continued to the next decades. (Klíma, 2003*)*

The biggest issue in African crises in 20th century was about production of food. Partly it was governmental fault. Their control and bans discouraged many businessmen. Government hold the price for the private products low, transport network wane and industrial goods were less available and more expensive.

3.3 West African economies

African GDP ranks always the lowest in the world. As seen in table 3 countries of West Africa had average GDP per capita in the year 2015 around 1349 US$. This number is highly affected by highest GDP of Nigeria around 2640 US$ which is given by high production of oil. Non-oil producing countries like Ghana and Cote d'Ivoire had also a high GDP per capita because of cocoa and coffee production. Rest of the countries have GDP per capita under 1000 US$ when Togo has only 547.97 US$ per capita. (The World Bank, 2016)

Overall economic situation in West Africa has improved markedly. During 1990s the growth varied in the region while Cape Verde, Ghana, Burkina Faso, Nigeria, and Mali experienced regular 2-3% annual growth, other countries stagnated or had negative growth due to conflicts, and poor governance. Growth was accompanied with unequal distribution of wealth, widening gaps between norther and southern parts.

Table 1 – GDP per capita in West Africa in US$

	1960	2011	2012	2013	2014	2015
Benin	93.02	799.04	807.69	882.64	903.46	779.07
Burkina Faso	68.42	665.81	673.03	709.07	713.46	613.04
Cote d'Ivoire	157.19	1231.87	1281.38	1447.22	1545.94	1398.69
Ghana	182.98	1587.19	1641.83	1827.10	1441.64	1381.41
Guinea	-	447.79	487.35	521.54	539.62	531.32
The Gambia	-	516.98	504.99	484.11	441.29	-
Guinea-Bissau	-	660.59	580.64	584.28	615.94	573.03
Liberia	170.04	378.81	414.19	453.34	457.86	455.87
Mali	-	829.85	772.25	798.32	842.11	744.35
Niger	132.40	378.20	393.64	417.67	431.38	358.96
Nigeria	92.81	2514.15	2739.85	2979.84	3203.24	2640.29
Senegal	249.51	1081.13	1019.27	1051.38	1067.13	910.79
Sierra Leone	147.60	505.26	637.65	802.54	792.58	693.41
Togo	76.64	572.03	573.21	589.01	630.00	547.97

Source: The World Bank, 2016

If looked at the annual growth (see table 2) it can be seen that it is fluctuated in most of the countries. Togo in 2013 had a remarkable 17.84 % GDP annual growth but two years later it went down by 22%. (The World Bank, 2016)

Table 2 – GDP annual growth in West Africa in %

	1961	2011	2012	2013	2014	2015
Benin	3.41	2.96	4.81	7.19	6.35	2.09
Burkina Faso	1.70	0.12	1.83	4.06	3.76	2.52
Cote d'Ivoire	2.66	3.38	3.35	0.65	1.06	1.01
Ghana	6.05	-6.58	8.09	6.59	5.93	5.84
Guinea	0.20	11.25	6.66	4.77	1.57	1.52
The Gambia	-	1.12	1.15	-0.44	-2.27	-2.54
Guinea-Bissau	-	-7.40	2.46	1.43	-2.33	-
Liberia	-	6.77	-4.15	-1.62	0.07	2.31
Mali	0.24	4.98	5.14	6.08	-1.65	-2.08
Niger	-	4.50	7.95	3.92	4.67	4.47
Nigeria	1.60	-1.64	7.44	1.12	2.82	-0.48
Senegal	-1.83	2.10	1.51	2.60	3.52	-0.01
Sierra Leone	0.22	-1.29	1.21	0.28	1.10	3.27
Togo	0.50	3.88	12.49	17.84	2.33	-22.00

Source: The World Bank, 2016

Agriculture account for average 30% of West African GDP. Highest percentage has Mali, Burkina Faso and Liberia. On contrary Nigeria, Niger, and Senegal has the lowest rate because of bigger industry. Industry make around 20% of GDP and services make 50% of GDP. (The World Bank, 2017)

Agriculture still holds a dominant position in terms of job and wealth creation. Apart from oil producing countries like Nigeria, Cote d´Ivoire more than half of population works in agricultural business. In Burkina Faso 85% of labours worked in agriculture. Number of new workers coming into agribusiness in is still growing in comparison to rest of the world. (Food and Agricultural Organization (FAO), 2016)

Child labour, forbidden in Europe, is still necessary in Africa. Many underage people work to help family situation. More than half of working children are operating in sector that directly endanger their health and safety. Study by Dwibedi and Chaudhun (2014) analysis child labour problem and found out that against popular believe if conditions of the poorest families would be improved, child labour would not be mitigated. Price subsidy policy affects the child labour problem only through the supply side and it cannot deliver the good. These policy alleviate the child labour problem only at cost of welfare of the poorer working families.

3.4 Agriculture

The chapter describes the agriculture in West African countries. Firstly, there are presented natural conditions (climate, soil, and water) and then usage of fertilizers, pesticides and machinery in agriculture. Separate chapters are devoted to agricultural trade and challenges for the development of the agriculture and food security.

3.4.1 Agricultural development

Agro-industry is vital sector for West Africa. This makes economy fragile and vulnerable to external factors. Agriculture in Africa increase with steadily rate and below but comparable to Asia growth. However, the growth is extensive type, they do not use modern science and technology, they only use more land and labour force. In 1960s Africa was self-sufficient since then population double, agriculture cannot support it and they must import the cereals. Import is 1.7 times the value of export. (FAO, 2016)

Around 42% of population works in the agriculture sector but it declined in last years. There are mostly family farms in West African agriculture. More than 80% of farms (33 million) has less than 2 hectares of land. However, family farming is under thread. It is not able to replenish soil fertility and investments are given to overseas groups more easily than to locals. Yet family farming is the best solution. It optimized labour and land use while reducing the risk of breaching rules. (Mills, 2015*)*

The contribution of women to labour in African crop production is around 40%. Research by Palacios-Lopez, Christiaensen and Kilic (2016) studies this topic. They suggest that there are no systematic differences across crops. However, it is higher in households where women are educated or owns a large share of land.

In other parts of the world mechanization was implement into harvesting. But that's not the case in Africa. It has been only partial improvement in West Africa considering improvement of labour use. Unreliable electrical supplies limit the implementation of modern machine. Electricity is expensive and even more when they need to buy generators to operate their plants at capacity. Bigger production is achieved by producing more, using more resources and not by improving quality of production. (Gordon, 2007)

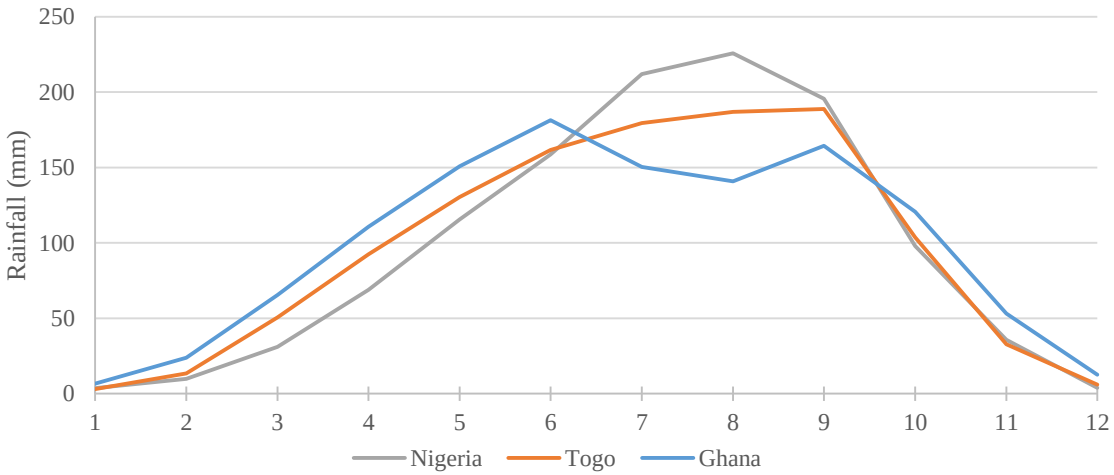
West Africa experienced a period of sustained growth that surpassed that of many Asian countries. Combination of higher labour productivity, higher yields and an expansion of the land area, all contributed to that growth.

Conservation agriculture (CA) is increasingly promoted in Africa. It answers the need to increase food production. Corbeels et al. (2014) studd the reasons for the limited adoption of CA and where it works the best. The lack of an immediate increase in income explains why the CA is no adapted in many cases. Another key factor is the fact that crop harvest residues are used as fodder for livestock, and not as soil cover. Main problem in implementing the CA according to the paper is that future benefits often do not compensate for immediate needs.

3.4.2 Climate

West Africa has wet and dry seasons resulting from two migrating air masses interacting there. The first, hot and dry tropical air mass, blows from the Sahara from November to February, when maximum occurs in January. The second, moisture-laden, produces southwest winds. The maximum of this wet air mass is in July. Where these two air masses meet is a belt of variable width and stability called Intertropical Convergence Zone (ITCZ). The migration of this ITCZ, which follows movement of the Sun, controls the climate of the region. (*Školní atlas světa*, 2007)

Figure 2 – Average monthly rainfall



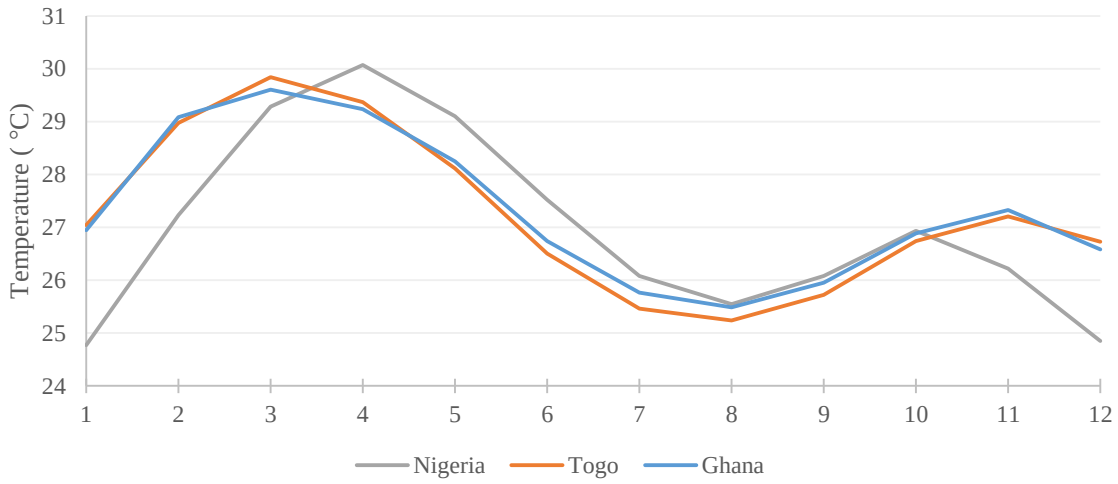
Source: Own elaboration, based on data from Climate Change Knowledge portal, 2016

West Africa's precipitation regime is characterized by latitudinal belts of decreasing rainfall and wet season length. At the Gulf of Guinea years are without marked dry season. At higher latitude, the wet seasons are shorter and precipitation decreases. The lowland climates of West Africa are characterized by high sunshine and high temperatures

throughout the year, annual temperature are usually above 18 °C. Not only scarcity of rainfall but also its unpredictability becomes more significant with latitude. Rainfall variability ranges form 10-20% in the coastal areas to over 40% in the northern Sahel. (FAO, 1983) Average monthly rainfall in examined West African countries can be seen at figure 2. The highest is in August in Nigeria, in September in Togo and in June in Ghana.

Drought is a recurring phenomenon in West Africa. A few heavy rainfall years are balanced out by a large number of below-average rainfall years. From the late 1960s to 1980s, the Sahel zone experience droughts. These droughts forced the abandonment of agriculture, triggered a famine crisis and has been blamed for widespread environment degradation in the region. Temperatures over West Africa have increased over the last 50 years. It is unpredictable how global warming will affect West Africa. It is certain that temperature will increases but its effects are unknown. Some models predict dry future, other a wetter future, and other no significant change in rainfall. (Earth Resources Observation and Science Centre (EROS), 2016) Average monthly temperature is the highest in April and the lowest in August. Another peak of higher temperature is in October in Nigeria and in November in Togo and Ghana (see figure 3).

Figure 3 – Average monthly temperature



Source: Own elaboration, based on data from Climate Change Knowledge Portal, 2016

Nigeria

Nigeria can be divided into four horizontal stripes each with different type of climate. On the North small part of Nigeria has warm desert climate. Next down south is warm semi-

arid climate, biggest part has Monsoon climate and small part on the south has tropical savanna climate. (Wikipedia, 2016)

Average temperature during the year is maximum in March and April, and lowest in August. The difference between highest and lowest temperature is only 7 °C. Overall average temperature grows where in 1960s the average temperature was around 26.6 °C. However, in 2000s the average temperature rose to 27.4 °C. (The Climate change Knowledge Portal, 2016)

Rainfall during the year changes. The maximum rainfall is in July during monsoon season, lowest is in December and January when there is almost no precipitation at all. From 1960s the average rainfall stays the same around 100 mm.

Ghana

Ghana can be divided into two parts according to the Köppen climate classification. The most part is covered by Tropical savanna and only small part on the coast has Monsoon climate. (Wikipedia, 2016)

Average sun hours during the year is high. 200 hours per month counts on average 5-6.6 hours of sunshine during the day. In the period from May to September average hours of sunshine decline to 3 hours per day. Percentage of sunny to cloudy days are in period from September to May more than 50%. Rest of the year the percentage of sunny days are less than 30%. Ghana.

The average temperature is higher than in Nigeria with highest temperature in March and lowest in August. During 1970s Ghana experienced lower temperature. For last 20 years' average temperature stays relatively the same.

The rainfall seasons is the same like in Nigeria. Rainy seasons starts in April and ends in October. Rest of the years sees almost none of the rain. Average precipitation is higher than in Nigeria around 180 mm of rainfall. (The Climate change Knowledge Portal, 2016)

Ghana's average sunlight hours is minimum 4 hours and maximum 8 hours per day. Percentage of sunny daylight hours is up to 80% in the winter months and 40% in the summer months.

Togo

Togo has only one climate of tropical savanna. Average temperature is relatively same as in Ghana. It has the same fluctuation of temperature as there. Togo experience decade of higher temperature in 1980s. After that average temperature stay the same around 27.5 °C. (Wikipedia, 2016)

Togo has more rainfall than any other country around them, with maximum 200 mm. It has two rain season, one from March to July, and second in September and October. The average rainfall stays the same throughout the years. (The Climate change Knowledge Portal, 2016)

Togo has more sunshine than rest of those three countries. Average sunlight per day is during winter months 7-8 hours per day, during summer months around 4 hours per day. Togo has also more percentage of sunny hours in winter time 60% in summer time 40%.

Prediction

For the period 2020–2039 many models were conducted on how the average temperature will rise. Some models are predicting that global warming will have great effect in Africa and predict rise of temperature by 2 °C. Some are more rational and predict rising only by 0.2 °C or none at all. (Climate Change Knowledge portal, 2016)

Changes resulting from higher temperatures and less rain fall as a result of climate change can cause regional water endowments and soil moisture that "will affect the productivity of crop land, leading to changes in food production and international trade patterns. High population growth elsewhere in Africa and Asia will put further pressure on natural resources and food security." (Calzadilla et al., 2014).

Roudier et al. (2011) assessed the potential impact of climate change on yields, and analysed the sources of climate change that can have the most negative impact. They found out that the worst impact comes "mainly from the temperature whose increase projected by climate models is much larger relative to precipitation change. However, rainfall changes, still uncertain in climate projections, have the potential to exacerbate or mitigate this impact depending on whether rainfall decreases or increases. Finally, results highlight the pivotal role that the carbon fertilization effect may have on the sign and amplitude of change in crop yields." (Roudier et al., 2011).

3.4.3 Soil

Much of West Africa is composed of ancient crystalline rocks which are resistant to erosion and weathering. These rocks form the highlands of Guinea, Adamawa and Atakora.

With few exceptions, the soils of West Africa are highly weathered but with low fertility. The main soil groups consist of Alfisols, Ultisols, and Oxisols. The Alfisols are coarse to medium textured soils overlying clayey subsoil they are formed in well-drained upland areas. The Ultisols are coarse to medium-textured acid soils with clayey subsoils with base saturation less than 50 percent Oxisols are strongly weathered fine or coarse textured soils. They cover large areas in southern Ghana, Benin and Nigeria. (FAO Soil Portal, 2016]

Table 2 – Productivity potential of soils

Soil Productivity grade	FAO Productivity Classes	Area (% of total)
High (1)		-
Good (2)	Fluvisols, Gleysols, Regosols	5.52
Medium (3)	Lixisols, Cambisols, Nitosols	46.45
Low (4)	Acrisols, Ferrasols, Alisols	31.72
Low (5)	Arenosols, Nitosols	16.32

Source: FAO Soil Portal, 2016

As seen in table 3 only 5% of soil has good fertility and good productivity grade. (Poch, 2008) Almost half of the soils are in last to categories of productivity grades. This creates a necessity for usage of fertilizers for higher yield. Every year the soil is exposed to the monsoons which degrades the soil and wash out the already low number of nutrients that the soil has. (FAO, 2016)

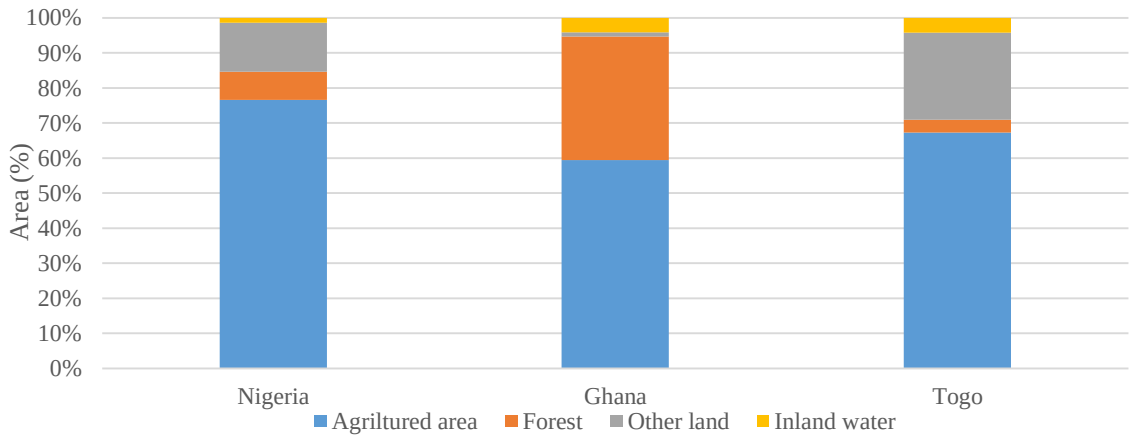
3.4.4 Water

The most water for the plants comes from natural resources. Therefore, rainfall is significant in production as it was discussed in climate chapter. Other resource is inland water. Division of the land can be seen at figure 4 (FAO, 2017)

The worst water situation has Nigeria out of 910 770 km^2 only 13 000 km^2 is occupied by water which makes only 1% of total area. In Togo, it is 2 400 km^2 out of 54 930 km^2 (4%). And in Ghana it is 11 000 km^2 out of 227 540 km^2 (5%). Which is not something unique Czech Republic has only 2% of inland water. However, in Czech Republic they use

irrigation which is none existing in West Africa. Maximum irrigated agricultural land there is 0.03%. (The World Bank, 2017)

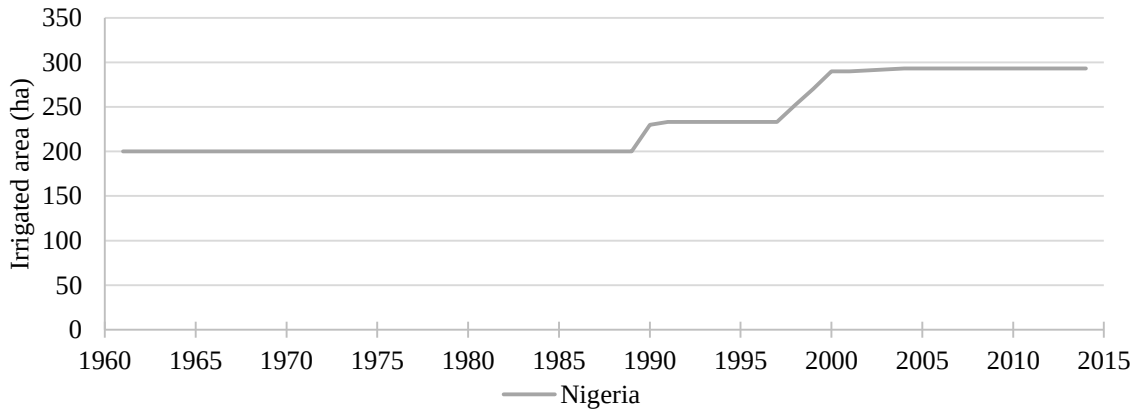
Figure 4 – Division of land in Nigeria, Ghana, Togo



Source: Own elaboration, based on data from FAO, 2017

In the figure 5, it can be seen, that total irrigated land stays the same in all three countries. There is a "jump" every few years. That shows that irrigation is done on small scale, only one farm at the time, and not enough attention is given by the government for better investments in this field. The total irrigated area in Nigeria increased from 200 hectares in 1960 to almost 300 hectares in 2015.

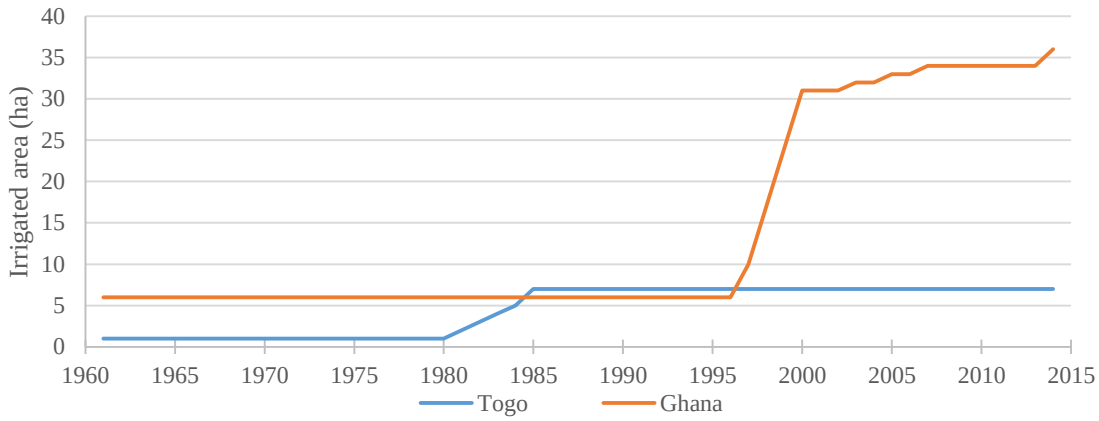
Figure 5 – Total irrigated area in Nigeria



Source: Own elaboration, based on data from the World Bank, 2016

Situation in Ghana and Togo is different (see figure 6) as their total irrigated area is much lower – only 7 hectares in Togo and 36 hectares in Ghana in 2015.

Figure 6 – Total irrigated land in Ghana and Togo



Source: Own elaboration, based on data from the World Bank, 2016

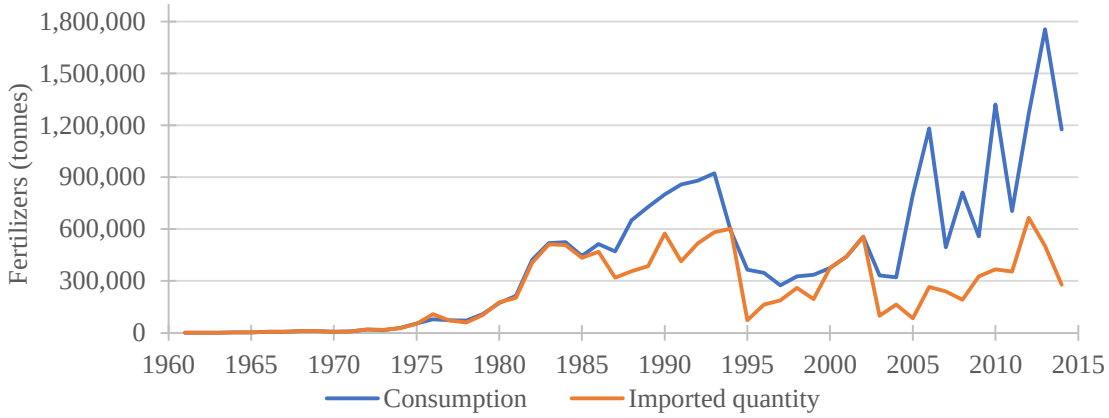
3.4.5 Fertilizers

Fertilizers are beside improved seeds the most important inputs that enhance agricultural productivity in African countries.

"Fertilizers are organic or inorganic substances containing chemical elements that improve the growth of plants and the fertility of the soil. The percentage content of nutrients in organic fertilizers (manures) is relatively low. In inorganic or mineral fertilizers, the nutrients are inorganic salts, obtained by extraction and/or physical and chemical processes. The three primary plant nutrients are nitrogen, phosphorus and potassium" (*Glossary of Environment Statistics, Studies in Methods*, 1997). Inorganic fertilizers are most common with varying proportion of NPK. (Nitrogen, Phosphorus, Potassium) In Africa use of fertilizer is the lowest especially in West Africa which is the lowest in the whole continent. (see figures 7, 8 and 9).

Usage of fertilizers are still in development. Almost all the fertilizers that are used must be imported into countries. That makes them very expensive and hard to spread inland. The most used fertilizers are ones containing ammonium than nitrogen fertilizer, potash fertilizers and phosphate fertilizers. So they have all the main nutrient (Nitrogen, Phosphate, and Potassium) fertilizers available but not in great amount.

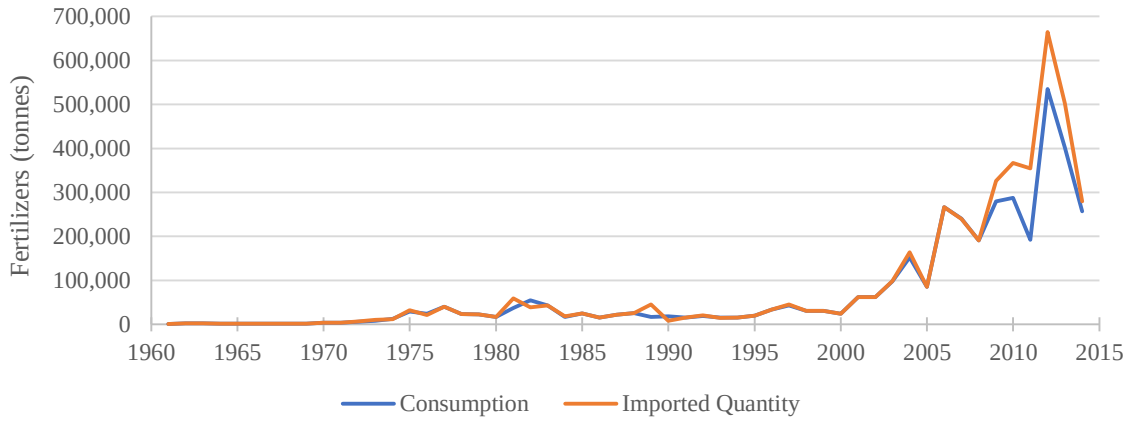
Figure 7 – Annual usage of fertilizers in Nigeria



Source: Own elaboration, based on data from Word Bank, 2016

As seen in figure 7, the consumption of fertilizers in Nigeria used to be equal to imported quantity. And in Ghana and Togo the situation is still the same till today.
Since 1986 Nigeria started to produce their own fertilizers. The production as always is not very stable. There was a maximum in 1992 and since then it went down a lot. In the period 2000-2008 there are no data available to determine how big the production was.

Figure 8 – Annual usage of fertilizers in Ghana

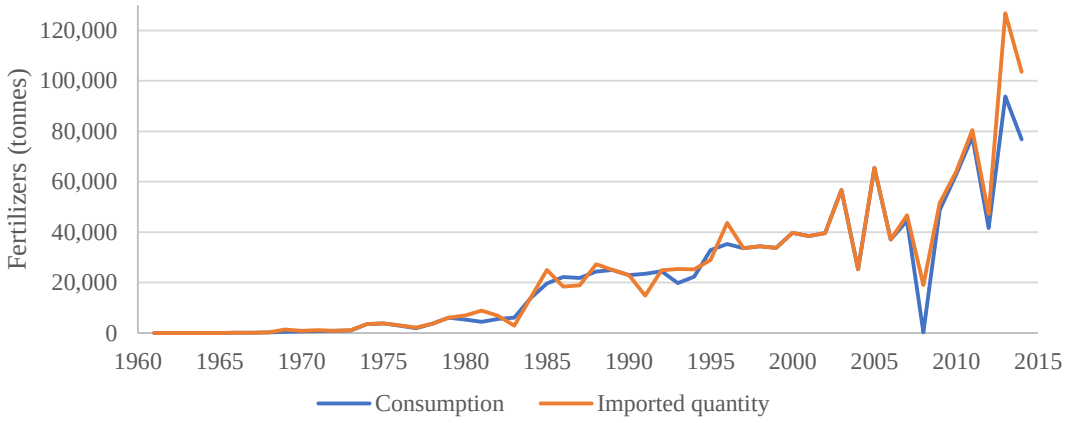


Source: Own elaboration, based on data from Word Bank, 2016

Ghana and Togo have similar conditions as can be observed from figure 8 and 9. They both import more than it is used. That is a great problem that have many causes. The main one is price of the fertilizers. Not all the farmers are able to pay for it and they rather use faeces as fertilizers. Price for 1 kg of fertilizers in Nigeria was the lowest around 13 Nigerian Niara, in Ghana was on average around 3000 Ghana's Cedi, and in Togo around

330 CFA franks. If converted to US$ the price for fertilizers in Nigeria is 40 $ per tonne, in Ghana 67 $ per tonne and 530 $ in Togo using exchange rate on 22. 2. 2017 using site http://mataf.net.

Figure 9 – Annual usage of fertilizers in Togo



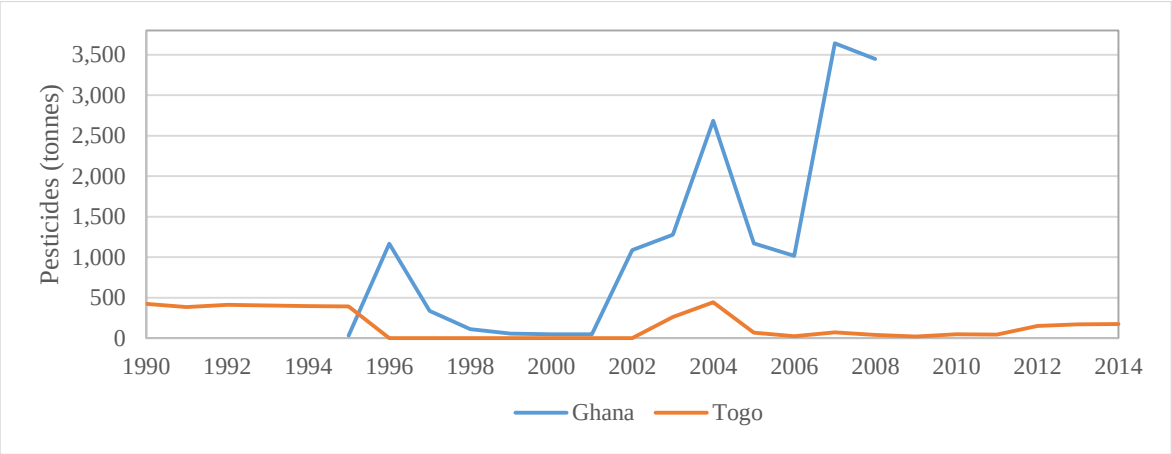
Source: Own elaboration, based on data from the World Bank, 2016

3.4.6 Pesticides

Pesticides are "any substance or mixture of substances that is used to prevent, destroy or control pests – including human or animal disease". (*Glossary of Environment Statistics, Studies in Methods*, 1997). They are divided into herbicide, insecticide, fungicide and rodenticide. Potential threat to the environment is usage of insecticide chlorinated hydrocarbons like DDT (Dichlorodiphenyltrichloroethane) which is forbidden to use in most of the countries but because it is cheap protection against malaria it is still used there. Not many data are available for determine how much pesticides are used in those three countries. Only data available is for Ghana and Togo in period from 1990–2014. From the data in figure 10 it is shown that the most used pesticides are insecticide, as expected, then herbicides.

Overall pesticide usage in Togo went down in the period from 1997–2002 where are no records of usage of pesticides. Since 2012 there was a small growth. Better situation is in Ghana they have bigger usage of pesticides however not very stable. That is given by price of pesticides and it availability to local farmers. Plant breeding is important role in boosting productivity. Adapting plants to local conditions and making them more resilient to insects, diseases, viruses, droughts, or floods.

Figure 10 – Annual usage of pesticides

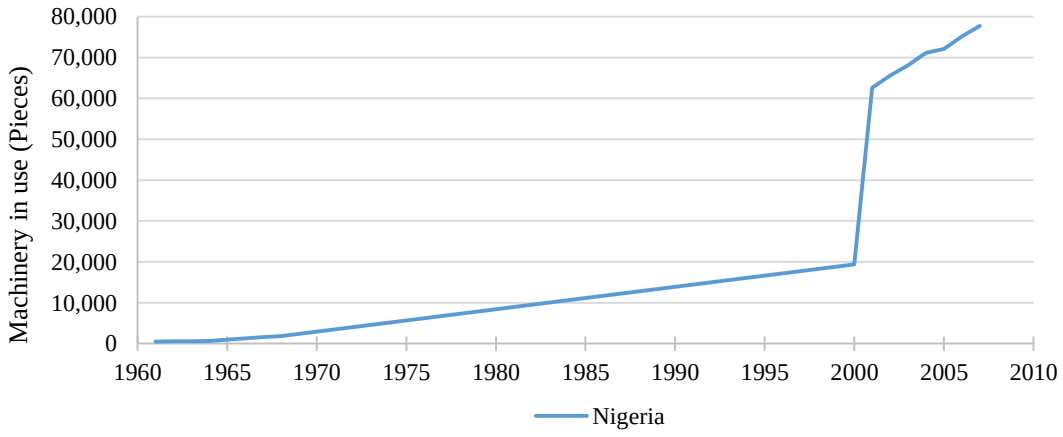


Source: Own elaboration, based on data from the World Bank, 2016

3.4.7 Machinery

Technology and machinery that are ordinarily used in Europe is not so common in West Africa. Many farmers are family farms and they do not have much credit to buy and take care of complicated machinery. Based on the data available the most common machine is tractor than they have some ploughs. The best situation has Nigeria where they have tractors, combine harvesters, few milking machines, and ploughs. Total annual machinery in use in Nigeria is displayed at figure 11.

Figure 11 – Total annual machinery in use in Nigeria

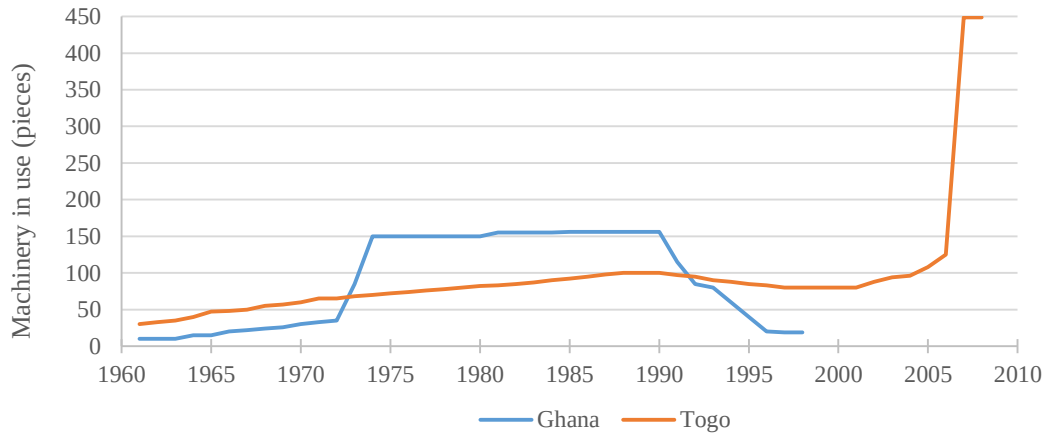


Source: Own elaboration, based on data from FAO, 2017

Total annual machinery in use in Ghana and Togo can be seen at figure 12. data for Ghana are not available since 1998. Both Togo and Nigeria experience a massive growth in

number of machinery in use since 2000. However, this trend in Togo stopped in 2006, in Nigeria the trend will increase but probably with different rate. On the other side is Ghana where it is proven that is more important to have money for care after purchase than purchase itself. During period 1971–1990 the number of machinery stayed the same. However, as tractors were getting older, the number of tractors declined and they have not been replaced.

Figure 12 – Total annual machinery in use in Ghana and Togo



Source: Own elaboration, based on data from FAO, 2017

3.5 Agricultural trade

Agricultural products are primary traded on national markets. Only Cote d´Ivoire or Ghana create have crops (cocoa and coffee) that export outside the continent. All African countries are net importers of agricultural products especially from EU.

Regional trade in Africa is small only 17% of trade is conducted between regions. Trade include wide range of products but only 10 of them (tobacco, beverages etc.) account for half of trade, valued at 10 billion dollars. Cereal trade is important for West Africa. Market, taxes monetary fragmentation limits the development potential. These barriers affect price instability and food insecurity.

Export of agricultural products has fallen to half since 1990s. It is composed of small number of products: cocoa (70% of all export), coffee, tea, cotton, sugar, fish, and exotic fruits like banana and pineapple. Most of the products are unprocessed, processing is done in importing countries mostly. (Mills, 2015*)* Continent has no influence on international prices with one exception which is cocoa.

Cross-border trade between West African countries impose significant transaction cost. Research on cross-border trade between Nigeria and Niger conducted by Aker and col. (2014) suggest that ethnicity plays an important role in trade in agricultural goods. Their research shows that political maps are important for the spatial geography of prices.

Undeveloped transport network creates another barrier for developing competing market. Worse situation is in landlocked countries like Niger with no access to ports. And even if there is road network most of it is not paved. Stone and sand paths destroys vehicles which heighten the price. It also undermines the competitiveness of export from West Africa. Increase in investment into transportation could help improve the competitiveness of agriculture.

Import represent 1.7 times the value of export that compete with local products. Trade balance over last 10 years decreased mainly because higher demand and rise of food prices. On the other hand, West Africa increased export in last years but there was a corresponding import increase so in the end they are in deficit situation. On the other hand, net trade of fruits and vegetables is positive, also net trade of coffee, tea, cocoa and spices is positive. Reason is simple, these products cannot be grown in Euro Atlantic world and needs to be imported. (*Agricultural Growth in West Africa: Market and Policy drivers*, 2015)

Economic and trade globalization accelerated the regional trade integration process. Unfortunately, Africa is still the least integrated continent in the world. (Mills, 2014)

3.6 Challenges for agricultural growth

There are several challenges for agricultural growth in examined countries. First is environmental as many of resources used in harvesting is non-renewable when the resources are use up there is no replacement and it is expensive. Also region remains vulnerable to natural disasters and human diseases, for example recent Ebola crisis.

Then there are political challenges. West Africa is not the most stable region in Africa. Many civil wars which were fought there, left the area damage. The market is not able to keep up with demand growth. As a result, it lost competitiveness for many products. Majority of value chains in agro-industry is uncoordinated and has limited trust among market actors. Also competition is increasing.

Challenges in investments is that there is small probability of return of investment. Government and private sector mistrust each other, government remains to control the sector

which limits private investments. Lastly there are human threats such as epidemic diseases. (Mills, 2015)

3.7 Food security

Africa is the only continent that despite significant progress in farming, has the biggest number of malnourished people. The situation varies in different areas, East Africa is the most affected, but Ghana made progress in recent years regarding economical and agricultural growth.

Hunger is more a rural phenomenon. Households buy food supplies from markets that are unstable. During poor harvest the price for food is higher and many people cannot afford it. Price also varies according to seasons. During the time of harvest prices are lowest but the longer period since harvest higher the prices. The instability has the highest impact on household which totally depend on market like pastoralist in Sahel.

Malnutrition has the biggest impact on young children and women. Women and children get the worse food because the better is kept for men. Child malnutrition has long-lasting effect on intellectual and physical capacities. Around 7-16% of cases where schoolchildren repeat a year are linked to undernourishment. The worst situation is in Nigeria, Burkina Faso, Niger, Mali, and Cote d´Ivoire. On the other hand, rate of underweight children is low in Guinea-Bissau and Senegal. (Mills, 2014*)*

Number on malnourished people in cities increases. Aplenty rural farmer while looking for better life move to the city where starve same as in the countryside.
Economical access to food has become factor in ending hunger. For poor communities' food is their main expenditure item. While destroying these inequalities and poverty the starvation could vanished.

Food insecurity in household is threatened by isolated events like loss of job or death of a family member. Political, economic, climatic problems affect whole region. Worldwide issues like food crises in 2007–2008 affects everybody, in West Africa it was worst in coastal cities.

Food quality and diversity is also important while dealing with this issue. It is important to oversee the health and safety condition regarding food preparation. In case of West Africa shows the complexity of the problem. During last 30 years per capita food production has increased with the same rate as in Asia. Nonetheless area has tremendous

rate of malnutrition children. Since 2000 crises after crises hit the region. Drought and floods, instability of markets, political instability and demographic booms eroded living condition making them vulnerable to future.

Food security is crucial in this area as food demand has been growing rapidly and changing in its composition over the past 30 years. Zhou and Staatz (2016) found out that among the patterns that emerge from an analysis of changes in per capita food availability there are certain implications for needed investments and policies regarding different commodities and components of the West African agrifood system. "Production shortfalls relative to demand for starchy staples (particularly rice and wheat) will continue to pose a major challenge", (Zhou and Staatz, 2016).

To achieve sufficient production of agricultural commodities and food security, Resnick (2010) suggests to use agricultural policies aimed at small farms. "As the experience of the 20th century has shown, implementing policies that increase agricultural productivity among smallholders is a particularly promising strategy to achieve pro-poor growth." (Resnick, 2010). Research by Laroche Dupraz and Postolle (2013 suggest that developing countries should be able to implement their food policy to protect their smallholder agriculture. Even though that means discrepancy with certain international commitments.

Productivity can be increased for example by investing to the mechanization. However, as was described in previous chapter, "while global agricultural mechanisation is on the increase, societal resistance has left its adoption stagnant in developing countries," (Adekunle, 2016). Besides, sometimes is used not optimal type of machinery that affect negatively the soil and soil organic matter. "Land clearing with heavy machinery is associated with removal of biomass from the field, while conventional ploughing and harrowing lead to soil organic matter depletion," (Ayanlaia and Sanwo, 1991). Therefore, these land management shall be modified or changed for more land-friendly practices.

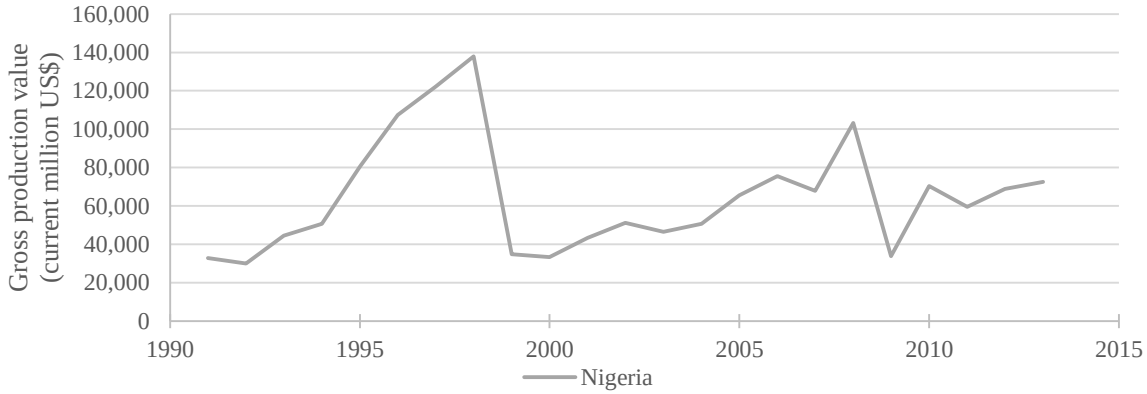
4 Practical Part

Practical part uses theoretical information from literature review and tries to find the determinants that affect agricultural production in Ghana, Nigeria, and Togo.

Agriculture is main part of money making in Nigeria, Ghana, and Togo. However, it is not stable and has a lot of places for improvements that are necessary to not only help economies in those countries but also ensure food for all its citizens.

Gross production value of all agricultural products produced since 1991 are in following graphs. In the figure 13 it is visible that value of agriculture is very volatile in Nigeria even the production is growing. This is given by price of the product which is changing depending on the domestic and foreign market situation.

Figure 13 – Gross production value of agriculture in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Gross production value of agriculture in Ghana and Togo is displayed at figure 14.

Table 4 – Correlation coefficients between gross value of agriculture and GDP

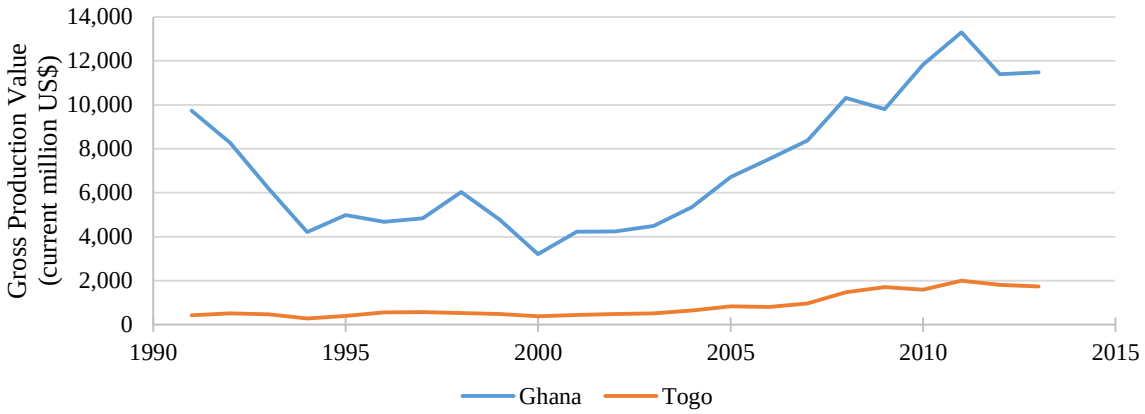
Country	Correlation Coefficient
Nigeria	0.086
Ghana	0.953
Togo	0.890

Source: Own elaboration, based on data from the World Bank and FAO, 2017

Conducting correlation analysis between gross value of agriculture and gross domestic product (GDP) of each country revealed that there are two trends. One trend is in

Nigeria where the value is 0.086. This low value indicates that there is only small positive relation between these two variables

Figure 14 – Gross production value of agriculture in Ghana and Togo



Source: Own elaboration, based on data from FAO, 2017

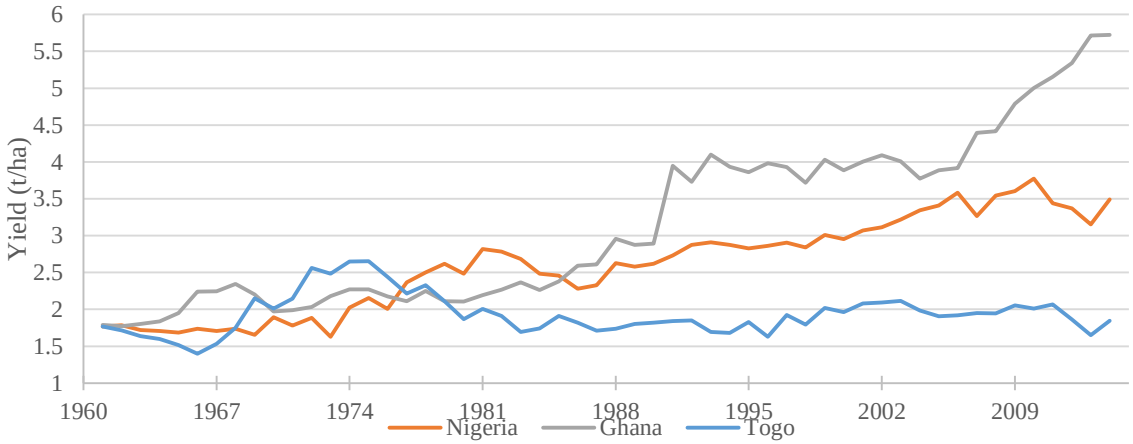
Other countries have high correlation coefficient. In Ghana the coefficient has value 0.953 which indicates strong direct relation. Same in Togo, 0.890 indicates strong direct relation. Values are displayed in table 4.

4.1 Crop production

In West Africa growth is mainly associated with expansion of harvested area, yield has not improved that much. For last 70 years total area harvested almost tripled in all three countries.

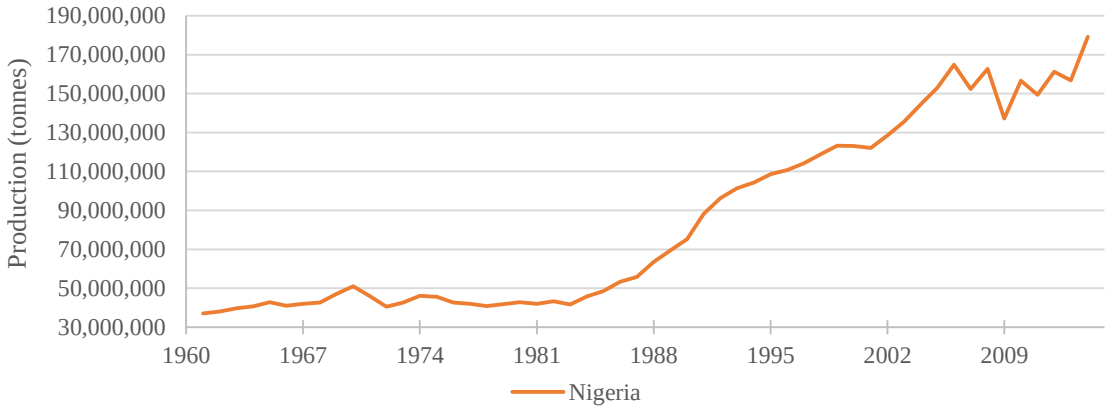
The only increasing trend in yield has Ghana which is given by high yield of pineapples, oranges and sugar cane which are higher than yield in rest of countries. On the other side there are Togo and Nigeria where the yield is stagnating. No big improvements were made since 1961. Average yield of crops is displayed at figure 13.

Figure 15 – Average annual yield (t/ha[1])



Source: Own elaboration, based on data from FAO, 2017

Figure 16 – Total annual production in Nigeria

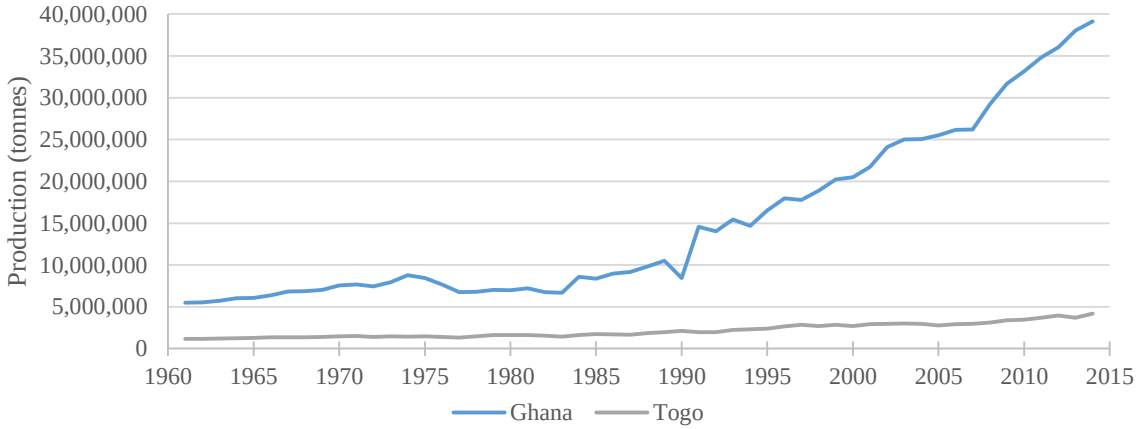


Source: Own elaboration, based on data from FAO, 2017

During the last years the total production is increasing. In Nigeria the increase stared since 80s of 20th century (see figure 16). In Ghana (see figure 17) the increase is quite dramatic and it seems to be sustainable. Togo's production in increased too however it is still insignificant compare to production in Ghana. In Nigeria the production is growing with the same rate as in Ghana.

[1] tonnes/hectare

Figure 17 – Total annual production in Ghana and Togo



Source: Own elaboration, based on data from FAO, 2017

Which factors are mostly affecting the agricultural production can be determined by linear regression model.

Table 5 – Factors affecting total agricultural production in Nigeria

y_1 - agricultural production	**Coefficient**	**Std. error**	**p-value**	**Significant**
x_1 - intercept	-330195722	83840405.30	0.00	yes
x_2 – temperature	399675.97	3120969.75	0.90	no
x_3 – rainfall	9039.70	9569.06	0.36	no
x_4 – fertilizers	13.71	2.98	0.00	yes
x_5 – area	4940.30	412.06	0.00	yes
x_6 – machinery	71.07	60.96	0.26	no
x_7 – yield	25891420.32	6469095.11	0.00	yes
F-test		195.54	0.00	yes
R^2	99.36%	**Adj. R^2**		98.73%

Source: Own elaboration, based on data from FAO, and the World Bank, 2017

The results of estimation are displayed in table 5. F-test shows that the model is statistically significant. The fit of the model is very good (99.36%). If usage of fertilizers goes up by 1 tonne the total production will go up by 13.71 tonnes. If area is increases by 1 hectare the total production will go up by 4940.3 tonnes. Lastly if yield increases by 1 t/ha the total production will increase by 25 million tonnes.

Table 6 – Factors affecting total agricultural production in Ghana

y_2 - agricultural production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-101237208.12	36836129.84	0.02	yes
x_2 – temperature	1723718.54	1396687.59	0.24	no
x_3 – rainfall	-690.20	2162.13	0.75	no
x_4 – fertilizers	3.47	3.48	0.34	no
x_5 – area	3816.58	669.59	0.00	yes
x_6 – pesticides	94.24	102.89	0.38	no
x_7 – machinery	4394.60	13983.47	0.76	no
x_8 – yield	5320907.57	826328.27	0.00	yes
F-test	143.86		0.00	yes
R^2	98.62%	Adj. R^2		97.94%

Source: Own elaboration, based on data from FAO, and the World Bank, 2017

As can be seen from table 6, in Ghana the total agricultural production is mostly influenced by area, and yield. If the area goes up by 1 hectare the production will increase by 3816.58. If the yield increases by 1 t/ha the total production goes up by 5.3 million tonnes. F- test shows that the model is statistically significant and overall fit of the model is 98.62%.

Results for Togo displayed at table 7 shows that the production is also mostly affected by area. Area increase by 1 hectare, increase total production by 1581.35. F-test shows that the model is statistically significant and fit of the model is 85.88%.

Table 7 – Factors affecting total agricultural production in Togo

y_3 - agricultural production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-6928106.14	8463071.53	0.43	no
x_2 – temperature	118622.46	306412.82	0.70	no
x_3 – rainfall	-60.24	600.54	0.92	no
x_4 – fertilizers	5.43	4.81	0.28	no
x_5 – area	1581.35	400.61	0.00	yes
x_6 – pesticides	-0.19	6.95	0.98	no
x_7 – machinery	930.60	446.99	0.06	no
x_8 – yield	379543.27	454442.31	0.42	no
F-test	12.16		0.00	yes
R^2	85.88%	Adj. R^2		78.81%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

In all three countries, the most influence has area of production as expected. Also Nigeria and Ghana have big effect of yield which is surprising base on how small it is and how small attention is devoted to it.

4.1.1 Rice production

Rice is important crop for nutrition and provide main meal for half of the population. In recent years, rice become an important crop throughout Africa. The overall trend in production is increasing but it is fluctuating. The highest production has Nigeria in terms of absolute value and in terms per capita (0.04 t/cap.[2]) – see figure 18 in appendix.

Both Togo and Ghana have the same size production even though Ghana is bigger. They have production per capita around 0.02 t/cap. The overall trend in production of rice is increasing – see figure 19 in appendix**.**

As can be observed from table 35 in appendix, rice yield since 1961 double in all three countries. In 2014 average yield was between 1.7-2.6 t/ha. Everywhere the yield is fluctuating but the best situation is in Ghana where it is somehow more stable than in the rest of them.

The results of the model that explains the factors that are influencing the rice production in Nigeria are displayed in table 8. F-test shows that model is statistically significant and fit is 85.88%. Production of rice in Nigeria is only affected by area, where if area increases by 1 hectare the production will increase by 1581.35 hectares.

[2] capita

Table 8 – Factors affecting rice production in Nigeria

y_4 – rice production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-6974711.13	11726124.39	0.56	no
x_2 – temperature	265110.95	437800.70	0.55	no
x_3 – rainfall	305.35	1378.02	0.83	no
x_4 – fertilizers	1.15	0.34	0.00	yes
x_5 – area	0.87	0.45	0.07	no
x_6 – machinery	-3.10	6.26	0.63	no
x_7 – yield	217151.59	290812.87	0.47	no
F-test		5.73	0.00	yes
R^2	69.62%	Adj. R^2		57.47%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Linear regression model for Ghana has fit only 69.62 percent, but according to F-test it is statistically significant. Production of rice is affected by area, machinery and yield. If area increase by 1 hectare the production will increase by 0.03 tonnes. If machinery is increase by 1 pieces the rice production will increase by 207.01 hectares and if yield is increase by 1 t/ha the total production of rice will increase by 130 thousand tonnes.

Table 9 – Factors affecting rice production in Ghana

y_5 - rice production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-92256.96	253014.09	0.72	no
x_2 – temperature	-8013.44	9286.29	0.40	no
x_3 – rainfall	10.62	12.60	0.41	no
x_4 – fertilizers	0.03	0.02	0.12	no
x_5 – area	2.30	0.08	0.00	yes
x_6 – pesticides	-0.02	0.65	0.97	no
x_7 – machinery	207.01	61.30	0.00	yes
x_8 – yield	130526.05	6279.42	0.00	yes
F-test		890.36	0.00	yes
R^2	99.77%	Adj. R^2		99.66%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

F-test shows that the model for rice production in Togo is statistically significant with 98.74% fit. Individual coefficients indicate that if area (or yield) increase by 1 hectare (or t/ha) the production will increase by 1.6 tonnes (or 36 thousand tonnes).

Table 10 – Factors affecting rice production in Togo

y_6 - rice production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-251115.74	155964.30	0.13	no
x_2 – temperature	7047.14	5661.32	0.23	no
x_3 – rainfall	-4.14	10.88	0.71	no
x_4 – fertilizers	-0.01	0.09	0.89	no
x_5 – area	1.60	0.08	0.00	yes
x_6 – pesticides	0.07	0.13	0.60	no
x_7 – machinery	18.43	8.90	0.06	no
x_8 – yield	36254.81	2661.34	0.00	yes
F-test		156.76	0.00	yes
R^2	98.74%	Adj. R^2		98.11%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

4.1.2 Cereals production

This chapter will look at three main cereals (sorghum, millet, maize) that are produced there.

Sorghum production

West Africa has negligible production of wheat. On the other hand, sorghum is popular in the area. In all three countries, it is the third most produced crop. Unfortunately, the yield is low only 1 t/ha where in Europe the yield is in Mt/ha. As seen in figure 20 and 21 in appendix, the production of sorghum is unstable. In the last years, Ghana's production even declined and will continue to decline in next few years. Same decline was observed in Nigeria but there is expected growth next years. On the other side is Togo which has quite stable growth since 1978.

All three countries have similar growth of area where they cultivate sorghum. Since 1961 the area of production grew only by 150-200%. The biggest change in yield is in Ghana where it doubled, in other two countries the yield has not improved since 1961 and stays around 1 t/ha. Average annual yield of sorghum is presented at table 36 in appendix.

If compered the size of the production in terms per capita, Togo has the biggest per capita production with 0.04 t/cap, after that is Nigeria with 0.038 t/cap, then Ghana with 0.01 t/cap.

F-test for sorghum production in Nigeria (table 11) shows that the model is statistically significant with 99.65% fit. If value of area goes up by 1 hectare the total

production will increase by 1.23. Than if yield increases by 1 t/ha the production will increase by 5.4·million tonnes.

Table 11 – Factors affecting sorghum production in Nigeria

y_7 – sorghum production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-7470795.35	2499920.38	0.01	yes
x_2 – temperature	25753.26	95800.06	0.79	no
x_3 – rainfall	-96.58	301.63	0.75	no
x_4 – fertilizers	0.15	0.09	0.10	no
x_5 – area	1.23	0.03	0.00	yes
x_6 – machinery	0.11	1.06	0.92	no
x_7 – yield	5467220.70	304631.69	0.00	yes
F-test		716.46	0.00	yes
R^2	99.65%	Adj. R^2		99.51%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Statically significant model for factors affecting sorghum production in Ghana (table 12) has fit only 64.93%. Only significant parameters are yield and area. If area increases by 1 hectare the production increases only by 1.32 but if yield increases by 1 t/ha the total production will increase by 20 thousand tonnes.

Table 12 – Factors affecting sorghum production in Ghana

y_8 - sorghum production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-1823248.70	1351057.97	0.20	no
x_2 – temperature	50866.98	50808.59	0.33	no
x_3 – rainfall	71.06	76.40	0.37	no
x_4 – fertilizers	-0.01	0.11	0.94	no
x_5 – area	1.32	0.34	0.00	yes
x_6 – pesticides	-0.92	3.68	0.81	no
x_7 – machinery	564.06	373.06	0.15	no
x_8 – yield	20228.16	10062.13	0.06	yes
F-test		3.70	0.02	yes
R^2	64.93%	Adj. R^2		47.39%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Model for factors affecting production in Togo is statistically significant and overall fit is 86.42%. Production is affected by area and yield. If area goes up by 1 hectare the

sorghum production will increase by 0.71 tonnes. And if yield increases by 1 t/ha the production will increase by 17 thousand tonnes.

Table 13 – Factors affecting sorghum production in Togo

y_9 - sorghum production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	451580.83	816322.68	0.59	no
x_2 – temperature	-17497.18	29812.79	0.57	no
x_3 – rainfall	-88.54	57.29	0.14	no
x_4 – fertilizers	0.13	0.47	0.79	no
x_5 – area	0.71	0.24	0.01	yes
x_6 – pesticides	-0.27	0.68	0.70	no
x_7 – machinery	94.44	56.56	0.12	no
x_8 – yield	171393.05	50370.09	0.00	yes
F-test		12.73	0.00	yes
R^2	86.42%	Adj. R^2		79.63%

Source: Own elaboration, based on data from FAO and the World Bank, 207

Millet production

Another cereal that is spread in area is millet. The production is fluctuating and in recent years went down a lot. Especially in Nigeria since 2007 (see figure 22 in appendix). It is expected that it will continue to decline in the future.

Also millet production in Ghana decreased sharply recently. Only in Togo, the decreased appeared already in 70s of 20th century (see figure 23 in appendix).

Yield (see table 37 in appendix), on the other hand, is not improving during the years and in all three countries is between 0.6-1 t/ha. The biggest production and production per capita has Nigeria. It has 0.008 t/cap, Togo is second with 0.006 t/cap and last is Ghana with only 0.002 t/cap.

Model for factors affecting millet production in Nigeria, as seen in table 14, is statistically significant and fit of the model is 99.23%. Statistically significant parameters are yield, machinery and area. If yield increases by 1 t/ha the millet production will increase by 3 million tonnes. If the area goes up by 1 hectare the production will increase by 1.20 and if machinery increases by 1 piece the total production will increase by 13.20 tonnes.

Table 14 – Factors affecting millet production in Nigeria

y_{10} - millet production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	3728563.00	4901023.06	0.46	no
x_2 – temperature	-345664.69	188499.76	0.09	no
x_3 – rainfall	671.87	704.04	0.36	no
x_4 – fertilizers	0.04	0.15	0.82	no
x_5 – area	1.20	0.09	0.00	yes
x_6 – machinery	13.20	3.96	0.00	yes
x_7 – yield	3592990.37	301294.74	0.00	yes
F-test		352.88	0.00	yes
R^2	99.23%	Adj. R^2		98.93%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

As seen in table 15 the model for millet production in Ghana is statistically significant and has 99.67% fit. Parameters affecting production are area and yield. If area increase by 1 hectare the production will increase by 1.32. If yield goes up by 1 t/ha the production will increase by 20 thousand tonnes.

Table 15 – Factors affecting millet production in Ghana

y_{11} - millet production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-1823248.70	1351057.97	0.20	no
x_2 – temperature	50866.98	50808.59	0.33	no
x_3 – rainfall	71.06	76.40	0.37	no
x_4 – fertilizers	-0.01	0.11	0.94	no
x_5 – area	1.32	0.34	0.00	yes
x_6 – pesticides	-0.92	3.68	0.81	no
x_7 – machinery	564.06	373.06	0.15	no
x_8 – yield	20228.16	10062.13	0.06	yes
F-test		612.10	0.00	yes
R^2	99.67%	Adj. R^2		99.51%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

In table 16 there is model for millet production in Togo. There can be see that the model is statistically significant and has 92.35% fit. Factors that are affecting production are area and yield. If yield goes up by 1 t/ha the production will increase by 81 thousand tonnes. And if area increases by 1 hectare the production will increase only by 0.51 tonne.

Table 16 – Factors affecting millet production in Togo

y_{12} - millet production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	14201.39	158463.34	0.93	no
x_2 – temperature	-1815.25	5695.32	0.75	no
x_3 – rainfall	-7.39	10.76	0.50	no
x_4 – fertilizers	-0.01	0.09	0.93	no
x_5 – area	0.51	0.04	0.00	yes
x_6 – pesticides	0.00	0.13	0.99	no
x_7 – machinery	4.17	7.40	0.58	no
x_8 – yield	81738.99	10252.70	0.00	yes
F-test		24.15	0.00	yes
R^2	92.35%	Adj. R^2		88.2%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Maize production

One of the most produced crops in West Africa is maize. This crop has better condition for cultivation than any other cereal. In all three countries is it in top 3 crops produced in terms of area harvested. In recent years all three countries met an increase in production. It can be expected that in next few years the production will increase or stagnate. The biggest production in total has Nigeria (see figure 24 in appendix), but in terms of production per capita it lags. It has only 0.06 t/cap which is same as in Ghana. On the other side is Togo with twice bigger production of 0.12 t/cap (see figure 25 in appendix).

Yield as seen in table 38 in appendix, improved in all three countries especially in Nigeria. However, it is not very stable and values fluctuates. In 2014 the best yield was achieved in Nigeria 1.8 t/ha, other countries are not that much behind with 1.72 t/ha in Ghana and 1.2 t/ha in Togo.

In table 17 there can be seen the results of estimation of the model. F-test shows that this model is significant and fit is 98.46%. Factors affecting maize production in Nigeria are area and yield. If area goes up by 1 hectare the production will increase by 1.41 tonnes. If yield increases by 1 t/ha the production will go up by 3.5 million tonnes.

Table 17 – Factors affecting maize production in Nigeria

y_{13} - maize production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-7177436.91	5221782.06	0.19	no
x_2 – temperature	67469.49	193286.24	0.73	no
x_3 – rainfall	38.58	579.78	0.95	no
x_4 – fertilizers	-0.06	0.17	0.71	no
x_5 – area	1.41	0.06	0.00	yes
x_6 – machinery	5.39	2.59	0.05	no
x_7 – yield	3558437.91	301575.78	0.00	yes
F-test		160.47	0.00	yes
R^2	98.46%	Adj. R^2		97.85%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Model on maize production in Ghana is statistically significant and has overall fit 99.72%. Results are displayed at table 18. Factors that affect this are area and yield. If area increases by 1 hectare the production will increase by 1.62 tonnes. If yield increases by 1 t/ha the production will increase by 788 thousand.

Table 18 – Factors affecting maize production in Ghana

y_{14} - maize production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-1015048.46	828040.87	0.24	no
x_2 – temperature	-7861.81	30942.96	0.80	no
x_3 – rainfall	-39.10	58.38	0.51	no
x_4 – fertilizers	0.11	0.07	0.14	no
x_5 – area	1.62	0.07	0.00	yes
x_6 – pesticides	-0.74	2.08	0.73	no
x_7 – machinery	318.50	213.87	0.16	no
x_8 – yield	788318.84	64592.70	0.00	yes
F-test		727.31	0.00	yes
R^2	99.72%	Adj. R^2		99.58%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

In table 19 there is model for maize production in Togo. According to F-test this model is statistically significant and according to R^2 the fit is 99.82%. Factors that are affecting the production are temperature, area, machinery, and yield. If temperature increases by 1 °C the production will decrease by 23 thousand tonnes. If area increases by 1 hectare the total production will increase by 1.10 tonnes. If machinery increases by 1 piece the

production will increase by 40.08 and mostly if yield increases by 1 t/ha the production will increase by 367 thousand tonnes.

Table 19 – Factors affecting maize production in Togo

y_{15} – maize production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	231760.64	290475.13	0.44	no
x_2 – temperature	-23442.50	10404.40	0.04	yes
x_3 – rainfall	0.82	19.26	0.97	no
x_4 – fertilizers	0.30	0.16	0.08	no
x_5 – area	1.10	0.03	0.00	yes
x_6 – pesticides	-0.08	0.23	0.72	no
x_7 – machinery	40.08	17.04	0.03	yes
x_8 – yield	367081.67	14807.93	0.00	yes
F-test		1118.57	0.00	yes
R^2	99.82%	Adj. R^2		99.73%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

4.1.3 Cassava production

Production in all three countries is crowing each year as displayed at figure 26 in appendix for Nigeria and figure 27 in appendix for Ghana and Togo. The most stable production has Ghana others have fluctuating production. Comparing the size of production Ghana have also the biggest one with 0.64 t/cap, Nigeria have only half of it 0.3 t/cap and Togo has the smallest with only 0.17 t/cap.

Average annual yield of cassava is presented in table 39 in appendix. Ghana has also the biggest yield with 18.5 t/ha. Nigeria has only half of it with 7.7 t/ha and Togo is behind with only 4.1 t/ha. Ghana is also only country where the yield is constantly growing and not fluctuating like in rest of them.

Model for Nigeria which results are in table 20 is statistically significant and has great fit 98.72%. Only factors affecting cassava production are area and yield. If area increases by 1 hectare the production will increase by 8.66 tonnes. If yield increases by 1 t/ha the production will increase by 3.7 million tonnes.

Table 20 – Factors affecting cassava production in Nigeria

y_{16} – cassava production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-7687425.96	23331816.25	0.75	no
x_2 – temperature	-879022.80	893863.85	0.34	no
x_3 – rainfall	-2699.26	2789.08	0.35	no
x_4 – fertilizers	-0.64	0.73	0.40	no
x_5 – area	8.66	0.54	0.00	yes
x_6 – machinery	28.47	13.14	0.05	no
x_7 – yield	3782899.97	337309.52	0.00	yes
F-test		193.59	0.00	yes
R^2	98.72%	Adj. R^2		98.21%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

In table 21 there is model for cassava production in Ghana. This model is statistically significant and has great fit 99.95%. Factors affecting the production are area, machinery and yield. If area increases by 1 hectare the production will increase by 12.67 tonnes. If machinery increase by 1 piece the production will increase by 5.9 thousand tonnes. If yield increases by 1 t/ha the production will go up by 868 thousand tonnes.

Table 21 – Factors affecting cassava production in Ghana

y_{17} – cassava production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-11012783.6	2793010.83	0.00	yes
x_2 – temperature	11844.79	103062.58	0.91	no
x_3 – rainfall	-219.80	155.82	0.18	no
x_4 – fertilizers	-0.07	0.24	0.77	no
x_5 – area	12.67	0.31	0.00	yes
x_6 – pesticides	-7.62	7.26	0.31	no
x_7 – machinery	5952.48	840.31	0.00	yes
x_8 – yield	868393.63	20046.40	0.00	yes
F-test		4324.44	0.00	yes
R^2	99.95%	Adj. R^2		99.93%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

The model in table 22 is statistically significant and has overall fit 94.55%. Cassava production in Togo is only affected by area. If area goes up by 1 hectare the cassava production will increase by 4.36 tonnes.

Table 22 – Factors affecting cassava production in Togo

y_{18} – cassava production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-3457998.32	1777364.19	0.07	no
x_2 – temperature	109651.77	62017.51	0.10	no
x_3 – rainfall	125.41	122.96	0.33	no
x_4 – fertilizers	0.25	1.04	0.81	no
x_5 – area	4.35	0.85	0.00	yes
x_6 – pesticides	1.76	1.50	0.26	no
x_7 – machinery	62.37	116.73	0.60	no
x_8 – yield	74416.68	35921.03	0.06	no
F-test		34.76	0.00	yes
R^2	94.55%	Adj. R^2		91.83%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

4.1.4 Cocoa production

Cocoa is the most important crop for Ghana. There its production is the biggest in the region. Its production per capita is 10 times bigger than in the rest. Value for Ghana is 0.03 t/cap., in Togo 0.004 t/cap. and in Nigeria 0.001 t/cap. However, the production not stable and fluctuates for last 20 years. From figure 28 in appendix can be seen that the production is still increasing in recent 15 years.

The biggest yield has Togo (0.93 t/ha) but it is fluctuating during the years. Same fluctuation is seen in Nigeria and Ghana at table 40 in appendix**.**

As seen in table 23 the cocoa production in Nigeria model is statistically significant but has fit only 62.40%. According to this linear regression model no parameter is significant for cocoa production in Nigeria.

Table 23 – Factors affecting cocoa production in Nigeria

y_{19} – cocoa production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-699935.28	1178135.47	0.56	no
x_2 – temperature	43532.27	43382.12	0.33	no
x_3 – rainfall	-77.68	143.29	0.60	no
x_4 – fertilizers	0.03	0.04	0.42	no
x_5 – area	-0.12	0.12	0.32	no
x_6 – machinery	2.07	1.00	0.05	no
x_7 – yield	-114384.08	185857.75	0.55	no
F-test		4.15	0.01	yes
R^2	62.40%	Adj. R^2		47.36%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Model of factors affecting cocoa production in Ghana shown at table 24 is statistically significant and has good fit (97.32%). Significant parameters are area, fertilizers, and pesticides. If usage of fertilizers increase by 1 tonne the production will increase by 0.53 tonnes. If area harvested goes up by 1 hectare the production will go up by 0.28 tonnes. Biggest effect has usage of pesticides, if it is increase by 1 tonne the production will increase by 12.90 tonnes.

Table 24 – Factors affecting cocoa production in Ghana

y_{20} –cocoa production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	3110096.79	1488014.65	0.06	no
x_2 – temperature	-113820.78	55070.37	0.06	no
x_3 – rainfall	-75.83	80.62	0.36	no
x_4 – fertilizers	0.53	0.11	0.00	yes
x_5 – area	0.28	0.05	0.00	yes
x_6 – pesticides	12.90	4.22	0.01	yes
x_7 – machinery	-304.55	575.62	0.61	no
x_8 – yield	383944.46	205923.81	0.08	no
F-test		72.70	0.00	yes
R^2	97.32%	Adj. R^2		95.98%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

As seen in table 25 the model for cocoa production in Togo is statistically significant with great fit 99.34%. Significant parameters are area, pesticides, and yield. Yield has the greatest effect if it is increase by 1 t/ha the production will increase by 19 thousand tonnes.

Smaller effect has area harvested and usage of pesticides, if they are increased by 1 hectare (1 tonne) the production will increase by 0.70 tonnes (0.36 tonnes)

Table 25 – Factors affecting cocoa production in Togo

y_{21} – cocoa production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-199006.58	167207.13	0.25	no
x_2 – temperature	6898.79	6049.19	0.27	no
x_3 – rainfall	-5.98	11.31	0.60	no
x_4 – fertilizers	-0.07	0.09	0.45	no
x_5 – area	0.70	0.04	0.00	yes
x_6 – pesticides	0.36	0.15	0.03	yes
x_7 – machinery	22.15	13.09	0.11	no
x_8 – yield	19299.80	8294.44	0.04	yes
F-test		304.10	0.00	yes
R^2	99.34%	Adj. R^2		91.83%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

4.1.5 Palm fruit production

Production of palm fruit and then making of palm oil is in top 5 production in all three countries. The biggest per capita production has Ghana with 0.09 t/cap., then it is Togo with 0.02 t/cap. And last is Nigeria with only 0.005 t/cap (see figure 29 in appendix). Trend in palm oil production is increasing everywhere caused by higher demand for palm oil.

Annual production of palm fruit in Ghana and Togo is displayed at figure 30 in appendix.

Average yield is quite high in comparison to other crops and during last 10 years it is increasing as can be observed from table 41 in appendix. The highest yield has Togo with almost 8.6 t/ha.

Model for palm fruit production in Nigeria is statistically significant with good fit 82.50% as can be seen at table 26. Parameters affecting the production are machinery and yield. If machinery is increased by 1 pieces the production will increase by 4.02 tonnes. And if yield goes up by 1 t/ha the production will increase by 1.4 million tonnes.

Table 26 – Factors affecting palm fruit production in Nigeria

y_{22} – palm fruit production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-6197255.52	2821828.10	0.04	yes
x_2 – temperature	80851.87	83704.36	0.35	no
x_3 – rainfall	365.89	277.12	0.21	no
x_4 – fertilizers	0.10	0.10	0.37	no
x_5 – area	0.17	0.20	0.41	no
x_6 – machinery	4.02	1.78	0.04	yes
x_7 – yield	1433428.76	433626.66	0.00	yes
F-test		11.79	0.00	yes
R^2	82.50%	Adj. R^2		75.51%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

As seen in table 27, the model for palm fruit production in Ghana is statically significant. However, the fit is only 79.43% and no parameter is significant.

Table 27 – Factors affecting palm fruit production in Ghana

y_{23} – palm fruit production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	50619.22	268428.00	0.85	no
x_2 – temperature	3133.51	9883.77	0.76	no
x_3 – rainfall	1.64	14.76	0.91	no
x_4 – fertilizers	-0.02	0.03	0.45	no
x_5 – area	0.11	0.05	0.05	no
x_6 – pesticides	-0.81	0.92	0.39	no
x_7 – machinery	-60.73	70.28	0.40	no
x_8 – yield	-7983.61	7454.49	0.30	no
F-test		7.73	0.00	yes
R^2	79.43%	Adj. R^2		69.15%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Lastly model for Togo displayed at table 28 is statistically significant and has great fit 99.99%. Parameters effecting palm fruit production are area, machinery, and yield. If area harvested is increased by 1 hectare the production will increase by 8.67. If machinery in use is increase by 1 piece the production will actually decrease by 1.20 tonne. And if yield is increase by 1 t/ha the production will go up by 13 thousand tonnes.

Table 28 – Factors affecting palm fruit production in Togo

y_{24} – palm fruit production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-113130.07	5077.53	0.00	yes
x_2 – temperature	-128.63	166.49	0.45	no
x_3 – rainfall	0.29	0.33	0.39	no
x_4 – fertilizers	0.00	0.00	0.72	no
x_5 – area	8.67	0.03	0.00	yes
x_6 – pesticides	0.00	0.00	0.29	no
x_7 – machinery	-1.20	0.29	0.00	yes
x_8 – yield	13437.05	213.09	0.00	yes
F-test		29274.48	0.00	yes
R^2	99.99%	Adj. R^2		99.98%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

4.1.6 Fruits and vegetables

Legumes like peas, beans, lentils, chickpeas, and soya are primary produced for its seeds called pulse its production is now declining in the region. Roots and Tubes are plants that create starch corms and stems, for example: potatoes or cassava. Per capita production of it in West Africa is the highest in continent and it is still rising. Citrus Fruit production increase for last year. Production of vegetable is stagnating throughout the continent.

Yams production

Yam is great nutritious crop with lots of sugar and proteins. Production of yams is in top 5 in all three countries. Trends in production are increasing everywhere. In terms of total production, the biggest one have Nigeria (see figure 31 in appendix), but if calculated production per capita Togo has actually the biggest production twice bigger than in Ghana and 10 times bigger than in Nigeria. Annual production of yams for Ghana and Togo is displayed at figure 32 in appendix**.**

Average yield is quite high and similar to yield of other fruits and vegetables. The highest yield as Ghana with 16.6 t/ha and lowest have Togo with only half of Ghana's number – 7.8 t/ha despite having the biggest per capita production and starting with higher number. The development is displayed in table 42 in appendix.

In table 29 there is statistically significant model for yams production in Nigeria. Total fit of the model is good 98.68%. Significant parameters are fertilizers, area, machinery, and yield. If fertilizers usage increases by 1 tonne the production will decrease 1.74 tonne. If area harvested is increased by 1 hectare the production will increase 9.05 tonnes. If usage of machinery is increase by 1 piece the production will increase by 3.3 million tonnes. What is interesting that yield have negative effect on production if it is increased by 1 t/ha the production decreases by 5.8 million tonnes.

Table 29 – Factors affecting yams production in Nigeria

y_{25} – yams production	**Coefficient**	**Std. error**	**p-value**	**Significant**
x_1 - intercept	-58784641.9	18930748.54	0.01	yes
x_2 – temperature	950866.30	702684.03	0.20	no
x_3 – rainfall	1734.13	2293.36	0.46	no
x_4 – fertilizers	-1.74	0.60	0.01	yes
x_5 – area	9.05	0.63	0.00	yes
x_6 – pesticides	17.67	12.46	0.18	no
x_7 – machinery	3290855.10	236059.69	0.00	yes
x_8 – yield	-58784641.9	18930748.54	0.01	yes
F-test		187.30	0.00	yes
R^2	98.68%	**Adj. R^2**		98.15%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Model in table 30 for the production of yams in Ghana is statistically significant and with great fit of 99.66%. Parameters affecting the production are area and yield. If area harvested is increased by 1 hectare the production will increase by 13.03 tonnes. And if yield is increased by 1 t/ha the production will increase by 232 thousand tonnes.

Table 30 – Factors affecting yams production in Ghana

y_{25} – yams production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-1266612.26	3868457.83	0.75	no
x_2 – temperature	-107936.83	142614.62	0.46	no
x_3 – rainfall	4.91	219.90	0.98	no
x_4 – fertilizers	0.50	0.33	0.15	no
x_5 – area	13.03	0.64	0.00	yes
x_6 – pesticides	-6.34	12.60	0.62	no
x_7 – machinery	1484.75	1022.46	0.17	no
x_8 – yield	323704.09	26542.15	0.00	yes
F-test		591.71	0.00	yes
R^2	99.66%	Adj. R^2		99.49%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Statistically significant model production of yams in Togo has fit of 99.43%. Parameters affecting the production are temperature, area, and yield. If temperature goes up by 1 °C the production will increase by 36 thousand tonnes. If area harvested is increased by 1 hectare the production will increase by 8.35 tonnes. And last if yield increases by 1 t/ha the production will increase by 56 thousand tonnes.

Table 31 – Factors affecting yams production in Togo

y_{26} – yams production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-1496839.54	386966.21	0.00	yes
x_2 – temperature	36813.02	14338.14	0.02	yes
x_3 – rainfall	13.38	26.84	0.63	no
x_4 – fertilizers	-0.21	0.20	0.31	no
x_5 – area	8.35	0.24	0.00	yes
x_6 – pesticides	0.49	0.31	0.14	no
x_7 – machinery	21.89	20.25	0.30	no
x_8 – yield	56807.12	2748.63	0.00	yes
F-test		354.88	0.00	yes
R^2	99.43%	Adj. R^2		99.15%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Plantains production

Plantains, or green bananas, are important crop cultivated in the region. Out of selected countries only Togo does not produce it. Therefore only the annual production of

plantains in Nigeria and Ghana is displayed in figure 33 in appendix. Plantains for its nutritious value are more and more cultivated in the region. Both Nigeria and Ghana have similar production in tonnes. But if calculated per capita Ghana have 10 times bigger production than Nigeria.

As always, the yield is not very stable and fluctuates during the year but overall trend is increasing as can be observed from numbers in table 43 in appendix. Average yield is around the same number as other fruits and vegetables.

Model for plantains production in Nigeria has 99.57% fit and according to F-test it is statistically significant. Parameters affecting the production are area harvested and yield. If area harvested is increased by 1 hectare the production will increase by 7.44 tonnes. But if yield goes up by 1 t/ha the production will go up by 400 thousand tonnes. Results are displayed in table 32.

Table 32 – Factors affecting plantains production in Nigeria

y_{27} – plantains production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-4026698.56	1018218.55	0.00	yes
x_2 – temperature	43612.86	38816.77	0.28	no
x_3 – rainfall	3.37	128.26	0.98	no
x_4 – fertilizers	-0.05	0.04	0.21	no
x_5 – area	7.44	0.37	0.00	yes
x_6 – machinery	-2.59	1.02	0.02	yes
x_7 – yield	400541.29	26520.91	0.00	yes
F-test		587.26	0.00	yes
R^2	99.57%	Adj. R^2		99.40%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

Model for plantains production in Ghana is statistically significant as the fit is 99.88%. Results are displayed in table 33. Area, machinery, yield are factors affecting the production. If area harvested or machinery increases by 1 hectare (1 pieces) the total production increases by 10.06 tonnes (2.7 thousand) tonnes. Biggest effect has yield where if it is increased by 1 t/ha the production will increase by 283 thousand tonnes.

Table 33 – Factors affecting plantains production in Ghana

y_{28} – plantains production	Coefficient	Std. error	p-value	Significant
x_1 - intercept	-668229.57	1451307.92	0.65	no
x_2 – temperature	-75061.97	54003.58	0.19	no
x_3 – rainfall	-69.11	85.77	0.43	no
x_4 – fertilizers	-0.02	0.13	0.90	no
x_5 – area	10.06	0.68	0.00	yes
x_6 – pesticides	-1.84	4.04	0.66	no
x_7 – machinery	2737.40	629.52	0.00	yes
x_8 – yield	283107.98	14457.93	0.00	yes
F-test		1707.36	0.00	yes
R^2	99.88%	Adj. R^2		99.82%

Source: Own elaboration, based on data from FAO and the World Bank, 2017

5 Results and Discussion

5.1 Results

Results are summarized in table 34. According to the conducted models, the total production in Nigeria, is affected by usage of fertilizers, area harvested and yield, where the highest effect has yield. Improvement by 1 t/ha is accompanied by increase in production by 10 million tonnes. In Ghana, the total agricultural production is mostly influenced by yield and slightly by area harvested. Lastly in Togo the production is only effected by area harvested.

Production of rice is in all three countries affected by area harvested but only to small degree. In Nigeria, there is not any other factor that it is affecting the production. In Ghana machinery and also yield impact the production. Than in Togo yield have huge effect on rice production.

All three countries have the same factor affecting the production of sorghum. They are area harvested and yield. Area harvested have only small effect but yield influence production in million tonnes.

Millet production in Nigeria is affected by yield, area harvested and surprisingly by usage of machinery. In other two countries, Ghana and Togo, yield and area harvested are the factors affecting the millet production.

According to models conducted the maize production in all three countries is influence by yield and area harvested. Besides that, in Togo, temperature and usage of machinery have effect on production. Temperature have negative influence on production and machinery have positive effect on it.

Production of cassava in West Africa is influenced by area harvested. Besides that in Nigeria it is affected by yield. The most depending production is in Ghana. There the cassava production is influenced by area, yield, and machinery.

According to the model cocoa production in Nigeria is not influenced by any factors tested. In Ghana the production is affected by fertilizers usage, area harvested, and usage o pesticides. Lastly in Togo cocoa harvest is influenced by area harvested, usage of pesticides, and yield.

Palm fruit production in Nigeria is positively affected by usage of machinery and yield. According to the model production in Ghana is not influenced by any tested factor. In

Togo the production is affected area harvested, machinery, and yield. Surprisingly usage of machinery have negative effect on whole production.

Production of yams in Nigeria is positively affected by area harvested and machinery. However, negatively by usage of fertilizers and yield. In Ghana production is positively influenced by area harvested and yield. Lastly in Togo the production is positively affected by temperature, yield, and area harvested.

Production of plantains in Nigeria and Ghana is positively affected by area harvested and yield. Besides that, in Ghana plantains production is influenced by machinery too.

Table 34 – Summarization of the results

Production		temperature	fertilizers	area	pesticides	machinery	yield
agricultural production	Nigeria		x	x			x
	Ghana			x			x
	Togo			x			
rice	Nigeria		x				
	Ghana			x		x	x
	Togo			x			x
sorghum	Nigeria			x			x
	Ghana			x			x
	Togo			x			x
millet	Nigeria			x		x	x
	Ghana			x			x
	Togo			x			x
maize	Nigeria			x			x
	Ghana			x			x
	Togo	x		x		x	x
cassava	Nigeria			x			x
	Ghana			x		x	x
	Togo			x			
cocoa	Nigeria						
	Ghana		x	x	x		
	Togo			x	x		x
palm fruit	Nigeria					x	x
	Ghana						
	Togo			x		x	x
yams	Nigeria		x	x		x	x
	Ghana			x			x
	Togo	x		x			x
plantains	Nigeria			x			x
	Ghana			x		x	x

Note: Statistically significant factors are marked with "x"; Source: Own elaboration

5.2 Discussion

As can be seen from the results, mostly, the production of the crops in West African countries is affected by the area on which the crop is planted and by yield. The possession of land is, however, linked with certain problems as there is a lack of registration of the ownership rights for example in Nigeria. "Land tenure systems drive economic agility and the growth of agribusiness, but also bring forth some ethical questions with regards to indigenous people and the break of their connection with the land," (Adenle, Manning and Azadi, 2017).

Therefore, it can be recommended to primarily to raise the yield of the planted crops. This objective can be achieved both by improving land management, fertilization etc., as well as increasing investment in agricultural technology, into new technologies and introducing innovations in agriculture. According to Nwoboshi (1981) in West African countries, there is only "little attention has been given to the soil, which is inherently poor and further impoverished by export of portions of the meagre nutrient reserve." This finding is in line with ours that also proved that the soil quality shall be improved by fertilizers. In Nigeria, the total agricultural production, rice and yams production is influenced by the amount of used fertilizers.

Also usage of machinery proved to be important in production of certain crops. However, the rate of adoption of new mechanisation in processing or cultivation by the African population depends on a combination of factors. Adekunle, Osazuwa and Raghavan (2016) name for instance "the circumstances surrounding production, the effect of the technology on gender equality in employment, the socio-cultural beliefs of the farming community, the economic realities of the society, sensitization and its applications to local production systems.

Surprisingly, the amount of rainfall was not statistically significant in any case. Temperature affected the production only in Togo and only of maize and yams.

5.3 Potentials

Nigeria, Togo, and Ghana have many places to improve to ensure enough nutrient for its population and stable economic growth. Along with Latin America, Africa has the largest surface area of uncultivated arable land. Farmers are using only 1/3 of the cultivable land. Problem is that these areas are not yet densely populated. Despite each year of

spreading the area of production more and more it is shown that it has only small effect on how much they will produce. On the other hand, it was shown that yield have the highest potential to increase the production. Unfortunately, they are more focusing on area growth instead of increase of yield.

All three countries have available water resources. Furthermore, optimizing the use of water resources would increase the productivity of region and prepare for droughts. Investments from government in irrigation ensure that global warming will not harm production of cassava, cocoa, and other crops vital for this region.

Many farming systems are struggling to replenish fertility of soil. It is difficult for them to obtain seasonal credit to buy fertilizer and they are also not properly informed about usage of fertilizers. Increase in fertilizers usage have great potential to increase yield and therefore production.

Infection carrying insects, knap weed, pests are dangerous for livestock and crop production. Many farmers are not able to buy them and they are not enlightening on proper usage and environmental danger they represent. Increasing investment in pesticide usage have great potential to increase yield.

Mechanization of production is an important step towards sustainable development. The devices are able to do many times more work than men, and it lasts longer work. The disadvantage is the high purchase price and maintenance costs. Other problem in Africa will be learning to operate and maintain the machine. These are the reason why it is not developed in Africa. The problem in Africa will also be learning to operate the instrument.

6 Conclusion

The aim of the thesis was to analyse the situation of agriculture in selected countries in West African countries – Nigeria, Ghana, and Togo. The theoretical part described the geographical conditions and economic situation in Nigeria, Ghana and Togo. It also dealt with the problems of agriculture and food security in these countries and presents the results of research in this area.

From various publicly available resources and databases were taken data about the agriculture in the West African countries. The research used secondary sources of information mainly from FAOSTAT and The World Bank.

The practical part of the thesis examined the factors that influence the total agricultural production and production of selected crops. Mainly are used quantitative methods, particularly linear regression models for each country and crop. Chosen crops were rice, cereals (sorghum, millet, maize, cassava), cocoa, palm fruit, yams, and plantains because they are the most frequently planted in West Africa. Explanatory variables (the determinants) were average year temperature (in °C), average year rainfall (in mm), total annual usage of fertilizers (in tonnes), area harvested (in ha), total annual usage of pesticides (in tonnes), total usage of machinery (in pieces), yield of a crop (in tonnes / ha).

It was found that Nigeria, Togo, and Ghana have a large space to improve to ensure enough nutrient for its population and stable economic growth. As the production is mainly influence by the yield and harvested area, it can be recommended to pay attention to those areas. Raising of yield can be achieved both by improving land management, fertilization etc., as well as by increasing investment in agricultural technology, into new technologies and introducing innovations in agriculture.

Also usage of machinery proved to be important in production of certain crops – millet, palm fruit and yams in Nigeria, rice, cassava and plantains in Ghana, maize and palm fruit in Togo. Fertilizers were important determinant of total agricultural production, rice and yams production in Nigeria and for cocoa production in Ghana. Cocoa is the only type of production for which is the usage of pesticides a significant determinant (in Ghana and Togo). Surprisingly, the amount of rainfall was not statistically significant in any case. Temperature affected the production only in Togo and only of maize and yams. Besides, the production of cocoa in Nigeria and of palm fruit in Ghana was not affected by any of the determinants examined in the thesis.

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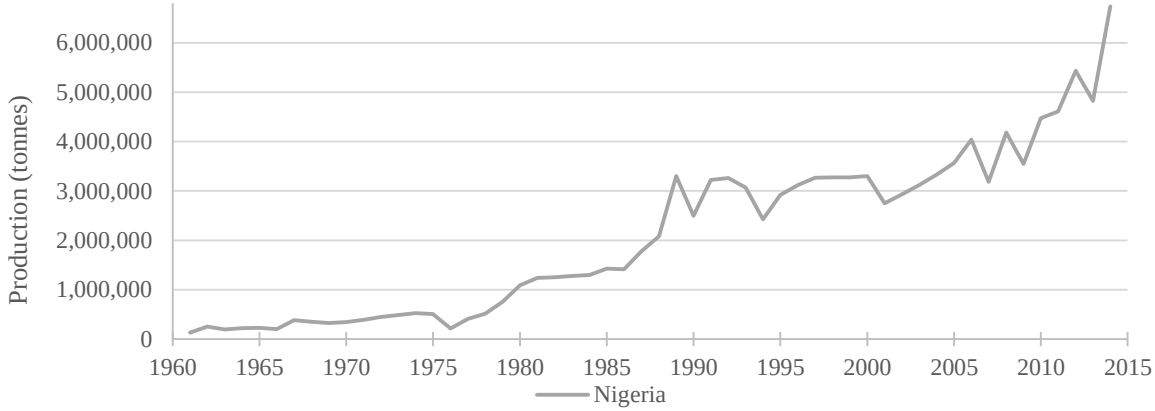
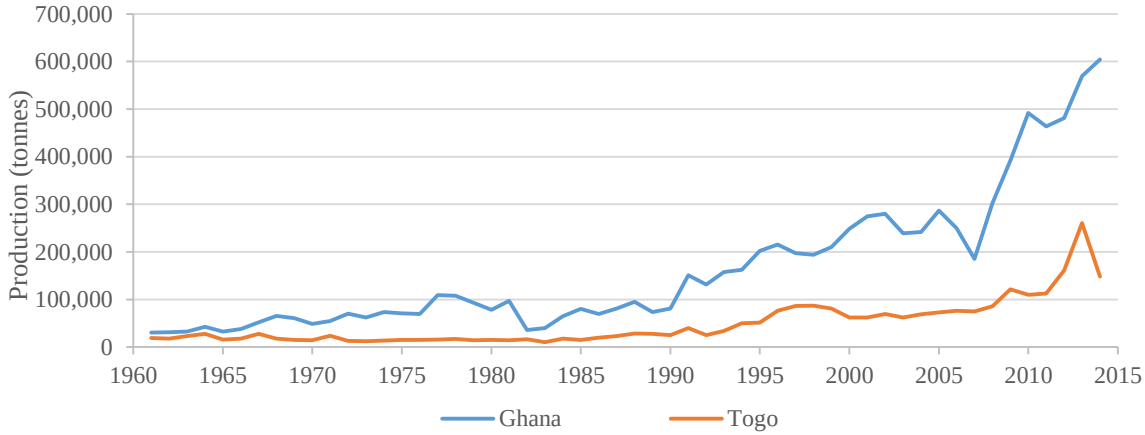
8 Appendix

Figure 18 – Annual rice production in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 19 – Annual rice production in Ghana and Togo



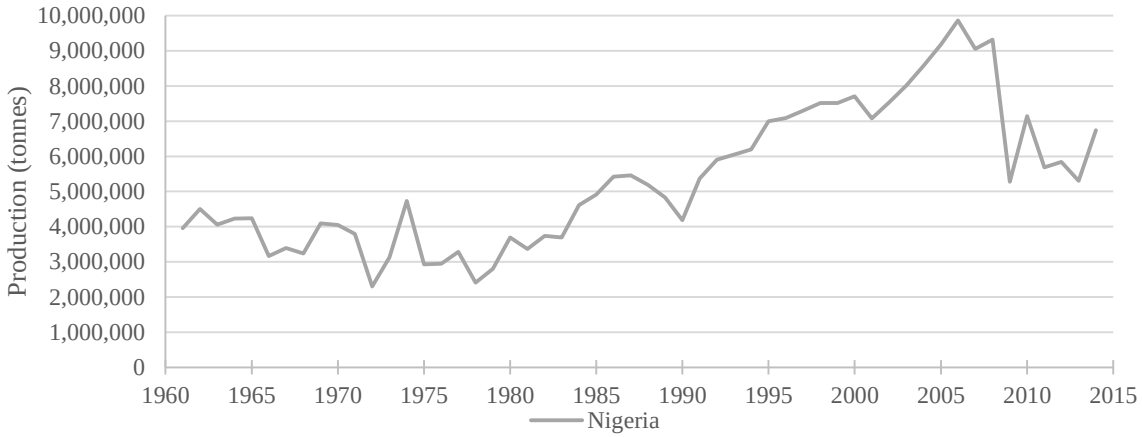
Source: Own elaboration, based on data from FAO, 2017

Table 35 – Average annual yield of rice (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	0.8926	1.4998	1.9306	1.8386	2.0325	1.8971	1.6454	2.1752
Ghana	1.1047	2.1589	2.4109	2.7126	2.3495	2.5386	2.6378	2.6964
Togo	1.2690	1.9223	2.654	2.3228	2.5101	1.6724	2.8233	1.7633

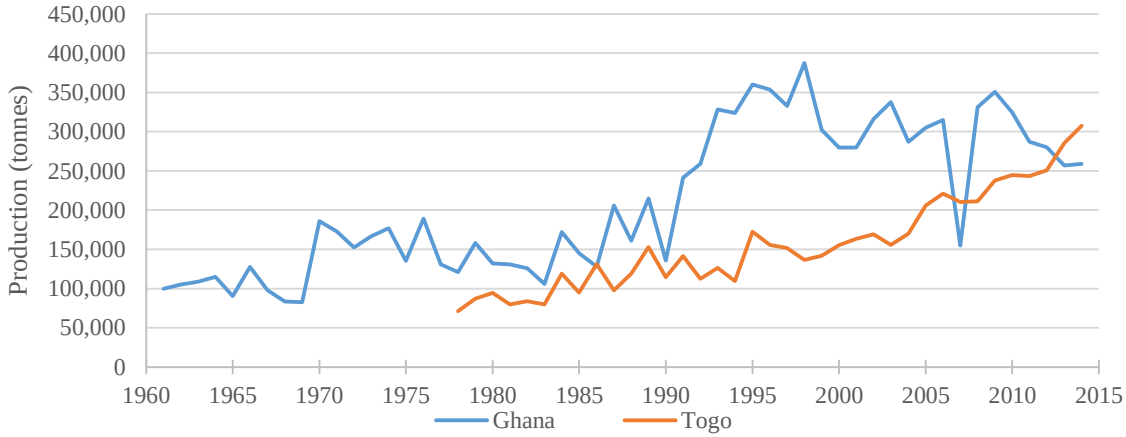
Source: Own elaboration, based on data from FAO, 2017

Figure 20 – Annual sorghum production in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 21 – Annual sorghum production in Ghana and Togo



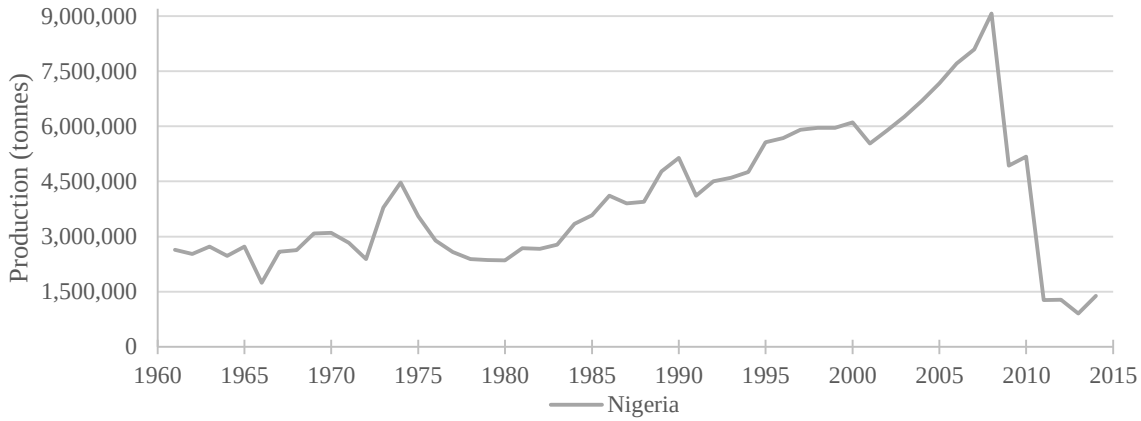
Source: Own elaboration, based on data from FAO, 2017

Table 36 – Average annual yield of sorghum (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	0.8497	1.1200	1.1145	1.4397	1.2206	1.1445	0.9727	1.2398
Ghana	7.500	12.2812	13.8074	15.4330	16.0124	16.7489	18.2704	18.5872
Togo	0.000	0.8485	1.0981	1.0943	1.1012	0.8635	0.9444	0.9501

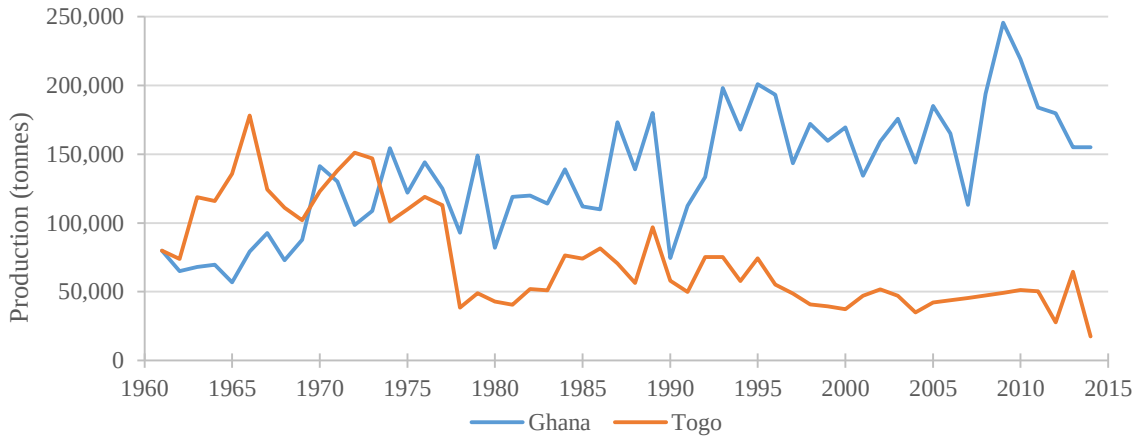
Source: Own elaboration, based on data from FAO, 2017

Figure 22 – Annual millet production in Nigeria



Source: Own elaboration, based on the data from FAO, 2017

Figure 23 – Annual millet production in Ghana and Togo



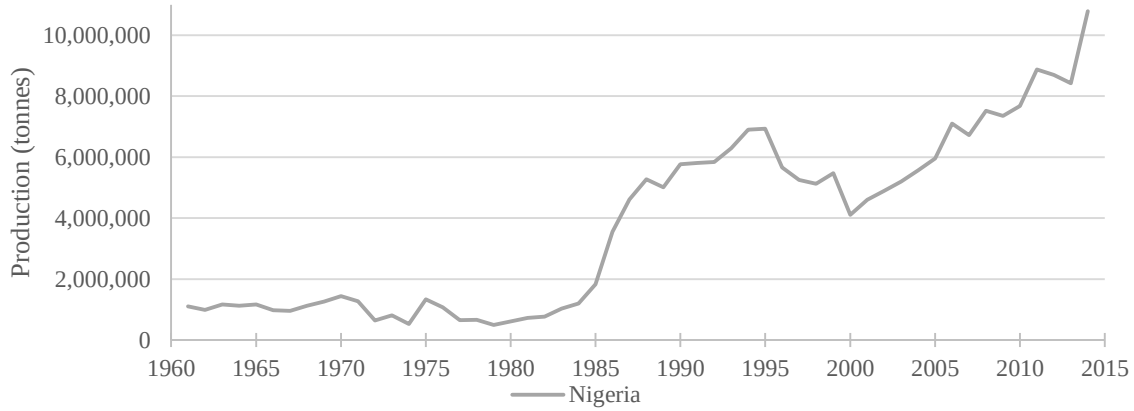
Source: Own elaboration, based on the data from FAO, 2017

Table 37 – Average annual yield of millet (t/ha)

	1961	**2000**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
Nigeria	0.6064	1.0501	1.3016	1.1848	0.4497	0.9642	0.6124	0.8787
Ghana	0.6667	0.8144	1.3152	1.2398	1.0294	1.0418	0.9651	0.9568
Togo	0.4082	0.4696	0.6877	0.6949	0.6865	0.4861	1.2755	0.6247

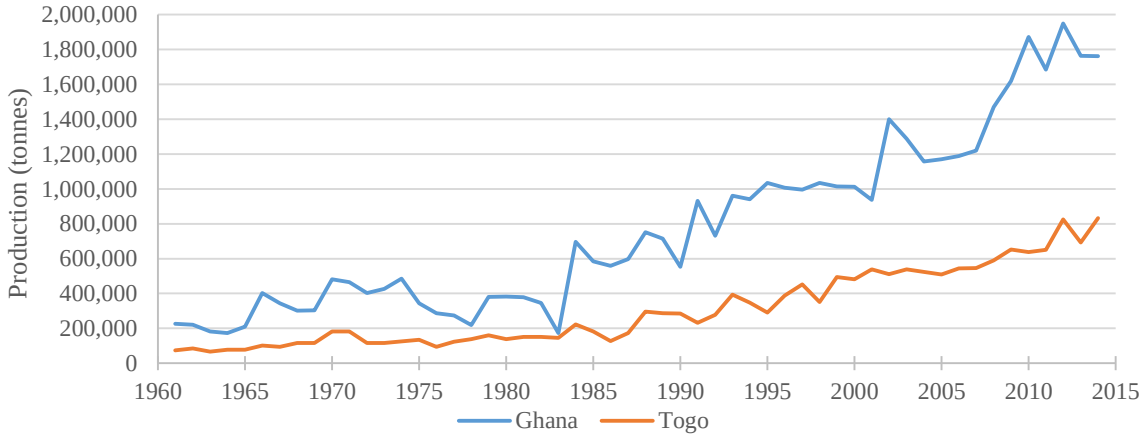
Source: Own elaboration, based on data from FAO, 2017

Figure 24 – Annual maize production in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 25 – Annual maize production in Ghana and Togo



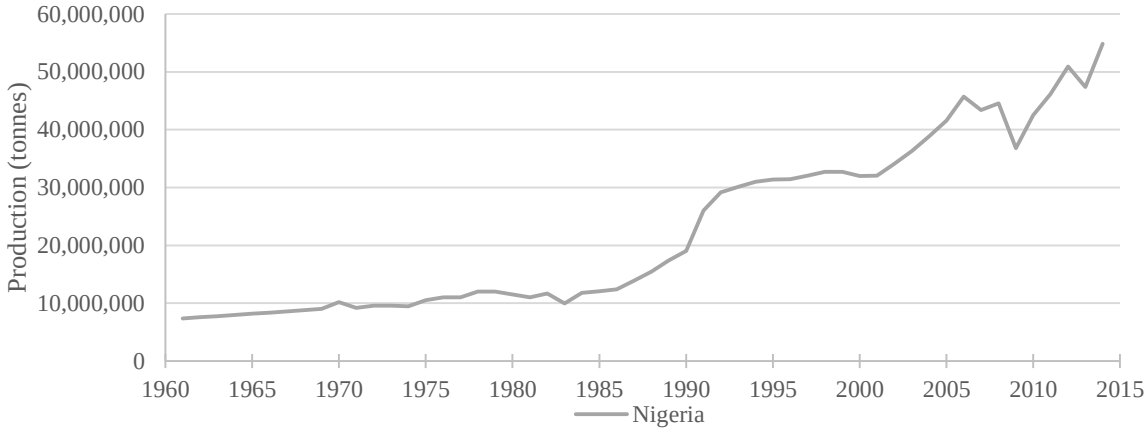
Source: Own elaboration, based on data from FAO, 2017

Table 38 – Average annual yield of maize (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	0.8051	1.3001	2.1961	1.8502	1.6271	1.5118	1.4616	1.8446
Ghana	0.9536	1.4578	1.6969	1.8874	1.6458	1.8712	1.7240	1.7291
Togo	0.4926	1.202	1.2559	1.1937	1.2453	1.1914	0.9244	1.1959

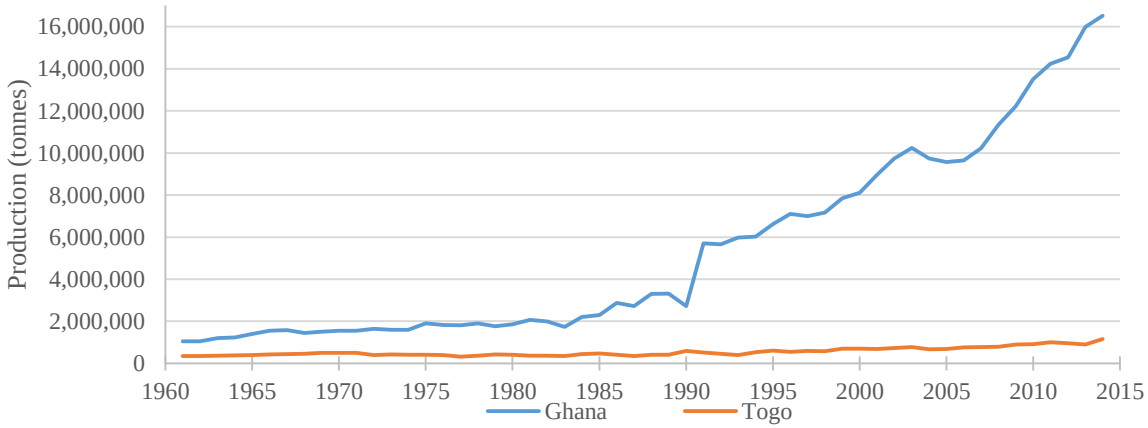
Source: Own elaboration, based on data from FAO, 2017

Figure 26 – Annual cassava production in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 27 – Annual cassava production in Ghana and Togo



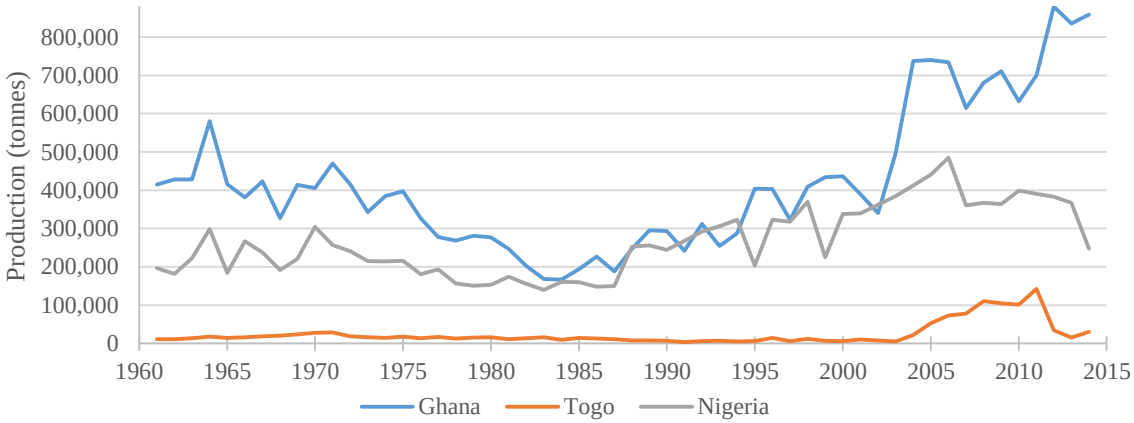
Source: Own elaboration, based on data from FAO, 2017

Table 39 – Average annual yield of cassava (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	9.4667	9.7000	11.7679	12.2155	11.2108	7.9585	7.0323	7.7203
Ghana	7.5000	12.2812	13.8074	15.433	16.0124	16.7489	18.2704	18.5872
Togo	15.9091	5.6535	6.2447	6.1679	6.5603	4.0837	3.5172	4.0805

Source: Own elaboration, based on data from FAO, 2017

Figure 28 – Annual cocoa production in Nigeria, Ghana, and Togo



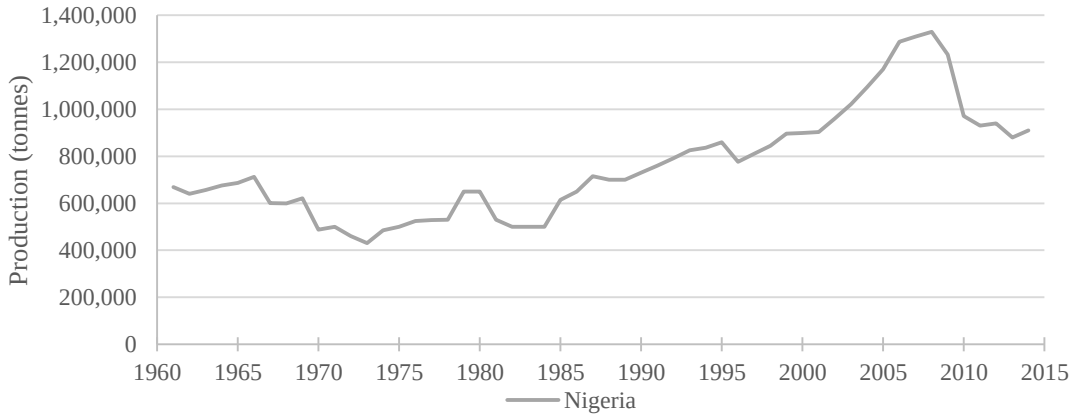
Source: Own elaboration, based on data from FAO, 2017

Table 40 – Average annual yield of cocoa (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	0.2814	0.3499	0.2684	0.3137	0.3136	0.3018	0.2948	0.1804
Ghana	0.2364	0.2911	0.4441	0.3950	0.4374	0.5495	0.5221	0.5100
Togo	0.7700	0.3939	0.7600	0.7793	0.8251	0.8621	0.8961	0.9300

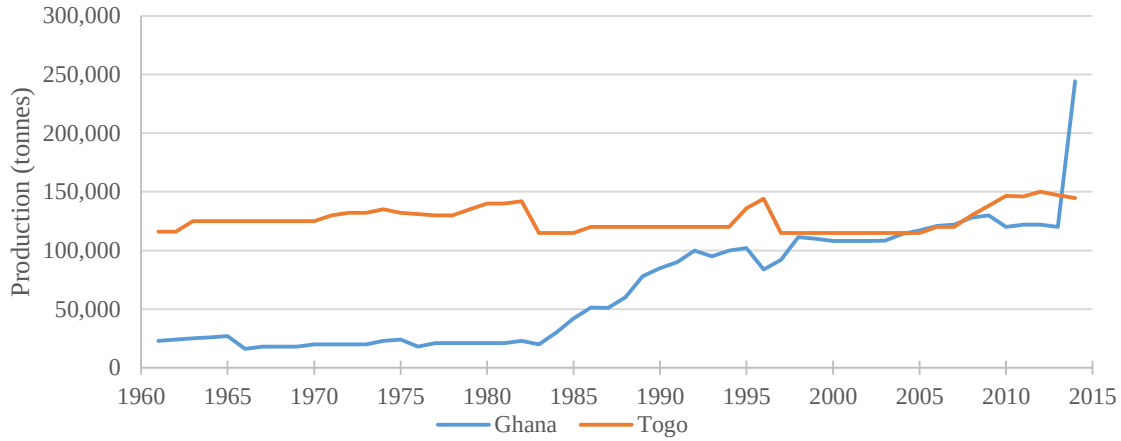
Source: Own elaboration, based on data from FAO, 2017

Figure 29 – Annual production of palm fruit in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 30 – Annual production of palm fruit in Ghana and Togo



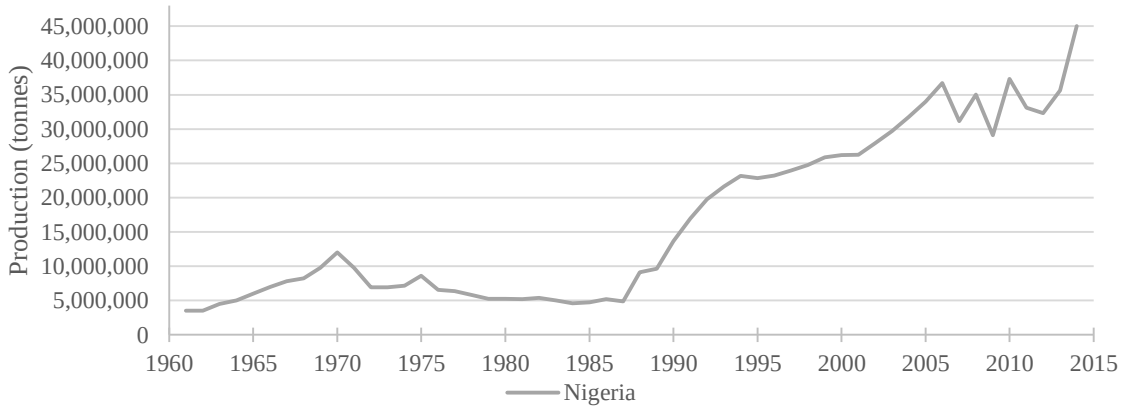
Source: Own elaboration, based on data from FAO, 2017

Table 41 – Average annual yield of palm fruit (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	2.500	2.6688	2.6563	2.5000	2.5000	2.4923	2.6667	2.6264
Ghana	8.3333	6.6652	5.9626	5.5675	5.8642	5.6747	7.2999	7.0000
Togo	8.000	8.5185	8.4923	8.4928	8.5882	8.5714	8.6471	8.6650

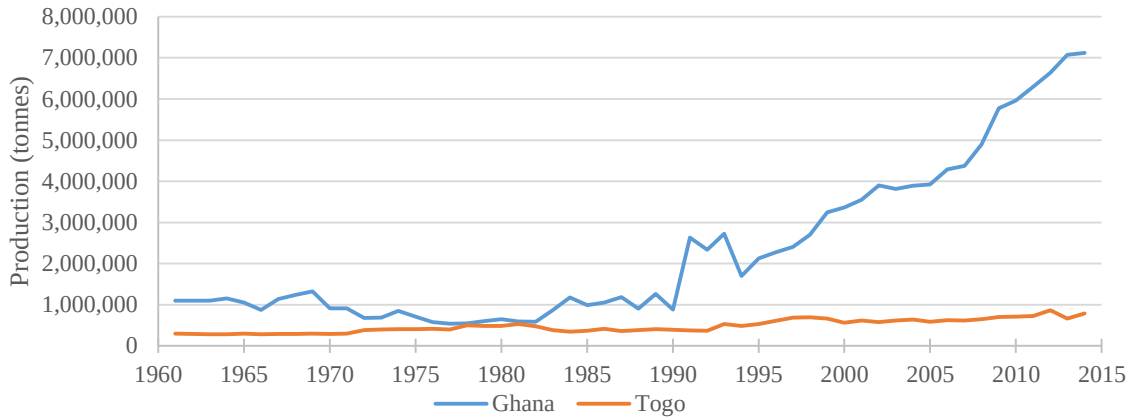
Source: Own elaboration, based on data from FAO, 2017

Figure 31 – Annual production of yams in Nigeria



Source: Own elaboration, based on data from FAO, 2017

Figure 32 – Annual production of yams in Ghana ant Togo



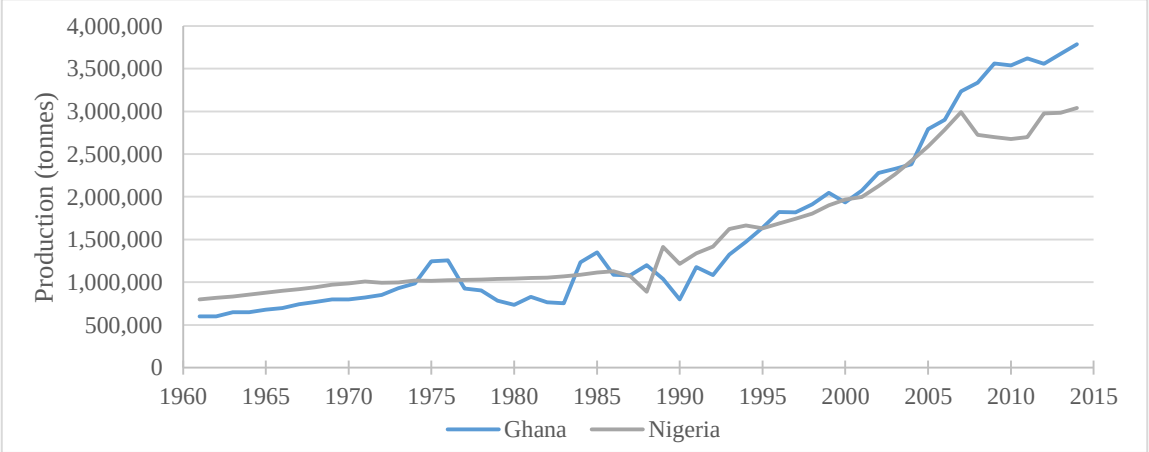
Source: Own elaboration, based on data from FAO, 2017

Table 42 – Average annual yield of yams (t/ha)

	1961	2000	2009	2010	2011	2012	2013
Nigeria	7.77	9.8984	10.4797	13.0109	7.4037	7.2013	7.0001
Ghana	7.33	12.8847	15.2555	15.4841	15.5906	15.5717	16.782
Togo	10	10.9974	10.1826	9.9328	10.2175	8.1334	9.8333

Source: Own elaboration, based on data from FAO, 2017

Figure 33 – Annual production of plantains in Nigeria and Ghana



Source: Own elaboration, based on data from FAO, 2017

Table 43 – Average annual yield of plantains (t/ha)

	1961	2000	2009	2010	2011	2012	2013	2014
Nigeria	3.99	5.10	6.00	5.95	5.94	6.10	6.19	6.24
Ghana	5.45	7.91	10.96	10.78	10.75	10.54	10.83	10.6

Source: Own elaboration, based on data from FAO, 2017