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EDITORIAL

On behalf of the scientific editorial board, I extend my deep appreciation to the contribution made by lecturers and researchers that has led to the successful compilation of this publication. The completion of this volume stemmed from their will, initiative and performance as lecturers and researchers.

KIGALI INDEPENDENT UNIVERSITY ULK has always paid regards to promoting education and impacting the complete development of Rwanda through coupling teaching and research. In the same context, the 33rd volume of ULK Scientific Journal is now out with 3 papers which tackle issues of national and regional concern. The authors of articles in this issue suggest scores of recommendations worth consideration to both policy makers and practitioners.

The first article by **Mr. NGABO YISONGA MATABARO Roch** and **GIRANEZA Olivier,** analyzed the relationship between external debt and economic growth for the period from 1992 to 2013.External debt is among ways the Government uses to face public deficit in view of negative consequences of bank note plate. According to results of analysis, series become stationary after the first difference and are co integrated at 1%. The long run and short run model showed that external debt (EXDT) has a short run and long run effects on gross domestic product in Rwanda for the period under study.

So, it has been concluded that though external debt has some consequences on the Rwandan economy in the long run, it is among engines of growth, especially when it is about a debt for investment.

The second article by **Dr. RUTERAHAGUSHA Roger** and **NZITUKUZE Lionel** is entitled Improved banana production and rural farmers' income growth. Case study of Rugerero sector. This paper shows that banana since long ago, among other agriculture products, has been considered as one of the Rwandan staple food mostly cultivated by rural peasants.

It is unfortunate that in 2005 the above plant was attacked by an expected disease named *xanthomonas wilt(BXW)* known as Kirabiranya in Kinyarwanda. Worried by this very rapid propagation disease, researchers have tried to come up with different alternatives in order to solve this problem through which new varieties of improved banana were introduced. This study was therefore conducted in order to verify if new introduced improved bananas have successfully played a great role in improving farmers' income compared to the local banana.

The last article by **Dr. RUTERAGUSHA Roger** and **NSHIMIYIMANA Jean Claude**is entitled Orange Fleshed Sweet Potato: an alternative for promoting food security and increasing farmers' income in Rwanda. Case study of farmers' cooperatives in Gakenke and

Rulindo districts. This research intended to assess the role of Orange-fleshed Sweet Potato in food security and increase of farmers' income in Gakenke and Rulindo districts of Rwanda.

The findings have revealed that the importance of Sweet Potatoes in the food chain of the two districts is clearly evident where an average of 47.6% of total land is allocated to Sweet potato compared to 52.5% allocated to all other crops. Therefore, the place of orange Fleshed Sweet Potato in providing food and generation of income was clearly identified during this research which confirms the significance role of this new variety as source of food security and income generating crop for its producers.

Dr. SEKIBIBI Ezechiel

Vice Chancellor

EMPIRICAL STUDY OF THE RELATIONSHIP BETWEEN EXTERNAL DEBT AND ECONOMIC GROWTH IN RWANDA PERIOD: [1992-2013].

By

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ABSTRACT

The objective of this article is to analyze the relationship between external debt and economic growth. In fact, external debt is among ways governments use to face public deficit in view of negative consequences of bank note plate. We used time series data for the period from 1992 to 2013. Data were collected from National Bank of Rwanda. The econometric method has been used in order to analyze data. According to analysis of results, series become stationary after the first difference and are co integrated at 1%. The long run and short run model showed that external debt (EXDT) has a short run and long run effects on gross domestic product in Rwanda for the period under study.

We have noticed that *when the external debt (EXDT) increases by 1%, the gross domestic product (GDP) will increase by 0.14% in the long run and by 0.12% in the short run ceteris paribus. So, we have concluded that though external debt has some consequences on the Rwandan economy in the long run, it is among engines of growth, especially when it is about a debt for investment.*

Key words: External debt, economic growth, public deficit, Rwanda.

1. INTRODUCTION

Developing countries are characterized by economic imbalance which occurs through several types of deficits. These imbalances are visible through inflation, weak economic growth rate, the depreciation of the currency, a high rate of unemployment, the imbalance in the balance of payments as well as budget deficit.

Despite efforts of African Governments to increase state revenue, deficit is always a rule for most African countries. Though public finances are a concern for the African States, the latter are unable to mobilize enough resources to deal with growing needs of populations in terms of consumption of public goods. Revenues of State are often insufficient to cover expenses related to operation of the State functioning, including the payment of salaries of public administrative staff, public offices supplies and expenses related to diplomacy, security (army and police), allowances for vulnerable persons and other indigents, expenses related to education, health, etc.

Indeed, the growth rate of the population in African countries is one of the highest in the world. The growth rate of African population is 4.8% per annum in 2013 (the population growth rate of the China, the more populated country in the world

is 0.46%), up from 3.4% in 2011, according to the International Planned Parenthood Federation. If current demographic trends persist, it is projected that the African population will reach 1.4 billion by 2025. According to UNICEF, by 2050, it is projected that one out of every three children born in the world will be an African. The population growth rate of Rwanda was 2.7% in 2013.

States should mobilize more resources to deal with this increase of population. The more the population increases the more government should produce public goods to meet needs of people. To this we can add the depreciation of national currency as well as inflation.

Both, depreciation and inflation end at the decrease national currency value. Hence facing public deficit i.e. increasing public resources is among political and economic measures to face inflation and money depreciation.

In front of public deficit, African countries have not stood idle. However for several decades, they are looking for way to face it. The best solution would be the increase in taxes. Unfortunately, this strategy which is implemented through the increasing of tax rates is of questionable effectiveness for the following main reasons:

- Firstly, it may lead to major economic disruptions through its impact on available income for some direct taxes, which can lead to the decrease in private consumption and thus domestic demand.

- Possible relocation of the production: It concerns especially multinational societies. This relocation can increase the number of unemployed persons.

Indeed according to many studies, tax is among causes of companies' relocation. For instance, an investigation conducted in France showed that 42% of enterprises relocations are due to the taxes increase MOUHOUD el M., (2006:37). The direct consequence of relocation is unemployment.

- It may cause a decrease in tax revenue in the long run: According to LAFFER Arthur quoted by HAYRAULT Jean Olivier (2008) all the burden of the fiscal and special taxes pressure beyond a certain threshold provokes proportionately more important reduction of the taxes basis and therefore of the public income «too many taxes kill the tax» and « too much rate kills the rates».

Intuitively the thesis of LAFFER presupposes that an optimal rate of fiscal pressure would exist and should not be exceeded.

- Reduction of investment and the financial eviction: heavy taxation of enterprises also pushes individuals to be less enterprising. A 2010 study published in the American Economic Journal has reconfirmed the conclusions mentioned above, but adding that an increase in the effective tax rate of between-harvest reduces the investment of those already present on the market, that entrepreneurship (GELOSO Vincent and GUENETTE Jasmine, 2010:1)

Also, African countries undergo constraints linked to the weakness of non-tax revenues. Public aids are insufficient. Therefore they cannot fill the gap due to the weakness of tax and non-tax revenues.

In front of these constraints and taking into consideration difficulties for the State to balance its budget, what means to mobilize sufficient resources in order to meet needs in terms of expenses (balance means that incomes of State must be equal to expenditure), State is obliged to find alternative solutions. Indeed, State faces expenses that cannot be reduced; as a result the latter resorts to other sources of funding apart from tax and non-tax revenues. Two solutions are available for African countries: monetary financing (deficit monetization) and the use of public debt.

Reference to the quantitative theory of money, the use of bank note plate should be reduced because it ends at the increase in the money supply whose consequence is inflation.

Money is linked to inflation by the equation of exchange (MV=PQ) proposed by Irving FISCHER (NATH H.S., 2012).

Thus, despite consequence of debt to the economy, State is obliged to use it as a way to face public deficit. Beside the internal debt which pushes the State to issue securities such as bonds, State also resorts to external loan.

Like other African countries, Rwanda appealed to external debt as exceptional resource to cope with the deficit. For instance, according to the National Bank of Rwanda, external debt of Rwandain 2013 was 338.6 billion Rwandan francs (7.4%) of GDP. In addition, several problems arise when it comes to external debt. These include its management, its contribution to public finances and especially its controversial contribution to growth and economic development.

Despite consequences of debt on the economy of Rwanda, the Government has not stopped resorting to debt from bilateral and multilateral sponsors.

Thus, we can say that the indebtedness of Rwanda is structurally given its connection with the economic situation characterized by weakness of economic growth, the deficit of the balance of payments, national currencies depreciation, inflation, unemployment, budget deficit, etc.

Rwanda is among heavily indebted poor countries in the world but this is particularly due to the 1994 genocide which led to the destruction of its productive potentials. As a result there has been an increased borrowing of money from various sources in order to build various sectors of the economy which has made also repayment of such debts difficult.

Rwanda has to rely on the external debt because of low income, low saving ratios, low investment levels and low taxable capacity which causes the saving- investment deficit as well as the deficit in the balance of payment (BOP). Rwanda's effort to achieve the country's long-term development aspirations as embedded in Rwanda vision 2020 where the objectives are to increase in an equitable way the GDP, to reduce the number of poor people to increase life expectancy and to reduce illiteracy.

The problem under study as presented in the problem statement pushes us to formulate the following question:

Is there any relationship between external debt and economic growth in Rwanda?

The objective of this study is to verify whether external debt and economic growth have relationship during the period of this case study.

During this research we have mainly used secondary data. They were drawn from annual reports of National Bank of Rwanda. We have collected data related to the evolution of the external debt of Rwanda from 1998 to 2013. We have also found data related to the evolution of GDP, debt, labor force, etc. As regards data analysis we have used the econometric method through the E-views software.

This study will be structured as follows: first part is devoted to the general introduction in which the basic part is the problem statement. As it is important to know some theories related to debt, the second part carries on literature review. The third part is devoted to the model building; the fourth part presents and discusses results and finally fourth part presents conclusions related to our findings.

2. LITERATURE REVIEW

A debt is an amount owed to a person or organization for funds borrowed. Debt can be represented by a loan note, bond, mortgage or other forms stating repayment terms and interest requirements if applicable. These different forms all imply intent to pay back an amount owed by specific date, which is set forth in the repayment term. (http://www.investorwords.com\1313debt.html#ixzz21919murN.Retreived on 12\August \2013)

A debt is created when a creditor agrees to lend a sum of assets to a debtor. Debt is usually granted with expected repayment in modern society, in most cases, this includes repayment of the original sum, plus interest.

A Debt is an obligation owed by one party (the debtor) to a second party, the creditor; usually this refers to assets granted by the creditor to the debtor, but the term can also be used metaphorically to cover moral obligations and other interactions not based on economic value.

In finance, debt is a means of using anticipated future purchasing power in present before it has actually been earned. Some companies and corporations use debt as a part of their overall corporate finance strategy.

(http://en.wikipedia.org\wiki\debt.Restrieved on 11\August \2013)

External debt is outstanding loans that one country owes to another country or institutions within that country. External debt also includes due payments to international organizations such as the International Monetary Fund (IMF). The debt may be comprised of fees for goods and services or outstanding credit due to a negative balance of trade. Total foreign debt can be a combination of short –term and long –term liabilities.

Economic growth is an increase in the capacity of an economy to produce goods and services compared from one period of time to another. Economic growth can be measured in nominal terms, which include inflation, or in real terms which are adjusted for inflation.

For comparing one country's economic to another, GDP or GNP per capital should be used as these take into account population differences between countries. Economic growth is an increase (or decrease) in the value of goods and services that a geographic area produces and sells compared to previous time.

If the value of an area's goods and services is higher in one year than the year before, it experiences positive growth, usually simply called "economic growth" in a year when less value than the year before is produced and sold; it experiences "negative economic growth" also called "recession" or "depression".

Economic growth can occur due to an increase in number of goods or services. It can also occur due to production of more expensive goods and services. For example, often as people become wealthier, the types of goods they want change.

While individuals may not eat more food, they may reduce the amount of pasta and potatoes they eat and may increase amount of more expensive foods like meat and dairy. Meeting these changes in consumer demand could create an increase in the value of goods produced and thus, economic growth. (MANKIW.N.G 2003:19)

According to TODARO Michael P. and SMITH Stephen C. (2009:674), external debt is a common phenomenon of developing countries at the stage of development where the supply of domestic saving is low, current account payment deficits are high, and imports of capital are needed to augment domestic resources. Prior to the early 1970s, the external debt of developing countries was relatively

small and primarily an official phenomenon, the majority of creditors being foreign governments and international financial institutions such as the IMF, the World Bank and regional development banks. Most loans were on concessional (low-interest) terms and were extended for purpose of implementing development projects and expanding imports of capital goods.

However, during the late 1970s and early 1980s, commercial banks began playing a large role in international lending by recycling surplus OPEC petrodollars and issuing general-purpose loans to LDCs to provide balance of payments support and expansion of exports sectors.

Although foreign borrowing can be highly beneficial, providing the resources necessary to promote economic growth and development, when poorly managed, it can be very costly. In recent years, these costs have greatly outweighed the benefits for many developing. The main cost associated with the accumulation of a large external debt is debt service.

Debt service is the payment of amortization (liquidation of the principal) and accumulated interest; it is a contractually fixed charge on domestic real income and savings. As the size of the debt grows or as interest rates rise, debt service

charges increase. Debt service payment must be made with foreign exchange. In other words, debt service obligations can be met only through exports earnings, curtailed imports, or further external borrowings. Under normal circumstances, most of country's debt service obligations are met by these exports earnings.

However, should the composition of imports change or should interest rates rise significantly, causing a ballooning of debt service payments, or should exports earnings diminish, debt-servicing difficulties are likely to arise. This has been the experience of most of the heavily indebted LDCs (TODARO Michael P. and SMITH Stephen C. 2009:675).

Furthermore debt is a weight for future generations

Indeed, NAUTET and MEENSEL (2011:10) stated that public debt tends to increase the disposable income of the current generation while – *ceteris paribus* – reducing that of future generations. It therefore seems obvious to assess the debt level in an intergenerational framework.

According to RAFFINOT (1991:63), it is worth distinguishing developing countries or groups of countries for which external financing has a positive impact on economic growth, allowing a no fault of foreign contracted debt repayment, and countries

which have faced difficulties of repayment.

Some countries seem to conform to the theory of the transmitted growth forecasts: external financing has allowed them to increase exports and incomes, thus the debt payback was easy. Cases mostly quoted are those of Asiatic countries, especially “New Industrialized countries”.

Nevertheless, there is no unanimity about the contribution of debt to development and growth when it is about to know whether the relationship is positive or negative.

The economic literature has investigated many channels through which a growing public debt might hamper long-run growth prospects in developing countries, particularly focusing on foreign borrowing. First, a large public debt might create debt overhang, a situation in which investments are reduced or postponed since the private sector anticipates that the returns from their investment will serve to pay back creditors (KRUGMAN, 1988; Sachs, 1989 as cited in PRESBITERO Andrea F., 2010).

LYOHA Milton A. (1999) found that debt stock reduction would have significantly increased investment and growth performance. A 20% debt stock reduction would, on average, have increased

investment by 18% and increased GDP growth by 1% during the 1987-1994 period. Thus, the results demonstrate that debt forgiveness could provide a much needed stimulus to investment recovery and economic growth in sub-Saharan Africa.

In designing a debt management strategy, government debt managers are faced with several choices as to the financial characteristics of the debt. Among them are the following (WHEELER G., 2004:17):

- The desired currency composition of the debt portfolio, including the mix between domestic currency debt and foreign currency debt
- The desired maturity structure and liquidity of the debt
- The appropriate duration or interest rate sensitivity of the debt
- Whether domestic currency debt should be in nominal terms or should be indexed to inflation or to a particular reference price
- Whether the portfolio composition should be transformed through swaps and other hedges, buybacks, or through new issuance.

Many of these decisions involve difficult tradeoffs. For example, foreign currency debt may be seen ex ante as cheaper than the domestic currency debt of the same maturity, since the latter often involves a higher country risk and liquidity premium- perhaps because of inflation and political risk considerations or because the domestic market may be in the infancy. But foreign currency debt exposes the government's balance sheet to currency risk, whereas development of domestic debt markets can help reducing the government's overall balance sheet risk, promote diversification of the investor base, and, on an ex post basis, may result in a lower borrowing costs. Foreign currency debt has in many situations proved to be expensive, especially when domestic economic policies and market conditions have caused the exchange rate to depreciate markedly.

Although the popular view of the burden of the government debt is faulty, economists have pointed out several ways in which the government debt can become a burden on the future generations (ABEL A.B., BERNANKE B.S. and CROUSHORE D., 2011: 591). Firstly, if tax rates have to be raised substantially in the future to pay off the debt; the resulting distortions could cause the economy to function less efficiently and impose costs on future generations. Secondly most people hold small

amounts of government bonds or no government bonds at all (except perhaps indirectly, as through pension funds).

In the future, people who hold few or no bonds may have to pay more in taxes to pay off the government debt than they receive in interest and principal payments; people holding large quantities of bonds may receive more in interest and principal than they pay in increased taxes. Bondholders are richer on average than non-bondholders, so the need to service the government debt might lead to a transfer of resources from the relatively poor to the relatively rich.

However this transfer could be offset by other tax and transfer policies, for example, by raising taxes on high-income people. The third argument is that government deficits reduce national savings; that is, when the government runs a deficit, the economy accumulates less domestic capital and fewer foreign assets than it would have if the deficit had been lower. If this argument is correct, deficits will lower the standard of living for our children and grandchildren, both because they will inherit a smaller capital stock and because they will have to pay more interest to (or receive less interest from) foreignersthan they otherwise would have.

This reduction in the future standard of living would constitute a true burden of the government debt.

Linkage between external debt and economic growth is explained by its answer to the weakness of internal saving.

Increases in savings, investment and macroeconomic variables in an economy lead to economic growth. The growth will not take off until capital stock has risen to a given threshold. As capital rises and investment and output rise, in a virtuous circle, the saving level will also continue to rise after a given level, the rise in both capital and savings will be sufficient to engender self-sustaining growth. The reason for opting for external finance, as a means of ensuring sustained development rather than utilizing only domestic resources is provided by the" dual gap "theory.

The theory postulates that investment is a function of savings and that in developing countries, the level of domestic savings is not sufficient to fund the needed investment to ensure economic development. Thus it is logical to seek the use of complementary external goods and services. The acquisition of external funds, however, depends on the relationship between domestic savings, foreign funds, investment, and economic growth.

A guiding principle on when to borrow is a simple one. Borrowing abroad so far as the funds acquired generates a rate of return that is higher than the cost of borrowing the foreign funds.

In essence, by following this guiding principle, a borrowing country is increasing capacity and expanding output with the aid of foreign savings. External debt does not automatically transform into debt burden when funds are optimally utilized. In optimal conditions, the marginal return on investment is greater than or equal to the cost of borrowing. According to Edelman (1983), the critical factors affecting debt services capacity are returns on investment, the cost of borrowing, and the rate of savings.

3. MODEL BUILDING

3.1. Model theoretical brainwave

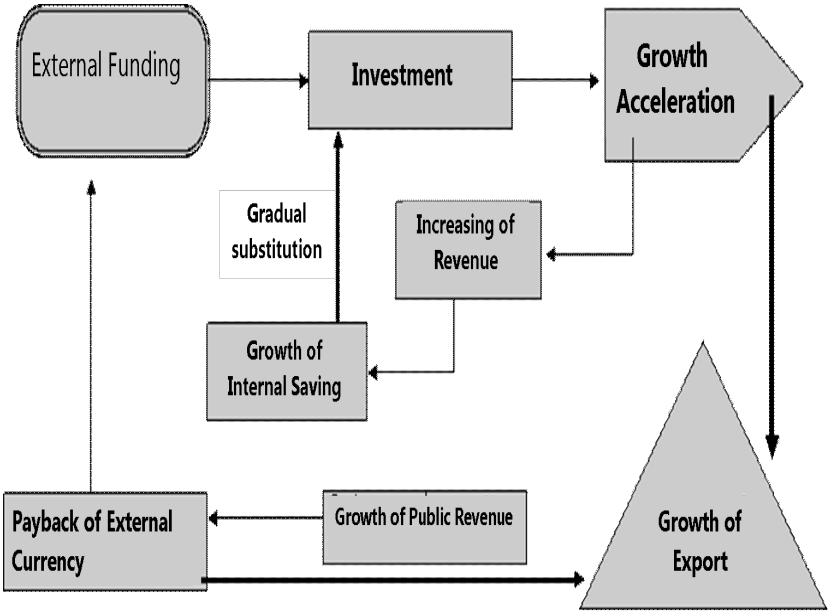
The objective of the model is to verify if external debt has contributed to the economic growth of Rwanda. So, it will be about to test the model to data from Rwanda. The starting point of the construction of the model to be developed in this study is the idea developed by RAFFINOT [1991: 43] according to that research on growth models have highlighted the importance of 'unexplained' part of growth by traditional factors of production (capital, labor). It is difficult to make a reliable assessment of non-directly unproductive expenditures (education, health) on growth. However, some countries have managed to use external financing in a productive way.

For poor countries particularly African countries, debt is unsustainable. Loan in general is used for the development of social and economic infrastructure, which even well managed, do not generate themselves ways for repayment. However even when external funding is not used in investments directly productive, public infrastructure, education and health projects, have a positive impact on growth through:

1. The positive externalities created by public infrastructure

2. The increase in the productivity of the labor factor generated by investment in the education and health sectors.

Therefore, the economic model to develop is inspired by the following frame:



The departure point of the model formulation is the Cobb-Douglas function. In the model apart from capital (investment) and labor as exogenous variables, external debt is taken into consideration.

3.2. Model specification

This model states the analysis of the relationship between external debt and economic growth, where variables like (EXDT), Gross Capital Formation (GCF), Gross national expenditure (GNE) and Labor force (L) are considered as independent variables and GDP as dependent variable.

The regression equation can be presented as following:

GDP= f (EXDT, GCF, GNE, EXPT)

Where:

GDP= gross domestic product at period t

EXDT=external debt period t

GCF= Gross Capital Formation at period t

GNE=Gross national expenditure period t

L=Labor force period t

$\beta_{0=}$ the Intercept.

β_1, $\beta 2$, β_3 and $\beta_{4=}$ the coefficient of the model of regression.

μ_t= error term at period t.

So, the model is presented as following:

$LGDP = \beta_0 + \beta_1 LEXDT + \beta_2 LGCF + \beta_3 LGNE + \beta_4 LL + \mu_t$

3.3.Expected signs

We assume at first that:

β_1, β_2 β_3 and $\beta_{4>}$ 0: This means that independents variables LEXDT, LGCF, LGNE and LL are positively related to dependent variable LGDP.

3.4. Data

The documentary technique was used to collect necessary annual data and they meet scientific standard to be interpreted. The websites of World Bank, IMF, Annual Reports from BNR and dissertations were used to gather the necessary data.

4. PRESENTATION AND INTERPRETATION OF RESULTS

4.1. Test and analysis of data

In this research, we used time series data for the period 1992 up to 2013. It is clear that most of macroeconomic time series data are not stationary. When dependent and independent variables in time series data are non-stationary, a non-sense regression or spurious regression model is likely to occur. The R-square is high but combined with low Durbin Watson statistic, and as a consequence the coefficients seem to be statistically significant while they aren't. This case can mislead the economic interpretation. In order to avoid obtaining misleading statistical inferences the researcher performed the stationarity test of all variables used in the model.

4.2. Stationarity test

Stationary test is the first test to perform on time series data to see whether they are stationary or not. Most of economic time series data are not stationary because they usually have a linear or exponential time trend. Stationary test is very crucial in modeling because since the macroeconomic data without the same moment cannot be included in the same model. In fact, a series to be stationary or not influences the choice of the model to be adopted.

When all series are stationary, we don't have to transform them until they become stationary by differencing them before modeling and estimating parameters associated to the stationarity component.

The rationale behind stationarity lies much on the conventional asymptotic theory for least squares method used in regression. This test is used to know the methodology to be adopted. When the series are stationary, we use the Ordinary Least Squares (OLS), but when the series are non-stationary OLS cannot be used because there may be a non-sense regression or a spurious regression in the terminology of GRANGER and NEWBOLD.

Consider $Y_t$and Y_{t-1}, Y_t is stationary when E (ε), variance and auto variances of Y_{t-1} remain identical to those of Y_t. When series are stationary, its mean, variance and auto covariance of various lags are constant for any point where they are measured, in other words they do not vary over time.

The series in stationary process will tend to turn around its mean and fluctuations around its mean (variance) will have generally constant amplitude.

The stochastic process is stationary if:

Mean: $E(Y_t) = \mu$

Variance: $Var(Y_t) = E(Y_{t-\mu}) = \sigma^2$

Covariance: Cov (Y_t, $_{Yt+k}$) = E $[(Y_t-\mu_t)(Y_{t+k}-\mu_{t+k})]=\Omega_k$

A stochastic process satisfying the above conditions is said to be weakly stationary. A time series that does not satisfy these conditions is said to be non-stationary. So a non-stationary process will have a varying mean over time, a changing variance or both.

A non-stationary process can be stationerized by differencing it n^{th} times. A time series is said to be integrated of order d, written I (d), when after being differencing it d times it becomes stationary. A series is integrated of order zerowhen it is stationary at level.

Examples:

- I (0): The series are stationary at level

-I (1): The series become stationary after the first difference

The Dickey- Fuller (DF) and Augmented Dickey-Fuller (ADF) tests are performed to test the unit root in time series. The following equations are used as basis for the tests:

Alternatives DF equations:

$\Delta Y_t= \alpha_a+\gamma_t+\delta_a Y_{t-1+}\varepsilon_t$: 1^{st} Alternative DF equation

$\Delta Y_t = \alpha_b + \delta_b Y_{t-1} + \varepsilon_t$: 2nd Alternative DF equation

$\Delta Y_t = \delta_c Y_{t-1} + \varepsilon_t$: 3rd Alternative DF equation

If $\delta=0$ is retained in one of these 3 models, there is unit root.

These alternative equations are augmented by addition of the shifted values of the dependent variables ΔY_t lags. The equations are called Augmented Dickey-Fuller Equations.

The equations become:

$\Delta Y_t = \alpha_a + \gamma_t + \delta_a Y_{t-1} + \delta at\ \Delta Y_{t-1} + \varepsilon_t$: 1st Alternative ADF equation

$\Delta Y_t = \alpha_b + \delta_b Y_{t-1} + \delta bt\ \Delta Y_{t-1} + \varepsilon_t$: 2nd Alternative ADF equation

$\Delta Y_t = \delta_c Y_{t-1+} \delta ct\ \Delta Y_{t-1} + \varepsilon_t$: 3rd Alternative ADF equation

The ADF is mostly used because it is assumed to be more accurate (inclusion of $\delta it\ \Delta Y_{t-1}$ improves the results of ADF)

The ADF tests follow these rules:

When $ADF_{cal} < ADF_{crit}$: There is no unit root and $\delta<0$

When $ADF_{cal} > ADF_{crit}$: There is unit root and $\delta>0$

The other test used to test the unit root is the Philips-Peron (PP) test. It follows the rules below:

When the PP_{cal}<PP_{crit}: There is no unit root

When the PP_{cal}>PP_{crit}: There is unit root

Stationary test of the series at level and at the first difference

Table 1: Stationary test of the series at level

STATIONARITY AT LEVEL								
SERIES	MODEL	ADF				PP		CONLUSION
		LAG	τ_t, τ, τ_μ	φ_3, φ_1	T	LAG	τ_t, τ, τ_μ	
LGDP	Constant and trend	4	-3.129	9.069	-3.129	0	-3.185	**GDP** is not stationary at level
	Constant	3	0.4861	3.33	0.4861	0	-0.2311	
	None	3	1.2921	-	1.2921	0	1.036	
LGNE	Constant and trend	4	2.412	5.71	2.412	2	2.514	**GNE** is not stationary at level
	Constant	3	0.489	3.786	0.489	1	0.321	
	None	3	1.379	-	1.379	1	1.488	
LGCF	Constant and trend	2	0.953	1.76	0.953	1	3.103	**GCF** is not stationary at level
	Constant	1	0.033	0.546	0.033	1	-0.206	
	None	1	1.096	-	1.096	2	1.105	
LEXT-DT	Constant and trend	0	-4.11*	9.64	-4.11*	3	-4.66***	**EXTD** is not stationary at level
	Constant	1	-0.482	0.587	-0.482	0	-0.893	
	None	1	0.679	-	0.679	2	0.66	
LL	Constant and trend	0	-2.396	2.87	-2.396	0	-2.39	**EXPT** is not stationary at level
	Constant	0	-2.376	5.64	-2.376	0	-2.376	
	None	0	0.163	-	0.163	3	0.216	

Source: Designed by the researcher from Eviews7 results.

Hint :(*): stationary at 10%

(**): stationary at 5%

(***): stationary at 1%

As series are not stationary at level, let us test the stationarity at the first difference.

Table 2: Stationary test of the series at first difference

STATIONARITY AT THE FIRST DIFFERENCE								
SERIES	MODEL	ADF				PP		CONLUSION
		LAG	$\tau_{t,}\ \tau,\ \tau_{\mu}$	$\varphi_{3},\ \varphi_{1}$	T	LAG	$\tau_{t,}\ \tau,\ \tau_{\mu}$	
DLGDP	Constant and trend	0	-5.566***	15.6	-5.566***	1	-5.551**	**GDP** is stationary at the first difference
	Constant	0	-5.177***	26.8	-5.177***	0	-5.177***	
	None	0	-4.967***	-	-4.967***	1	-4.967***	
DLGNE	Constant and trend	0	-4.638***	10.78	-4.638***	0	-4.638***	**GNE** is stationary at the first difference
	Constant	0	-4.163***	17.33	-4.163***	1	-4.155***	
	None	0	-3.851***	-	-3.851***	2	-3.89***	
DLGCF	Constant and trend	0	-5.878	17.29	-5.878	2	-5.913	**GCF** is stationary at the first difference
	Constant	0	-5.45***	29.7	-5.45***	1	-5.47***	
	None	0	-5.31***	-	-5.31***	1	-5.299	
DLEXT-DT	Constant and trend	4	-3.58*	14.76	-3.58	2	-5.716***	**EXTD** is stationary at the first difference
	Constant	0	-5.34***	28.59	-5.34***	2	-5.377***	
	None	1	-6.56***	-	-6.56***	0	-5.377***	

DL	Constant and trend	0	-4.678***	10.94	-4.678***	2	-4.703***	**EXPT** is stationary at first difference
	Constant	0	-4.812***	23.16	-4.812***	2	-4.847***	
	None	0	-4.937***	-	-4.937***	2	-4.98***	

Source: Designed by the researcher from Eviews7 results.

Hint :(*): stationary at 10% **(**):** stationary at 5%

(***): stationary at 1%

According to the above results extracted from E-views 7, the researcher found that all series are non-stationary at level but they become stationary after the first difference.

4.3 Estimation of the long run model

The long run equation shows the long run relationships in the model. The E-views 7.1 software provided the estimated long run equation as follows:

Table 3: The long run equation of LGDP

Dependent Variable: LGDP				
Method: Least Squares				
Sample: 1992 2013				
Included observations: 22				
Variable	Coeffi-cient	Std. Error	t-Statistic	Prob.
L	0.428267	0.104558	4.095994	0.0008
LGCF	0.348780	0.083273	4.188369	0.0006
GNE	0.017821	0.024858	0.716897	0.4832
LEXDT	0.135271	0.053396	2.533337	0.0214
C	2.388570	1.201247	1.988408	0.0631
R-squared	0.997500	Mean dependent var		21.66251
Adjusted R-squared	0.996912	S.D. dependent var		0.621160
S.E. of regression	0.034517	Akaike info criterion		-3.698007
Sum squared resid	0.020254	Schwarz criterion		-3.450043
Log likelihood	45.67808	Hannan-Quinn criter.		-3.639594
F-statistic	1695.942	Durbin-Watson stat		1.189393
Prob(F-statistic)	0.000000			

Result from E-views 7.1

RGDP=0.428267 *LL +0.348780 *LGCF +0.017821*LGNE +0.135271*LEXDT+2.388570

P-value 0.0008 0.0006 0.4832 0.0214 0.0631

R^2=0.997500

According to these results, the model is over fitted by the gross national expenditure (GNE) because his probability is greater than 10%. The results showed that this variable do not affect the Gross domestic

product in Rwanda. Other variables are statistically significant but are not accurate due to the inclusion of unnecessary variables in the model. The gross national expenditure should be removed.

After removing the gross national expenditure, the E-views 7.1 provided the following results:

Table 4: The long run equation of GDP after removing the EXPT

Dependent Variable: LGDP				
Method: Least Squares				
Sample: 1992 2013				
Included observations: 22				
Variable	Coeffi-cient	Std. Error	t-Statistic	Prob.
LGCF	0.344677	0.081947	4.206086	0.0005
LEXDT	0.141367	0.051998	2.718698	0.0141
LL	0.426098	0.103093	4.133142	0.0006
C	2.767220	1.064232	2.600204	0.0181
R-squared	0.997425	Mean dependent var		21.66251
Adjusted R-squared	0.996995	S.D. dependent var		0.621160
S.E. of regre-ssion	0.034048	Akaike info criterion		-3.759132
Sum squared resid	0.020867	Schwarz criterion		-3.560761
Log likelihood	45.35046	Hannan-Quinn criter.		-3.712402
F-statistic	2323.835	Durbin-Watson stat		1.087470
Prob(F-statistic)	0.000000			

Result from E-views 7.1

Substituted Coefficients:

==========

LGDP = 0.141367*LEXDT + 0.344677*LGCF+0.426098*LGNE +2.767220

P-value (0.0141) (0.0005) (0.0006)

According to these results, the LNGDP, LEXDT, LGCF and LL are statistically significant as their respective probabilities **(0.0141), (0.0005), (0.0006)** are less than a critical value of 10%. The **R^2=**0.997425 and is greater than **0.5.**

From the above findings, the economic interpretation can be stated as follows:

- When **LEXDT** increase by **1%,** then the **LGDP** will increase by 14% and Ceteris paribus.
- The **R^2=**0.997425**>0.5** means that the goodness of fit is better. The variation in LGDP is explained at **99.7%** by LEXDT.

Based on the theory, this result is true because when the External debt increases, the Gross domestic product increase based on the income of people which increases.

4.4. Co integration Test

As many time series data are not stationary, this has pushed some econometrics to develop other theories for time series analysis. ENGLE and GRANGER assumed that a linear combination of two or more non stationary time series may be stationary. The main requirement is that these series are in the same moment, it means that they integrated by same order or the highest order is at least on two series. If this linear combination exists, the non-stationary series are said to be co-integrated. The linear combination that is stationary is said to be the co-integrating equation and may be taken as the long run relationship between variables.

According to ENGLE and GRANGER, different variables in the model are co integrated if the residuals from the long run estimated model are stationary. The co integration suggests the following steps:

1. Test the order of integration of all variables
2. Estimate the long run model
3. Test the stationary of residuals

The 1st and 2nd steps have been performed previously; the remaining step is to test the stationarity of the residuals.

The researcher tests the stationarity of the residuals by using ADF and the formula from MACKINNON. MACKINNON conceived the formula to provide the smaller value than normal critical values. The formula is as follows:

$C(p) = \emptyset_{\infty} + \emptyset_1 T^{-1} + \emptyset_2 T^{-2}$

Where:

- C: MACKINNON value at probability p
- P : Level of probability
- Ø: Response surfaces for critical values of co-integration tests.

Using the MACKINNON formula, these are new critical values computed:

C(1%):-4.298+((-13.790)*1/22)+((-46.37)*1/22^2) = -5.02072

C(5%):-3.7429+((-8.352)*1/22)+((-13.41)*1/22^2) = -4.15024

C(10%):-3.4518+((-6.241)*1/22)+((-2.79)*1/22^2) = -3.74125

The E-views 7.0 provided the following results for co integration

Null Hypothesis: D(RESIDL) has a unit root
Exogenous: Constant

Lag Length: 0 (Automatic - based on SIC, maxlag=4)				
			t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic			-6.093828	0.0001
Test critical values:	1% level		-3.808546	
	5% level		-3.020686	
	10% level		-2.650413	
*MacKinnon (1996) one-sided p-values.				

According to the results from E-views 7, the ADF calculated is equal to -6.093828 The condition of co integration is that the residuals should be stationary, integrated of order 0: I(0). The ADF calculated should be less that the Mackinnon values. In this case:

The ADF cal=- 6.093828 < C (1%) = -5.2072

< C (5%) = -4.15024

< C (10%) = -3.74125

This implies that variables of our model are co-integrated at 1%, 5% and 10%. In other words, the residuals are stationary at level means that there is a long run relationship between the dependent variable and independent variable in our model.

4.5. Error Correction Model (ECM)

The ECM is performed to test whether there is a short run relationship among variables and it is done once we have found co-integration. This shows the correspondence between the co-integration and the error correction mechanisms. For each set co-integrated variable there exist a valid error- correction representation of the data. This correspondence is expressed in the error correction term added in the ECM, the E-views 7.0 helped to run the following ECM model.

Estimation Equation:

==========

DLRGDP =0.128622*DLEXDT+0.322195*DLGCF+0.554655*DLL– -0.628329*RESIDLR (-1)

Where:

$D(LRGDP_t)$: The difference of logarithm of real GDP at period t

$RESIDLR_t(-1)$: Error correction term

$D\ (LEXDT_t)$: Difference of logarithm of external debt at period t

D (LGCFt): Difference of logarithm of gross capital formation at period t

D (LLt): Difference of logarithm of labor force at period t

These are the results found:

Table 5: The error correction model for the LGDP in Rwanda

Dependent Variable: DLGDP
Method: Least Squares
Date: 08/14/14 Time: 14:02
Sample (adjusted): 1993 2013

Included observations: 21 after adjustments				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDL(-1)	-0.628329	0.200664	-3.131247	0.0061
DLEXDT	0.128622	0.041563	3.094596	0.0066
DLGCF	0.322195	0.054135	5.951644	0.0000
DLL	0.554655	0.094881	5.845807	0.0000
R-squared	0.991730	Mean dependent var		0.061947
Adjusted R-squared	0.990271	S.D. dependent var		0.272022
S.E. of regression	0.026832	Akaike info criterion		-4.228821
Sum squared resid	0.012239	Schwarz criterion		-4.029864
Log likelihood	48.40262	Hannan-Quinn criter.		-4.185642
Durbin-Watson stat	1.524848			

Source: E-views 7.0

DLGDP = -0.628329*RESIDLR (-1) +0.128622

*DLEXDT+0.322195*DLGCF+0.554655*DLL

P-value (0.0061) (0.0066) (0.0000) (0.0000)

R2 Adjusted= 0.991730

R^2 Adjusted= 0.991730

The statistical significance of the EC term is that it measures the deviation of the dependent variable from its long run trend. The error correction term represents the mechanism of self- correcting of the system for deviation from its long run trend.

From the results, the EC term is statistically significant; this suggests that the RGDP adjusts to EXDT as lag about 62.8 % discrepancy between long run and short run.

According to the above results, the researcher concludes that there is a short run relationship in our model, because the probability of independent variable is less than 10%. The error correction term is also negative **($RESIDLR_t$ (-1) =** -0.628329.This is a good indicator that the correction of errors is possible. Basing on the value of the error correction term, the researcher conclude that around 62% of all errors will be corrected in one year and seven months

The EXDT explain GDP as his respective probability 0.0066 is less than 10% level of significance.

R^2 Adjusted=0.991730 means that the goodness of fit in short run model is better. The LGDP is explained at 99% by LEXDT in short run.

4.6. Diagnostic tests

The diagnostic tests are useful whether the regression is meaningful. The estimators of the model should be BLUE (Best Linear Unbiased Estimator), a set of classical assumption should be verified. After testing the short run, the supplementary tests are necessary to verify these classical assumptions. The diagnostic tests performed on our regression are:

1. Residual tests
2. Stability tests

4.6.1. Residual tests

These tests are performed on residuals. The residuals tests performed on our regression are the following:

- Residual Histogram Normality Test
- Heteroskedasticity Test
- Correlogram test for autocorrelation
- Serial correlation LM test

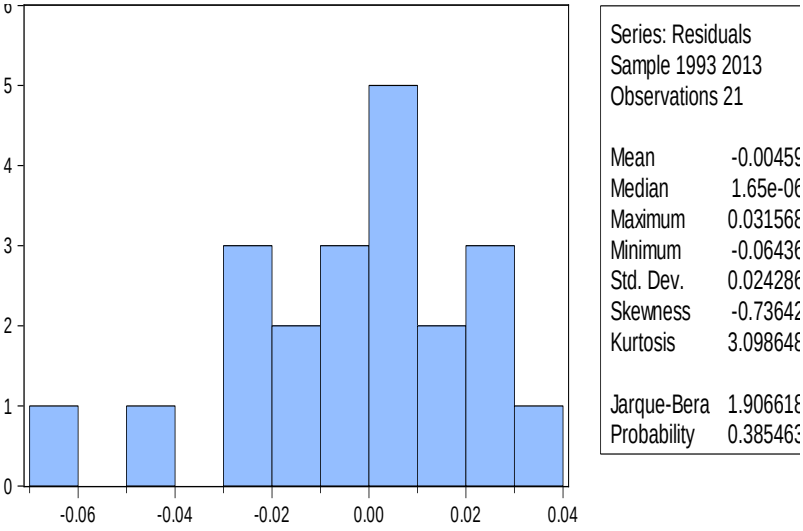
4.6.1.1. Normality test

The normality test is performed on residuals to see if they normally distributed. The two hypotheses of this test are:

- Null hypothesis: Ho: The residuals are normally distributed
- Alternative hypothesis :H1: The residuals are not normally distributed

The researcher, using the E-views, performed this test of JARQUE-BERA and found the following results:

Figure 1: Normality test



Source: E-views 7.0

From this table, the probability of JARQUE-BERA is equal to 0.385463, greater than 10%, so when the JARQUE-BERA probability is greater than critical probability (1%, 5% or 10%), the Ho is accepted. The calculated probability is greater than critical probability, the Ho is accepted. The residual are normally distributed. The normality of residuals shows that the residuals are stationary.

4.6.1.2. Serial correlation

The researcher performed a test to see whether there is no serial correlation. The no serial correlation is one of 10 classical assumptions that should be verified to say that the estimation is BLUE. The following are the hypothesis of this test:

Ho: Absence of serial correlation

H1: Presence of serial correlation

The Ho is accepted when the probability is greater than 10%, in the different case, it is rejected and the model has serial correlation.

Table 6: Breusch-Godfrey Serial Correlation LM Test

F-statistic	1.352661	Prob. F(2,15)	0.2883
Obs*R-squared	2.541626	Prob. Chi-Square(2)	0.2806

Source: E-views7.0

According to the above results, the researcher concludes that there is no serial correlation in the model; the probability is 28% means greater than 10%. The null hypothesis of the no serial correlation is accepted because the probability is greater than 10%.

4.6.1.3. Heteroskedasticity test

The heteroskedasticity test is performed to see whether the variance of residuals is constant and if the classical assumption of homoskedasticity is respected. The following are the hypothesis of the test:

Ho: No heteroskedasticity (presence of homoskedasticity)

H1: Presence of heteroskedasticity (absence of homoskedasticity

Table 7: Heteroskedasticity test

White Heteroskedasticity Test

	White	White	White	White
F-statistic	1.312378	Prob. F(10,10)		0.3378
Obs*R-squared	11.91844	Prob. Chi-Square(10)		0.2906

Source: E-views 7.0

According to the above results, the probability equals 29.06% means that greater than 10%, so the null hypothesis of presence of homoskedasticity is accepted. There is homoskedasticity; the variance of residuals of model under consideration is constant.

4.6.1.4. Correlogram squared residuals

The objective of this test is to show whether the model contains the problem of residuals. The non-autocorrelation assumption should be respected in the choice of the model.

There is autocorrelation when the error of period t influences the error of t influences the error of the following period t+1. The probability of the errors in period t should be independent of the probability of the occurrence of errors in period t+1. The following are the hypothesis of the test:

Ho: Absence of autocorrelation of errors

H1: Presence of the autocorrelation of errors.

The E-views 7.0 provided the following result

Table 8: Correlogram squared residuals

Date: 08/20/14 Time: 10:43						
Sample: 1993 2013						
Included observations: 21						
Autocor-relation	Partial Correla-tion		AC	PAC	Q-Stat	Prob
. | . |	. | . |	1	0.037	0.037	0.0337	0.854
. | . |	. | . |	2	-0.005	-0.006	0.0343	0.983
. *| . |	. *| . |	3	-0.169	-0.168	0.7970	0.850
. *| . |	. *| . |	4	-0.092	-0.082	1.0353	0.904
.**| . |	.**| . |	5	-0.216	-0.219	2.4386	0.786
. *| . |	. *| . |	6	-0.098	-0.131	2.7464	0.840
. | . |	. | . |	7	-0.005	-0.049	2.7472	0.907
. | . |	. | . |	8	0.034	-0.064	2.7894	0.947
. *| . |	. *| . |	9	-0.073	-0.173	3.0050	0.964
. *| . |	.**| . |	10	-0.119	-0.240	3.6293	0.963
. | . |	. | . |	11	0.069	-0.039	3.8591	0.974
. | . |	. *| . |	12	0.023	-0.103	3.8864	0.985

Source: E-views 7.0

The results confirm that there is no autocorrelation in the model because up to 12th lag the probability is greater than 10% critical value.

4.6.2. Stability and Misspecification tests

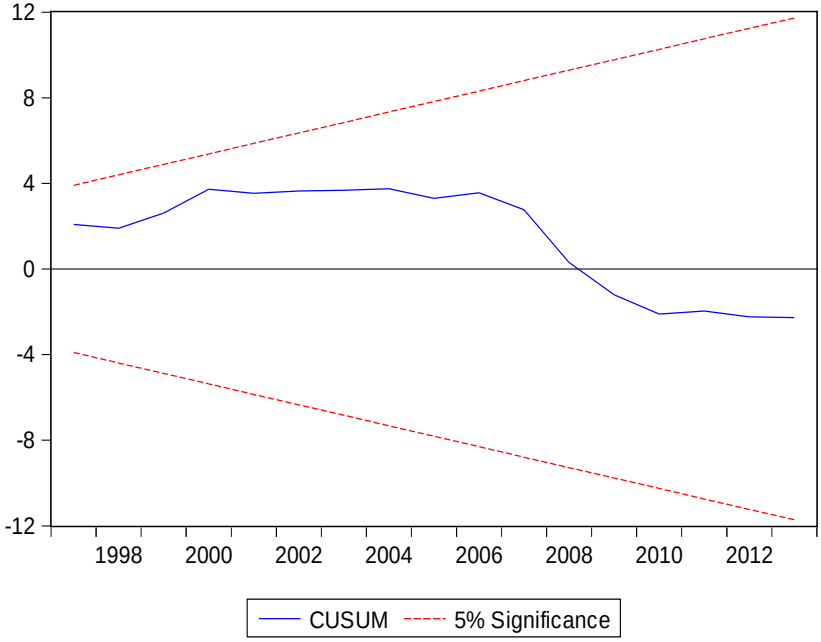
The stability tests are very crucial in econometrical methodology; and the stability condition is determinant in forecasting and policy purpose.

4.6.2.1. Stability test

The stability test is done by the COSUM TEST. This test is based on the cumulative sum of recursive residuals.

The cumulative sum is plotted with the 5% critical lines. The parameter instability is found when the cumulative sum goes outside the area between the two critical. The following figure was provided by E-views 7.0

Figure 2: CUSUM test for stability of parameter



Source: E-views 7.0

The parameters are stable because the cumulative sum does not go outside the area of two critical lines at 5% significance. This test is very important in economics because when the parameters are stable, the predictions or forecasting are possible with the model.

4.4.2.2. RAMSEY RESET test

There is error specification when some necessary variables are omitted in the model or there is adoption of wrong functional form of the model. This error can occur when the stochastic assumption is wrongly made. The model should be well specified to provide results which are not questionable for interpretation, for policy application and for forecasting. The RAMSEY RESET test is used to test the wrong specification of the model. These are the two hypotheses:

Ho: The model is correctly specified

H1: The model is not correctly specified

The following results are provide by the E-views 7.0

Table 9: Ramsey RESET Test

Equation: CORRECT

Specification: DLGDP RESIDL(-1) DLEXDT DLGCF DLGNE

Omitted Variables: Squares of fitted values

T

	Value	Df	Probability
F-statistic	0.111735	(1, 16)	0.7425
Likelihood ratio	0.146142	1	0.7022

Source: E-views 7.0

According to the above results, the probability of the log likelihood ratio is equal to 0.702 or 70.2%

This probability is greater than 10% the null hypothesis is accepted. The model is correctly specified.

5. GENERAL CONCLUSION AND RECOMMENDATIONS

The general objective of this article was an attempt to analyze the relationship between external debt and gross domestic product in Rwanda from 1992 to 2013 using the econometrics. The secondary sources were used to collect data from the National Bank of Rwanda (BNR).

We have analyzed and tested data. Therefore, after testing the relationship between external debt and gross domestic product, the study leads to some results. The series become stationary after the first difference and are co integrated at 1%. The long run and short run model showed that external debt (EXDT) has a short run and long run effects on gross domestic product in Rwanda for the period under study.

The diagnostic tests showed that the model is good and respects the classical assumption of homoskedasticity, no autocorrelation, no serial correlation, and normality of residuals, stability of parameter and correct specification of the model.

Findings of this study suggest that the external debt (EXDT) affects positively the gross domestic product in long run and in short run. When the external debt (EXDT) increases by 1%, the gross domestic

product (GDP) will increase by 0.14% in long run and by 0.12 % in short run ceteris paribus. Based on these results, researchers confirm that external debt (EXDT) has a long run and a short run relationship with Gross Domestic Products (GDP) and external debt (EXDT).

Taking into consideration the following result, we can conclude that, though debt has some disadvantages, it is among the tools likely to help Government of Rwanda to reach its objectives in terms of economic growth. We recommend the Government use debt especially for financing investments whose contribution to economic growth is more direct.

However, resorting to debt should be limited in view of its long run consequences on future generations, on balance of payment, etc.

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IMPROVED BANANA PRODUCTION AND RURAL FARMERS' INCOME GROWTH. CASE STUDY OF RUGERERO SECTOR

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ABSTRACT

Globally the Rwandan agriculture sector has played a very paramount importance in the daily life of the population despite what life could be impossible. The banana since long ago, among other agriculture products, has been considered as one of the Rwandan staple food which could justify the reason why most of rural peasants had banana plantations around their houses or elsewhere in their land.

Recently this crop was attacked by an expected disease named *xanthomonaswilt(BXW)* known as Kirabiranya in Kinyarwanda. In October 2005 this Banana disease was found in two infected sites of Cyanzarwe sector in Gisenyi province now Rubavu District, and in 2006 the banana production declined. Since then the disease has quickly propagated to all sectors of Rubavu District.

Worried by this very rapid propagation disease, researchers have tried to come up with different alternatives in order to solve this problem through which new varieties of improved banana were introduced.

Therefore, this study was conducted in order to verify if those new introduced improved bananas

have successfully played a great role in improving farmers' income compared to the local banana.

The research was conducted following a methodological approach whereby determining the sample size the researchers used the purposive sample and the selection of the sample followed a random stratified method. All banana farmers of Rugerero sector were included according to their sexual and status identity. The size of the sample helped to ensure the accuracy of the reliable data that why it must be optimum.

An optimum sample is the one which fulfills the requirements of efficiency, representativeness, reliability and flexibility.

The formula determined a representative samples of 60 individual as it detailed here bellow.

After analyzing gathered data it was found that the improved banana variety contributes very significantly in increasing the farmers' income than how the local banana can. The facts of that difference are very convincing if the comparison is made between the productivity and the mode of consumption of both varieties.

The reality is that the total income earned in three months (Quarterly income-cost of inputs deducted) as presented in the table 7, is red openly where the improved banana producers at every end of a term earn an income of RWF 406.400 while local banana producers earn only 195.350 after three months.

The improved banana production plays a great role in increasing the income of farmers in Rugerero Sector very significantly far more than local banana.

1. GENERAL INTRODUCTION

Rwandan economy is essentially based on agriculture which contributes nearly 46 % of GDP and occupies 90% of active population. Rwanda development target is guided by Vision 2020 in long term plan and Economic Development and Poverty Reduction Strategy (EDPRS, 2007) in medium term. Due to limited presence of minerals and other natural resources, and current low level of industrialization; the agriculture and animal husbandry will, in the period covered by Vision 2020 and EDPRS, be the main engine for accelerated economic growth and sustained development. The Government of Rwanda perceives the agricultural sector as the major engine of growth, as indicated in the EDPRS, and that agriculture is the largest contributor to national income and food security, and must lead any effort to increase Rwanda's real growth rate.

Rwanda's adoption of an export-oriented growth strategy has implications for the agricultural sector which will seek to increase the unit value of agricultural exports by improving quality and by producing new exportable products. Under EDPRS the agricultural sector aims to promote commodity

chains and support the development of agribusiness. The Government will assist the private sector by improving the investment climate, so that Rwandan exports are competitive in regional and world markets. This will require significant improvements in product quality, and more use of improved agricultural technologies and innovations.

In order to achieve its objectives, the agricultural sector must apply technology innovations to make it competitive in the liberalized global markets by increasing the quantity and the quality of the production.

Taking into account the importance of agriculture sector discussed above, it appears absolutely mandatory to analyze the contribution of this sector to the economic development of the country in general and of the rural households in particular and this research focused on one of the agricultural crops namely the improved banana.

2. **PROBLEM STATEMENT**

Through its vision 2020, the government of Rwanda is determined to make the country become a middle income national in which Rwandans will be more prosperous in all sectors namely economic, health, education, communication, and agriculture. Rwanda expects to transform the dependent country to an economically independent country.

Bananas and plantains constitute the fourth most important global food commodity (after rice, wheat and maize) grown in more than 100 countries over a harvested area of approximately 10 million hectares, with an annual production of 88 million tons (Frison and Sharrock, 1999). The Great Lakes region covering parts of Uganda, Rwanda, Burundi, Tanzania, Kenya and DRC is the largest producer and consumer of bananas in Africa (Smale, 2006) where per capita consumption has been estimated at more than 250 kg; the highest in the world (FAO, 1985).

As reported by the MINECOFIN (2001), banana is the second major food crop in Rwanda next only to beans. It is used both as food and cash crop which presents its very considerable importance in the economies of rural farmers of Rwanda.

Unfortunately in October 2005 a banana disease known as *xanthomonas wilt (BXW)* was found in two infected sites at Cyanzarwe sector in Gisenyi province now in Rubavu District according to the new nominations of the local government reform, and consequently in 2006 its production declined. Since then the disease has quickly propagated to all the surrounding sectors. In 2005 the district began to address BXW through the community work (known as Umuganda in Rwandan language) to remove their infect bananas. www.rab.gov.rw.

However, Rwanda Agriculture Board has introduced a new improved banana variety in order to alleviate such problem of that disease affecting the local bananas by replacing the old variety by a new one as improved by the agriculture research institution.

Despite that those old bananas were affected by the aforementioned disease, it was also paramount to search on new varieties more productive that the existing local crops.

Considering the paramount role of this crop in the Rwandan economy in general and its contribution to the food security of citizens, it has been a trigger for the researchers to conduct a research in order to

assess the impact an improved banana variety can play to assure the non disappearance of the food provider crop.

Therefore, to go in deep the importance of banana production and its role in the Rwandan economy, the research based on the question ”Does improved banana production play a role in increasing incomes of Rugerero Farmers”?

3. OBJECTIVES OF STUDY

This study has both general objective and specific objectives.

3.1. General objective

The main objective of the study is to analyze the contribution of improved banana production in boosting the income of rural farmers.

3.2. Specific objectives

The specific objectives of this work are the following:

- To describe the practice of improved banana cultivation by Rugerero farmers.

- To determine the role of improved banana production in increasing the income of farmers in Rugerero Sector.
- Elaborate some suggestions which can be used in increasing improved Banana production and extension.

4. LITERATUR REVIEW

4.1. Definition of some key concepts

4.1.1. **Banana:** as defined in the web site

(www.hort.purdue.edu/newcrop/morton/banana.html) the word "banana" is a general term embracing a number of species or hybrids in the genus *Musa* of the family Musaceae.

4.1.2. **Xanthomonas wilt (BXW):**

As defined by Bioversity International (2008), *Xanthomonaswilt*, commonly known in East Africa as banana *Xanthomonas wilt* (BXW), banana bacterial wilt or inset wilt, is a devastating disease caused by the bacterium *Xanthomonascampestrispv. musacearum*. It was first reported in 1968 in Ethiopia, where it remained confined until it was discovered simultaneously in 2001 in Central Uganda and the North Kivu, province of the Democratic Republic of Congo (DRC).

4.2. History on origins and spread of edible banana

As read in Uganda National Council for Science and Technology (*UNCST*) (2007),the bananas originated from South East Asia, a region considered as the primary centre of diversification of the crop and where the earliest domestication has occurred. This is an area bordered on the west by India and on the east by Samoa, Fiji and other South Pacific islands (Simmonds, 1962 as cited in *UNCST, 2007)*. *Musa acuminata*is said to have originated from Malaysia, while the hardy *Musa balbsiana* originated from Indochina.

According to Ortiz and Vuylsteke, 1994 as cited in *UNCST (2007)*, the low land areas of West Africa contain the world's largest range of genetic diversity in plantains (*Musa* AAB).

4.3. Varieties

Edible bananas are classified into several main groups and subgroups. Simmonds placed first the diploid *M. acuminata* group 'Sucrier', represented in Malaya, Indonesia, the Philippines, southern India, East Africa, Burma, Thailand, the West

Indies, Colombia and Brazil. The sheaths are dark-brown, the leaves yellowish and nearly free of wax. The branches are small and the fruits small, thin-skinned and sweet. Cultivars of this group are more important in New Guinea than elsewhere. (K. and J. Morton, 1946).

4.4. Banana propagation, growth requirements and agronomic practices as developed by (UNCST, 2007).

Edible bananas do not produce seeds and therefore are clonally propagated using a number of methods. The methods include tissue culture derived plantlets, suckers and split corms sometimes called bits. For good establishment sources and selection of suckers are very important. A new and most promising planting material consists of in-vitro plants which are small suckers produced from meristem culture (Swennen, 1990).

Planting materials can also be collected from an existing old field, and or a multiplication plot planted only for the production of suckers. Seed propagation is only possible in wild bananas which produce vast seeds from open pollinations.

Bananas are mostly cultivated between 30° N and S of the equator demanding a mean monthly temperature of 27°C for optimal growth. They do shrive in both low and high altitudes for instance plantains grow well in lowlands while the East African highland bananas (matooke) survive at altitudes between 1000 and 1800 metres above sea level.

Bananas require well distributed rainfall of an average of 2000 to 2500 mm throughout the year and short dry seasons. Although bananas can be grown on a wide range of soils, deep well drained retentive loam soils, with high humus content are the best (Zake, et.al. 2000). Bananas require considerable amounts of mineral nutrients to maintain yields. Nitrogen, potash and phosphorus are the major nutrients required in bulk quantities and can either be supplied by fertile soils or by commercial fertilizers.

Furrowing and mulching are very necessary to control soil erosion and soil moisture conservation. Mulching can also improve soil fertility as well as controlling weeds at the same time. Sources of mulch can consist of elephant grass (Pennistum purpureum .L), dried weeds and kitchen refuse.

Weed control is an important operation from planting time onwards. Once plants are as tall as 1.5 meters high, herbicides registered for use on bananas can be applied. These include ametryne, simazine, diuron, paraquat and glyphosate (Robinson, 1995). Weeds particularly perennial grasses such as couch grass should be controlled by spraying with systemic herbicides like glyphosate. However, Glyphosphate, diuron and gramuron are not recommended for plantains because they can be phytotoxic (Swennen, 1990).

Although bananas can have good yields as a mono crop, they are mainly intercropped with annual crops such as beans and groundnuts or perennial crops like coffee and cocoa. The usual spacing is 3 x 3 metres when planted as a mono crop but it is adjusted when intercropped. The average size of the hole required for planting bananas is 60 cm wide and 60 cm deep.

4.5. The place of banana in economic development

According to joint research of ATDT-CIAT/ISAR/ IITA-FOODNET/CRS (2002), banana is of great strategic importance in the rural sector in Rwanda

and has been the dominant traditional crop for many years. Over 80% of Rwanda's farms/households (710,280) grow bananas. Its cultivation has for a long time been a feature of great socioeconomic importance from the point of view of food security and job creation. It is associated with several cultural ceremonies. Within the traditional sector of the rural economy, it is used mainly to shade coffee and is an essential component of the diet.

ATDT-CIAT/ISAR/IITA-FOODNET/CRS continue stating that banana makes a significant contribution to food security in Rwanda and the tropics at large. It has a privileged position in urban food distribution and this role has grown over time. Delicate and highly perishable, bananas are produced all year round. The fruit is nutritious, easily digestible and a rich source of carbohydrates, phosphorus, calcium, potassium and Vitamin C. It is eaten both green and very ripe and is prepared using different recipes in various regions of the country. It can be made into different forms such as meal, chips and snack foods and can also be processed industrially.

This importance is convincing looking at the way rural peasants of Rwanda and neighboring countries, since their tradition, have considered

and used the banana as the main source of beer. Bananas were not only consumed as beer but also like fresh eaten bananas and cooked food.

The ATDT-CIAT/ISAR/IITA-FOODNET/CRS (2002), confirmed that Banana is the world's most popular fruit. Its world trade value, estimated at more than US $ 3bn each year, is higher than all other tropical fruits combined. World import demand is estimated at around 12 million tons, representing about 14% of bananas and plantains production.

The rest, estimated at about 65 million tons is eaten locally, implying that only a small proportion of production is being traded. Global trade is in fresh bananas, banana products being of limited importance.

5. METHODOLOGY

5.1. Research design

A case study and survey research designs were used. A case study was used for two main reasons: First, it gave the researchers an opportunity to do an in-depth analysis of one administrative entity namely Rugerero Sector; which could make it possible to understand deeper and better the issues under investigations as far as the distances and size were concerned. Second, since the researchers could not study the entire country of Rwanda due to unlimited limitations such as funds, time concentration among others, a case study of Rugerero Sector was chosen and used as a better substitute.

The production of banana plantation is an activity of a small group of farmers and consequently due to that a purposive sample was essential for such case. Therefore, the researchers targeted a specific group of banana producers among the large number of farmers in order to maximize all necessary information.

5.2. Scope of the study

The study was conducted in Rugerero Sector which is located in the Western Province, in Rubavu District. The study was conducted between September and December 2014. It mainly focused on establishing and analyzing the contribution of improved banana production to rural farmers' income.

5.3. Target Population and sample

In determining the sample size the researcher used the purposive sample and the selection followed a random stratified method, where all banana farmers of Rugerero sector should be included according to their gender and status identity. The size of the sample helped to ensure the accuracy of the reliable data that why it must be optimum.

An optimum sample is the one which fulfills the requirements of efficiency, representativeness, reliability and flexibility.

The formula determined a representative sample of 60 individuals as it is detailed here bellow.

The sample size calculation was done using the formula of Kothari as cited by Mugenda and

Mugenda (1999).

$$n=\frac{z^2 \times p \times q \times N}{d^2(N-1)+Z \times p \times q}$$

Where n: simple size

N: Size of population

(Number of householder)

Z: Coefficient on normal distribution

P: Probability of success

Q: Probability of failure

D: margin error

- The margin error varies between 5% and 10% the study used the margin error 9%
- The confidence level is 95%
- The probability of success (p) is 0.5
- The failure probability (q) is 0.5
- The coefficient normal (distribution (Zo.25) is 1.65
- The size of population is 536 banana farmers

By $n = \frac{z^2 \times p \times q \times N}{d^2(N-1) + Z \times p \times q}$

$$n = \frac{(1.6)^2 \times 0.5 \times 0.5 \times 536}{(0.1)^2(536-1) + (1.6) \times 0.5 \times 0.5}$$

$$n = \frac{2.7225 \times 0.25 \times 536}{5.35 + 0.680625}$$

$$n = \frac{364.815}{6.030625} = 60$$

Using the formula of Kothari, the calculation shows that the sample size to use in this study equal to 60 individuals.

5.4. Methods of data collection

The study used three methods of data collection, namely: self-administered questionnaires, informal interview and document review. The selection of these tools was guided by the nature of data to be collected, the time available as well as the objectives of the study. The overall aim of this study is to analyze the contribution of improved banana production to rural farmers' income in Rugerero sector.

The research was mainly concerned with views, opinions, perceptions, feelings and attitudes. Such information could be best collected through the use of questionnaires and informal interview techniques.

5.5. Data Analysis

Primary data were collected from the respondents in sampled households and secondary data were generated through documentary review. Data were organized in a more meaningful and interpretive way to answer to the study objectives and research questions. After being collected from the field, data were organized and sorted using percentages, tables and tabulation by putting similar findings in one category and dissimilar in another; this was possible with the use of coding and the use of SPSS.

6. PRESENTATION AND INTERPRETATION OF RESULTS

6.1.The Improved Banana Cultivation In Rugerero Sector

There are two types of improved bananas produced in Rugerero sector namely FHIA 17 and FHIA 25. FHIA 17 is consumed firstly as banana fruit and secondly as cooking food. FHIA 25 is an improved banana that produces banana beer and banana juice. Some techniques used in cultivating it in Rugerero sector are the followings: 1) soil preparation by digging a hole of 60 cm of deep and 90cm of width, separate the soil when digging a hole, the first soil in 30cm the one to be mixed with the fertilizer (organic manures). 2) Put the seed in the hole then put that soil mixed with organic manures.

Table1: Agricultural techniques used by farmers in Rugerero Sector

Techniques	Frequency	%
Using fertilizers	51	85
Pest and disease control	60	100
Selection of seeds	60	100
Planting	47	78.3

Source: Field data, November 2014

As it is indicated in the above table, 100% of respondents use the techniques relating to pests and disease control and in planting they use selected seeds. Concerning the planting techniques, 78.3% of respondents use them while the remaining still practice the traditional methods. The use of fertilizer is respected by 85% of respondents.

So far, it is observable that the majority of Rugerero farmers understands and uses the appropriate agriculture techniques. This is confirmed by the high percentage of users as it was highlighted in the table above. The facts that in these sectors farmers are aware and apply the appropriate agriculture techniques, it is an opportunity to enhance the agricultural production. Thus this was the significant reason of adopting the new varieties that can present

the most a high productivity as it is the case of improved banana.

6.2. Source of improved banana seeds in Rugerero sector

Rwanda Agriculture Board (RAB) as a governmental institution in charge of agriculture sector has several ways of which it intervenes in this sector. In accordance with its attributions, RAB has provided for Rubavu District 3 (three) small houses called Macro propagation used to multiply improved banana seeds. Those Macro propagations are constructed in 3 different cells of Rugerero Sector, which are: Gisa, Kabirizi and Muhira. In these three cells one macro propagation has a capacity of multiplying more than 100 seeds. These Macro propagations have been established in order to avail and bring nearer the improved banana seeds to farmers. In the following table gathered data concerns the types of bananas produced by farmers.

Table 2: Types of Banana produced in Rugerero sector

Types of Banana	**Frequency**	**%**
Local Banana	24	40
Improved Banana	36	60
Total	**6o**	**100**

Source: Field data, November 2014

The above table shows that a big number of respondents 60% practices improved banana in their cultivation while 40% of respondents are still practicing the local banana, despite their awareness of its low productivity.

The production of improved banana is still low in this sector and some of the reasons behind that unwillingness of farmers are namely the poor extension of the new variety of banana, the cost of seeds whereas the local seeds are found for free of charge, inaccessibility of seeds, the mind set where farmers still have in their minds that traditional bananas are the only ones of good taste among others. But the number of those who adopted the new variety have proven and convinced some others why the number has increased so far to 60% of producers.

6.3. Factors that affect the choice of farmers

The quantity and quality of produces depend on various factors such as the quality of seeds, production techniques used, the season and different intermediate consumptions.

Also the choice of an agricultural product should be motivated by a number of determinants. Some of them are technical determinants like adaptability of the crop to the region, economic determinant like the availability of market and interesting price, and food security determinant like short period productive crop and high productivity.

Thus, farmers in Rugerero Sector before producing a type of banana thing and decide on which one to produce according to the determinant.

Table 3: Reasons of choosing improved banana

Reasons	**Frequency**	**%**
Productivity	56	93.3
Disease Resistance	51	85
Both reasons	46	77

Source: Field data, November 2014

Based on answers given by respondents 93.3% apply the improved banana due to its productivity. Farmers who prefer to produce improved banana because are more productive equal to 85% and those motivated by the both factors productivity and resistance to disease are representing 77%.

Referring to the above high rates of improved banana adoption, it clearly realized that the cultivation of this crop owe a particular interest.

6.4. Production of improved banana in Rugerero sector

As the improved banana was adopted by a good number of farmers in Rugerero Sector some results of its production are observable. In the following table are presented data concerning the weights of improved bananas produced.

Table 4: Weights of improved bananas produced.

Weights (one banana)	Frequency	%
More than80kgs	18	30
80kgs-60kgs	56	93.3
60kgs-45kgs	40	67
Less than 45kgs	6	10

Source: Field data, November 2014

The average weight produced of improved bananas in Rugerero Sector is between 80kgs-60kgs as it was confirmed by the majority of respondents is 93.3%.

It is obvious to everyone who is familiar to the agriculture sector to compare how this weight of 80kgs-60kgs for one banana is far beyond what is produced from local bananas that normally can't exceed forty kilograms. According to productivity of this variety it is obvious to understand why so many farmers adopted its production.

6.5. Contribution of improved banana in increasing farmers' income in Rugerero Sector

Table 5: Comparison of local and improved bananas in boosting the producers' income

Types of banana	Average land	Number of bananas trees and production in kgs (Quarterly production)	Quarterly income(price of one kg= RwF90)
Local bananas	1ha	67bananas=3015kgs	3015*90=271.350
Improved bananas	1ha	67bananas=5360kgs	5360*90=482.400

Source: Field data, November 2014

The data from the table above show the difference between local and improved bananas production in (kgs) and in income. The average of cultivated land is 1 ha for both, local and improved banana. For the weight of one banana, the average is 60 kgs for improved bananas and 45 kgs for local bananas.

In making the comparison between local and improved banana's income and production, on the same size of land used of 1ha, the quarterly production of local banana is 3015 kgs that gives an income of RwF 271.350. The quarterly production for improved banana is 5360kgs, which gives an income of RwF482.400.

According to the abovementioned differences, the improved banana is highly contributing to the producers' income almost the double than the local banana. That significant difference proves that this variety can contribute to the economic development of farmers but also to the economy of the country if adopted by all banana producers instead of wasting time and capitals producing local crops.

Table 6: Different usages of banana production

Product	Consumption of a variety of banana	
	Local	Improved
Banana juice	23	5
Banana beer	37	10
Eating banana	0	45
Other	0	0
Total	**60**	**60**

Source: Field data, November 2014

The consumption of both varieties is different taking into consideration the points of views of respondents. As it was indicated by farmers, the local banana is consumed as drinks either as juice or beer. 23% of them use it to produce juice and 37% they produce beer from their produced banana. For the improved banana majority of respondents 40% confirmed that is produced in their area and consumed as food. Considering the importance of food in the entire family, it is clear enough that the improved banana place a very significant role in the whole welfare of the community.

Some of the benefits people may gain from this type of crop are linked to the daily life. Here it can be highlighted that first of all human being before

satisfying all their other need must feed themselves. In this respect, it is obvious to be worried when the family lacks food and is in shortage of drinks. However, even though food is necessary and very important in the family welfare, the drinking is also needed. This variety of banana is both food source and drinking making product.

According to this, all these benefits from improved banana should be recommended to all banana producers in order to increase not only their welfare but also their economy as long as it is needed by so many people.

Table 7: Quarterly total income received by farmers from banana cultivation

Types of bananas	**The approxi-mate cost of inputs used in 3 months (in RwF)**	**Quarterly income (in RwF)**	**Total income earned in three months (Quarterly income-cost of inputs used) in RwF**
Local bananas	76.000	271.350	271.350-76.000=195.350
Improved bananas	76.000	482.400	482.400-76.000=406.400

Source: Field data, November 2014

The above table shows how the total quarterly income of improved bananas is greater than the total quarterly income of local bananas. Those two types of bananas have the same cost of inputs of RwF76.000 approximately because inputs used are the same in local and improved bananas cultivation.

The comparison using calculations quarterly production for improved banana is RwF482.400 and the quarterly production for local bananas is RwF271.350. The above results show that improved bananas help farmers increase their income positively far more than local bananas.

The total income earned in three months (Quarterly income-cost of inputs deducted) it is presented as follow: the improved banana producers at every end of a term earn an income of RWF 406.400 while local banana producers earn only RWF195.350 after three months.

6.6. Marketing of improved banana production in Rugerero sector

Banana products are consumed by different people in different areas as shown in the table 8 below.

Table 8: Banana consumers

Consumers	**Frequency**	**%**
Local farmers	10	16
Village market	34	57
Gisenyi market	16	27
National market	0	0
Total	**60**	**100**

Source: Field data, November 2014

More than half of respondents which is 57% sell their banana products to nearest markets located in their villages. 27% try to go and find markets of their production at Gisenyi town market where they expect to get a high price than what they get from the local market. Only 16% sell their products to the neighbors.

The production of improved bananas in Rugerero Sector is a reality but the producers are still lacking a sure market of what they produce. Some of the reasons can be mentioned namely the poor infrastructures like bad status of roads which

affects negatively the price of products due to a high cost of transportation, there is also the problem of spending much time while taking the products very far where many customers are, the long distance from the field to market is another challenge which leads to the lack of confidence in fixing profitable prices by sellers, to name but a few.

CONCLUSION

Guided by the question "Does improved banana production play a role in increasing income of Rugerero farmers?" and basing on the main objective of the study which was to analyze the contribution of improved banana production in boosting the income of rural farmers, primary and secondary data were collected and analyses. Some scientific techniques and methods were used in order to test the validity of findings.

After analyzing the collected data it was found that the improved banana variety contributes very significantly to the increase of the farmers' income than how the local banana can. The facts of that difference are very convincing if the comparison is made between the productivity and the mode of consumption of both varieties.

The reality is that the total income earned in three months (Quarterly income-cost of inputs deducted) as presented in the table 7, is read openly where the improved banana producers at every end of a term earn an income of RWF 406.400 while local banana producers earn only 195.350 after three months.

The improved banana production plays a great role in increasing the income of farmers in Rugerero Sector very significantly far more than local banana.

Suggestions

To Rwanda Agricultural Board (RAB)

It is noted that in recent years plenty of efforts have been put into analyzing banana production, constraints and identification of appropriate solutions. Some of solutions were already on shelf in other countries, other solutions still require a lot of efforts to generate them (example: resistance hybrids), though the work has already been initiated but it is still at a low level for example the distribution of resistant varieties. Therefore, for the extension of improved banana cultivation, RAB must increase the number of farmer field school in order to increase the number of producers of improved banana.

To improved banana farmers of Rugerero sector

- Replace the production of traditional varieties of banana by the improved ones due to its productivity which is higher than local banana.

- The population of Rugerero Sector should practice the cultivation of improved banana professionally for benefiting from the potentials of their sol which favorable to this crop.

- The farmers should group themselves into cooperatives so that they can access easily the necessary facilities for the banana production, marketing and processing.

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ORANGE FLESHED SWEET POTATO:

AN ALTERNATIVE FOR PROMOTING FOOD SECURITY AND INCREASING THE FARMERS' INCOME IN RWANDA

Case study of farmers' Cooperatives in Gakenke and Rulindo Districts.

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ABSTRACT

Sweet potato is a food crop that is widely cultivated in most parts of the world and is particularly very important to human and animal health due to its high nutrition value. This was the trigger factor for carrying a research concerning the importance of Orange Fleshed Sweet Potato as an alternative for promoting food security and increasing the farmers' income in Rwanda under the case study of Gakenke and Rulindodistricts.

The research intended to assess the role of Orange-fleshed Sweet Potato in food security and increase of farmers' income in Gakenke and Rulindo districts of Rwanda through the following specific objectives: to assess the average proportion of the households' land (in square meters) that is under Orange-fleshed Sweet potato farming compared to the other varieties/ crops grown at household level in Gakenke and Rulindo districts, to assess the average proportion of nutrients found in Orange-fleshed Sweet potato varieties compared to those found in other type of Sweet potatoes varieties grown (white and yellow flesh colored) and to assess the average proportion of income earned from Orange-fleshed Sweet potatoby local farmers compared to those earned from other varieties/crops grown by the households in Rulindo and Gakenke districts.

The findings have revealed that the importance of Sweet Potatoes in the food chain of the two districts is clearly evident where an average of 47.6% of total land is allocated to Sweet potato compared to 52.5% allocated to all other crops. Orange fleshed Sweet potato has been allocated an average of 30.5% compared to 17.1% allocated to white and yellow fleshed Sweet potato. It was also highlighted that Orange fleshed Sweet Potato was the second with (18.8%) in comparison of crop contribution to production and income generating where the maize was with (35.6%) in ranking the greatest contributor to the household income.

Therefore, the place of orange Fleshed Sweet Potato in providing food and generation of income was clearly identified during this research which confirms the significance role of this new variety as source of food security and income generating crop for its producers. So far its adoption in the areas of Sweet Potato production is still limited and that why a particular extension should be applied.

1. General Introduction

1.1. Background to the study

Agriculture is one of the key growth engines for Rwandan economy. It is at the heart of Rwanda's economy. The sector employs 79.5 percent of the labor force, contributes one-third of GDP and generates more than 45 percent of the country's export revenues. Agriculture also plays a very critical role in ensuring national food security, accounting for over 90 percent of all food consumed in the country. The sector plays a key role in the realization of Rwanda's vision of transforming the country's economy by the year 2020.

Given its predominant role in the economy, agriculture is considered as a main catalyst for sustainable growth and poverty reduction (World Bank, 2011). Some of the commonly grown food crops in Rwanda include Sweet potatoes, Irish potatoes, cassava, bananas, beans, wheat and maize. Small-scale farmers also raise livestock, such as goats, cattle, sheep, pigs and chickens.

Sweet potato (Ipomoea batatas L) is important in human and animal nutrition. It is commonly referred to a subsistence, food security or famine relief crop, its uses have diversified considerably in the developing countries (Scott and Maldinado, 1999).

Sweet potato is highly perishable once harvested unless processed, immediately consumed or supplied to the market. Because of the importance attached to the crop there was need to introduce clones that are high yielding and high in vitamins to the farming community so as to improve their nutrition, secure food security and income generation to supplement maize, wheat and dairy enterprises (Lusweti et al, 1999). Sweet potato is an important food security crop in Rwanda grown mainly for local consumption and to generate family income.

Rwanda is indeed Africa's second leading producer of Sweet potatoes after Uganda, followed by Burundi (Ingabire & Vasanthakaalam, 2011). These facts therefore demonstrate the significance attached to the Sweet potato crop and the vital place it occupies in the food chain for the Rwandan population and beyond.

According to Hacineza et al (n.d) citing Food and Agriculture Organization (FAO) and International Potato Center (CIP) reports published in 2002 and 2000 respectively, Sweet potato ranks as the world's seventh most important food crop after wheat, rice, maize, Irish potato, barley, and cassava . It is rich in starch, calcium, potassium, vitamins A and C and anti-oxidants, all of which are very essential for optimal health. Although Sweet potato leaves are

also eaten in some parts of the world, the root is the most popular part of the crop.

Sweet potato leaves are also very nutritious as they contain iron, potassium and vitamin C and K.

In the recent years, its uses have diversified considerably, especially in developing countries. For example, apart from being boiled, it can be ground into flour for making bread and other baked products (Ogero, 2009).

Per capita sweet potato production in Rwanda is among the highest in Sub-Saharan Africa over 80 kgs per capita with the white-fleshed variety most consumed which contains negligible amounts of beta-carotene (Tumwegamire*et al*; 2004). Although there are over 212 varieties of Sweet potatoes cultivated in Rwanda (Ingabire & Vasanthakaalam, 2011), most of these are basically broadly classified in terms of the color of the tuber skins with common colors being yellow, and white, purple and orange colored Sweet potatoes. Others are popularly known by their local names usually in Kinyarwanda dialect such as the Kwezikumwe, Mugande and Rutambira.

The recently introduced Orange-fleshed Sweet potato (OFSP) varieties have particularly generated great interest from both farmers, consumers, researchers, governmental and Non-Government

Organizations. Early indications point to these varieties rapidly gaining acceptance by among others the farmers in Rwanda.

The Government of Rwanda in its efforts to raise the productivity of rural economies has recognized the need for promoting these traditional crops, and particularly the new varieties which have potential for high yields.

This is in line with the general agricultural policy to ensure sustainable development by transforming the agricultural sector into a high value and high productivity sector.

One of those activities that can contribute more in rural development is moving from traditional agriculture to modern agriculture by growing high value and nutritional orange Sweet potato varieties (NISR, 2012).Below is a quick overview of the OFSP.

After the introduction of OFSP varieties in Rwanda, it was realized that these new varieties have the potential to address VAD concerns and further boost rural farming productivity.

For instance, preliminary observations show that the adoption of OFSP in Gakenke District and respect of agronomic practices increased yield from 4 tons to 12 tons per hectare leading farmers to appeal to government to avail more land to them to undertake the

cultivation of the crop (New Times, 15/10/2012), the leader of one of farmers' association attested to this when he was quoted by The New Times (Rwanda) in an interview lamenting, "we have a new variety of Sweet potatoes which is more productive despite our small farm sizes of land".

Research done by ISAR (2006), has also shown that there is a potential for Sweet potato flour to substitute imported wheat flour at 20% for bread and 40% for other bakery products.

Even though there is the potential of substituting 20 to 40% of wheat flour with Sweet potato flour, the willingness of processors to adopt the technology is still limited. However, currently there are some famer's groups and cooperatives which are interested in the promotion of white and orange fleshed Sweet potato by substituting 20% of wheat flour with Sweet potato either as flour or as mashed fresh Sweet potato in biscuits and potentially in bread and doughnut.

Despite being a relatively new variety of Sweet potato in Rwanda, the Orange-fleshed Sweet potato appears to harbor huge potential both in terms of nutritional value and productivity thereby contributing to increased farmer incomes, as well as boosting food security in Rwanda.

More needs to be done to entrench the crop firmly within the farming fraternity. However, due to its newness in the Rwandan economy, studies targeting the Orange-fleshed Sweet potato were found to be scanty.

There is urgent need therefore for researchers and other interested parties to carry out more studies to generate more knowledge on Orange-fleshed Sweet potato variety and its role in the food chain of the Rwandan society.

This study sought to assess the role of Orange-fleshed Sweet potato in food security and household incomes in Rwanda, with specific focus on four farmers' cooperatives in Gakenke and Rulindo districts respectively.

1.2. Problem Statement

Sweet potato is the single most important provider of calories in the Rwandese diet and has been a key contributor to Rwanda's self-sufficiency in food especially during the period of production. Sweet potato is unparalleled in its ability to provide a wide variety of nutrients, all from one type of food. It is rich in starch, calcium, potassium, vitamins A and C and anti-oxidants such as β-carotene, all of which are very essential for optimal health.

Sweet potato is grown abundantly in rural areas including Gakenke and Rulindo districts but some people suffer from hunger after a short time of harvesting and because Sweet potato is perishable and there is not simple techniques of storage for keeping the roots for longtime (Mutuyemaliya, 2012). In period of high production of sweet potato, sometime, there is problem of malnutrition diseases to the children due to vitamin A deficiency (VAD) by lack of additional nutritional value while the production was high with less demand then low income to the growers.

In terms of food security and malnutrition, the country has made a lot of efforts but Rwanda is still facing many developmental challenges including population growth, widespread poverty and high levels of chronic malnutrition (NISR, 2012). According to the reports of National Institute of Statistics of Rwanda (2012 & 2009), one in five Rwandan households (21%) had unacceptable food consumption and could be considered to be food insecure.

Out of the total population, 4% had poor food consumption, which represents an extremely insufficient food consumption. The prevalence of chronic malnutrition among children aged between six months and five years has remained 'very high'

in Rwanda over the last 20 years and still stands at 43,9% making it one of the countries with the highest chronic malnutrition rates in the region. The northern livelihood zones (where Rulindo & Gakenke districts are located) have the highest rates of stunting, exceeding 60%.

In terms of household income, households relying on more diversified activities, and especially urban households not involved in agricultural production, are better off in terms of food security and their household income is high. Some 60% of farming households cultivate plots smaller than 0.5 ha (26% below 0.2 ha) often on steep slopes with poor soil fertility (NISR, 2009).

The role and place of Sweet potato in the Rwandan society can not therefore be over-emphasized. Sweet potato is simply part and parcel of the Rwandan diet and the crop yields highly. Despite the importance of sweet potato, its progress has however been hampered by limited land and use of inadequate agricultural techniques leading to the low productivity, use of traditional sweet potato varieties (white and yellow) which have low nutritional values, inappropriate/ lack of storage methods and facilities, lack of sustainable market and limited value addition techniques (Kirimi, 2013).

The recent introduction of new Sweet potato varieties in the Rwandan economy known as Orange-fleshed Sweet potato was therefore a blessing in boosting the productivity of Sweet potatoes in the country, increase farmer incomes and overcome challenges related to Vitamin A Deficiency (VAD) as well food security. The new OFSP varieties were found to increase fourfold the Sweet potato productivity per hectare of land besides being a source of several vital nutrients required by the body for optimal health.

There is however little or no adequate studies conducted in Rwanda in the past to provide more facts and the role of this new type of sweet potato. In particular studies on the role of Orange-fleshed Sweet potato in boosting incomes and food security are scarce. This study aims at assessing the role of Orange-fleshed Sweet potato in increasing farmer incomes and increasing food security in four districts of Rwanda namely Rulindo and Gakenke via two farmers' cooperatives formed and operational in the two districts.

1.3. Objective of the study

1.3.1. **General objective**

The general objective of the study is to assess the role of Orange-fleshed Sweet

potato in food security and increase of farmers' income in Gakenke and Rulindo districts of Rwanda.

1.3.2. **Specific Objectives**

- To assess the average proportion of the households' land (in square meters) that is under Orange-fleshed Sweet potato farming compared to the other varieties/crops grown at household level in Gakenke and Rulindo districts.

- To assess the average proportion of nutrients found in Orange-fleshed Sweet potato varieties compared to those found in other type of Sweet potatoes varieties grown (white and yellow flesh colored).

- To assess the average proportion of income earned from Orange-fleshed Sweet potatoby local farmers compared to those earned from other varieties/crops grown by the households in Rulindo and Gakenke districts.

1.3.3. **Research Questions of the study**

1. What is the average proportion of the households' land (in acres) that is under

Orange-fleshed Sweet potato farming compared to the other varieties and crops grown at household level in Gakenke and Rulindo districts?

2. What is the average proportions of nutrients found in Orange-fleshed Sweet potato compared to those found in other type of Sweet potatoes grown (white and yellow flesh colored)?

3. What is the average proportion of income earned from Orange-fleshed Sweet potato by local farmers compared to those earned from other crops varieties/grown/livestock kept by the households in Rulindo and Gakenke districts?

1.3.4. **Significance of the study**

The results of the study contributed in solving the problems of the farmers where they were facing a shortage of adequate food of rich nutrients and also rareness of necessary income for their families' daily life. The findings of this study would be highly contributing as follow:

a) The farmers after practicing the cultivation of this Orange-fleshed Sweet potato rich in vitamins will no more face a rare of calories necessary for their health.

b) Considering the values of this variety the producers will gain more income useful purchasing other needed good.

c) The economy of the country will get improved due to the increase of the agriculture production as long as the role of the agriculture sector in the Rwandan economy is not negligible.

d) The high level of Orange-fleshed Sweet potato production can stimulate the processing of this crop into other products.

2. Review of Related Literature

2.1. Theoretical Perspectives

The concept of 'food security' has developed over the past three decades. Concerns about food security up to the end of the 1970s were directed more at the national and international level, and concerned the ability of countries to secure adequate food supplies. Only later did the level of analysis shift to include a focus on food security at local level, even down to households and individuals.

Food insecurity may cause irreparable damage to livelihoods, thereby reducing self-sufficiency. It is therefore part of the process leading to malnutrition, morbidity and mortality (Helen Young, 2001).

The same author defines food security as: when everyone has at all times access to and control over sufficient quantities of good quality food for an active healthy life. The two elements of food security are: availability (the quality and quantity of the food supply); and access (entitlement to food through purchases, exchange and claims).

According to FAO (2011), Food Security is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life. Food security is essentially built on three pillars: food availability, food access, and food utilization.

An individual must have access to sufficient food of the right dietary mix (quality) at all times to be food secure (FAO 2011). Based on the theory of FAO, by food availability, sweet potato provides higher yields per given area in a shorter time compared to maize or cassava and Improved, early maturing sweet potato varieties are ready in 3- 5 months and can be grown the whole year around.

For food access, some sweet potato varieties can be stored in the ground for sometimes and farmers in rural areas eat sweet potato roots almost every day during the week. Food utilization, unlike white or yellow varieties, orange-fleshed sweet potato

provides significant amounts of vitamin A, which is critical for children and pregnant women. Both the roots and leaves of sweet potato are highly nutritious.

A wide range of OFSP roots, OFSP-based processed products, such as bakery products, juice, chips, crisps, flour and noodles, can open up new markets for the food industry and thus increase the income of farmers and household in general.

According to the reports of National Institute of Statistic of Rwanda, 2012 & 2009, one in five Rwandan households (21%) had unacceptable food consumption and could be considered to be food insecure. The prevalence of chronic malnutrition among children aged between six months and five years has remained 'very high' in Rwanda over the last 20 years and still stands at 43%,9 making it one of the countries with the highest chronic malnutrition rates in the region.

The northern livelihood zones (where Rulindo&Gakenke districts are located) have the highest rates of stunting, exceeding 60%.

In terms of household income, most of households are relying on faming activities and hence the income is lower compare to those who are not involved in agricultural production which is better off in terms

of food security and their household income is high. Some 60% of farming households cultivate plots smaller than 0.5 ha (26% below 0.2 ha) often on steep slopes with poor soil fertility (NISR, 2009).

To overcome these challenges, SASHA project in Rwanda investigated on how to effectively connect smallholder sweet potato producers to the sustainable markets (including agro-processors, urban and rural markets, school and supermarkets) through effective sweet potato value chains.

Four cooperatives located in two districts of Rulindo and Gakenke are producing and selling orange fresh roots to the processors (mainly at SINA Gerard), local markets (nearby cooperatives location), Schools and individual consumers as well as selling vines to the fellows' farmers and International Non-Governmental Organizations. During the project, following assumption are being tested:

(i) That clean planting materials (vines) of high yielding orange-fleshed sweet potato are available and accessible to the farmers and multiply them.

(ii) That farmers' cooperatives are willing to grow and sell the production at the agreed markets in form of flesh roots, semi processed products and final products.

A clear model has been developed as described below.

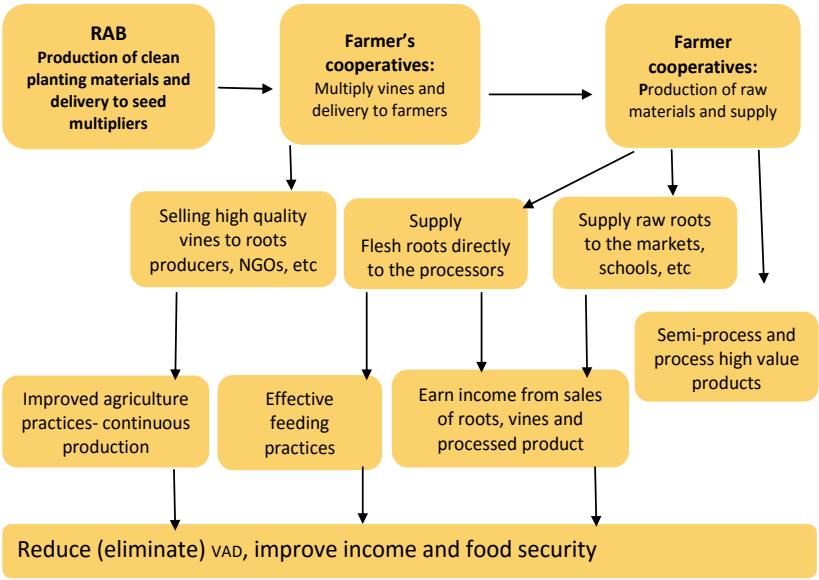


Figure 1. Sweet potato value chain under SASHA Project

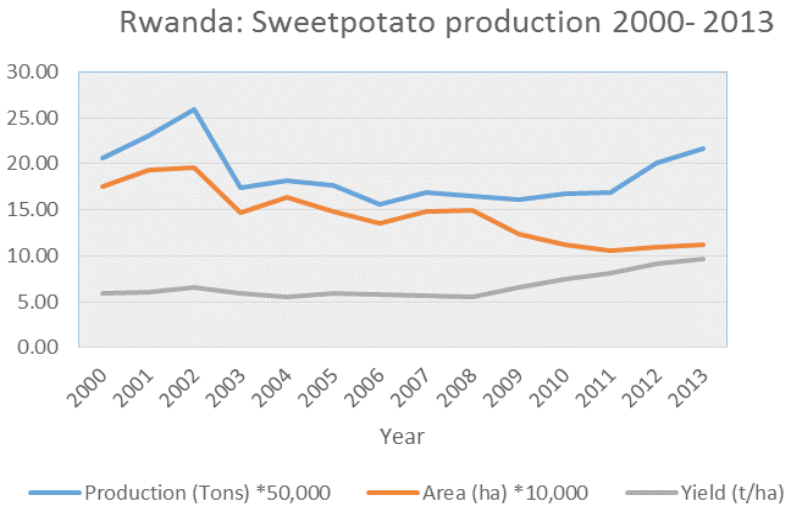
2.2. **Sweet potato in Rwanda**

Sweet potato has been widely adopted in Rwanda, as in many relatively humid areas of Africa, due to its high yield (relative to land, labor, and time), its capacity to grow in poor soils, and its high content of carbohydrates and vitamins. Sweet potato and beans provide the common diet of Rwandans, beans for most people being the essential source of protein, as meat is a rare luxury for most (Lenné, 1991).

Sweet potato plays a crucial role in the country's production system offering potential benefits to poor farm households and urban consumers.

Sweet potato is grown throughout the country and is a major staple food crop in the densely populated mid-elevation and highland regions. Sweet potato comes second to banana in terms of production and is among the five most important food crops produced on an annual basis. Sweet potato production has grown at a very rapid rate over the past several decades. However, production since then has generally not kept pace with population growth as indicated below (FAO & CIP, 2014).

Figure 2. Sweet Potato production in Rwanda



Source: FAOSTAT, 2014 & CIP, SP atlas, 2014)

According to data reported by the FAO (2014), Sweet potato production as well as the area under that crop has been increased in 2002 and then decreased up to 2011. That is due mainly to the land consolidation policy where mainly all marshlands areas are allocated to the priority crops excluding sweet potato on the list while a big part of marshland was occupied by Sweet potato before the policy. In addition to that, because of population growth, more space was allocated to the dwelling place.

The figures indicate that even if after 2011 the area has not been increased but the yield has been increased as well the production.

Sweet potato is also being developed as a means to address one of the most serious health and nutrition problems of sub-Saharan Africa, Vitamin A deficiency. Lack of Vitamin A can weaken the immune system, leaving an individual more susceptible to deadly diseases such as measles, malaria, and other diseases. Vitamin A deficiency is also a leading cause of visual impairment and a major risk factor for pregnant and lactating women (cip, sp atlas consulted on 17-sep-2014).

2.3. **Sweet potato as pillar of food security and house hold income**

The sweet potato (*Ipomeabatatas*) is an important source of calories in the cool humid climates of the highlands of the western branch of the Rift Valley of Africa, of which Rwanda is typical (FAO, 2007 and Tardif, 1991). Since its introduction in the early 18th century, the sweet potato has become the most important staple crops to be cultivated by nearly all peasant farm households in this densely populated, high elevation, and rugged "thousand hills" country (Ndirigwe, 2006 and Ferris *et al.*, 2002).

It is regarded as a flexible source of food as it can be grown on soils of limited fertility and is relatively drought tolerant. Planting and harvest periods are more flexible than those of maize and other cereals. Sweet potato is a basic food crop in Rwandan diet which is most consumed fresh after boiling and is also used as snack (Ndirigwe, 2006 and Tardif, 1991). In calorie terms the Rwanda diets consists of beans (22.3%), sweet potatoes (21.6 %), manioc (14.2 %), bananas (14.1 %), Irish potato (11.9 %) and maize (8.6%).

Sweet potato is an important crop in terms of food security, assisting to reduce hunger periods in years when other crops fail or in specific seasons before the main harvest.

It is a flexible source of food as it can be grown on soils of limited fertility and is relatively drought tolerant. Also, planting and harvest periods are more flexible than those of maize and other grains. Sweet potato has become even more important where production of other food staples like banana and cassava is hindered by disease. Sweet potato is prized as a fresh nutritious product, contributing to improved nutrition, through provision of vitamin A and other micronutrients and energy. It is also an important source of calories (152 MJ/ha per day of edible energy). Sweet potato produces more edible energy per hectare per day than any other major food crop (Ferris R. et al, 2002).

2.4. **Comparison of nutrientsin Orange fleshed Sweet potato (OFSP) and Yellow Sweet potato (YSP).**

The proximate composition of among others carbohydrates, protein, fat, ash, moisture content and fiber were analyzed. Also the total reducing sugar, β-carotene and vitamin Ccontent wereanalyzed. This comparison shows how much important orange fleshed sweet potato are compared to others type of sweet potato in terms of nutrient content and their effect on food security and fighting against malnutrition and Vitamin A deficiency (VAD).

The results documented are presented in table below.

Table 1:Comparison of nutrients content in fresh, dried chips and processed flours from OFSP and YSP

N°	Nutrients (%)	Fresh		Dried chips		SP flour flo-flourflour	
		OFSP	YSP	OFSP	YSP	OFSP	YSP
1	Carbohydrate	7.65	8.7	64.8	73.6	64.8	73.6
2	Protein	2.5	1.9	5.2	2.4	5.2	2.4
3	Fat	1.15	0.6	2.1	0.7	2.1	0.7
4	Fiber	3.4	5.3	4.12	6.09	4	5
5	Total ash	4.7	3.5	4	3	4	3
6	Moisture content	81	80	17	15	17	15
7	Total Reducing Sugar	6.73	6.83	6.78	6.87	6.78	6.87
8	Vitamin C*	50.17	39.7	47.9	30.15	47.89	30.13
9	β carotene*	8.75	0.045	8.04	0.04	8.04	0.04

Source: Hacineza et al. 2012.

The view of the table above revealed how the comparison was made regarding selected nutrients that are essential to human body. The comparison was made at three levels namely fresh, dried chips and Sweet potato flour. From this table it can be noticed that the OFSP contained the highest amounts of Vitamin C, β-carotene, proteins and fats among others. All these nutrients are very essential in the healthy functioning of the human body.

The uniqueness of OFSP to provide high amounts of β-carotene was of particular importance.

2.5. **Related case studies**

Related studies have been conducted focusing on the adoptability of Orange Fleshed Sweet potatoes (OFSP), their nutritional value and contribution to farmer incomes and food security. This study discusses four such cases, their findings and implications.

2.5.1 **Case study of Gaza Province in Mozambique**

The objective of this study was to assess the socio-economic and institutional factors associated with the adoption of OFSP varieties by smallholders in two districts of the Gaza province (Mazuze, 2004). This study in Mozambique is particularly interesting for Rwanda given that both countries have gone through catastrophic civil strife, leading to underperformance of the agricultural sector. Mozambique was drastically affected by more than 15 years of civil war (1975-1992) while Rwanda suffered the catastrophic genocide in 1994. Now roughly 20 years after overcoming the civil strife, both have reported steady growth.

In particular, the study sought to assess among others (1), the adoption rate of the available OFSP varieties, major determinants associated with farmer adoption/non-adoption of the recommended varieties (e.g. in terms of contribution to income, nutritional benefits of OFSP varieties, etc.), (2) whether increasing OFSP varieties production does sufficiently increase the bio availability and conversionof β-caroteneso as to alleviate VAD, and (3) what institutional and agricultural policy interventions are needed to spurthe rate of technology adoption and thereby increase Sweet potato production and household income.

The study found that the willingness and expectation of farmers to grow OFS varieties will greatly affect the program's impact on reducing VAD. Other factors identified included social and economic factors that affect farmers' technology adoption decision--including access to farmlabor, farm machinery, storage and distribution facilities, inputs and output markets, credit availability, farmsize, level of education, land tenure, profitability of the technology, farmer's awareness of existing technologies,and government policies.

However, since the effect of those explanatory variables (and interactions among them) on farmer's technology adoption varies from region to region,

location-specific studies are required to understand factors that affect adoption of a new technology in a given country.

2.5.2. **Case study of Busia and Rachuonyo districts of Kenya**

This study was conducted in Kenya to assess the factors influencing adoption and intensity of adoption of orange flesh Sweet potato varieties in Nyanza and Western province, Kenya (Kaguongo, GF Ortmann, E Wale, MAG Darroch and J Low, 2010).

The study involved what was deemed a representatives ample of 340 farmers in the Busia and Rachuonyo districts of Kenya in2009.

The study also investigated whether participation in avalue chain extension intervention program increased these farmers' likelihood of adopting OFSP.The results suggest that the district where the farmer comes from, knowledge on value addition and nutritional benefits, and availability of vines were the key factors for adoption.

The results also suggest that participation in avaluechain extension program enhanced the probability of adoption.

Factors affecting intensity of adoption were site, value addition,vines availability, level of commercialization and having a child of up to five years.

2.5.3. **Women farmers' adoption of OFSP varieties in raising Vitamin A intake, Kenya**

Another study in Kenya (Hagenimana and Oyunga, 1999) which sought to evaluate the effect of women farmers' adoption of OFSP varieties in raising Vitamin A intake, found that several of the new OFSP varieties grown in on-farmtrials were adapted to the agro-ecological conditions with respect to yield, pest and disease tolerance, as well as the ability to provide reasonable beta carotene content.

The study found thatwomen farmers were likely to adopt the OFSP varieties if the clones were sufficiently introduced through community-level education programs that focused on the health of young children. According to Hagenimana and Oyunga, (1999), the new OFSP varieties were widely accepted (with respect to their appearance, taste, and texture) by both producers and consumers, and substantially contributed tothealleviation of VAD. In this study however, there is no emphasis on the contribution of OFSP varieties to farmer incomes and food security.

2.5.4. **Orange Fleshed Sweet Potato in Rwanda**

One of the traditional food crops that has drawn considerable attention of development agencies and nutritionists is the Sweet potato, and specifically the orange flesh Sweet potato (OFSP) which has continued to gain prominence in the last few years since its introduction in Rwanda. For example, a recent study by Okelo J.(2014), cited in Chowdhury et al. 2013) found that OFSP can supply the nutrients required to avert vitamin A deficiency in children and pregnant mothers. However, most households still consume regular Sweet potato in mostly raw and boiled forms.

Certain varieties of Sweet potato, especially orange-fleshed, are being promoted as part of the strategy to combat vitamin A deficiency in children and pregnant mothers. However, the consumption of Sweet potato is more widespread in rural households where it is mainly boiled or eaten raw (Julius, O. 2013).

Although studies focusing on OFSP are scanty, few attempts have been made to examine the role of OFSP in the Rwandan society and the extent of its adoption. For example, a report by the National Institute of Statistics of Rwanda (2012) acknowledged the significance of the OFSP in terms of its nutritional value, source of income and its contribution to food

security.

The report further observed that one of those activities that can contribute more in rural development is moving from traditional agriculture to modern agriculture by growing high value and nutritional orange Sweet potato varieties. Another study in Rwanda, Ingabire & Vasanthakaalam (2011) observed that although there were over 212 varieties of Sweet potatoes cultivated in Rwanda, most of which are basically broadly classified in terms of the color of the tuber skins with common colors being yellow, white and purple, the most recently introduced orange colored Sweet potatoes was unique and superior than others especially based on its nutritional value.

3. Research Design

A research design describes the nature and patterna study intends to follow.This study focused on a case study of four cooperatives: two cooperatives among three from Rulindo District and two others from Gakenke District operating in the production of Orange-fleshed Sweet potato were selected. The total number of members who participated in this survey was 73 people.

All the cooperatives' members were considered for this study. Given that studies on Orange-fleshed

Sweet potato (OFSP) in Rwanda required a numerous facilities and time; the chosen four cooperatives were selected and helped in deeply examining the proportion of each household's land allocated to the OFSP compared to that allocated to other farming activities.

A further review was made to establish the average quantities of various vital nutrients present in the OFSP compared to those found in other varieties of Sweet potatoes grown (or were previously grown) by the households.

This enabled the researchers to establish the importance attached to OFSP by the farmers in terms of acceptability of the crop and its nutritional value. In doing so, the researchers were able to fulfill the first and second specific objectives of this study as outlined previously. This helped gauge the contribution (role) of OFSP towards food security in Rulindo and Gakenke districts.

The study further examined the proportion of each household's income that comes from the OFSP compared to other farming activities. This was necessary to fulfill the third specific objective of the study which gauged the significance of OFSP in helping contribute to the overall farmer's income.

In the end, this procedure led to a determination of whether or not the OFSP does or not contribute to food security and farmers' incomes, and if it does, to what extent?

To be able to bring out the extent to which this happens, the study adopted a descriptive approach of the data, mainly in terms of percentages and ratios. This study therefore employed both case study and descriptive research designs.

3.1. **Population of Study**

The study targeted a population of 126 farmers, and those are members of seven cooperatives from both districts Gakenke and Rulindo of Northern Province of Rwanda. Each district has a number of Orange-fleshed Sweet potato cooperative producers as follow: Gakenke district has four of them whereas Rulindo district has three.

3.2. **Sampling procedure**

Sampling is the act, process, or technique of selecting a suitable sample, or a representative part of a population for the purpose of determining parameters or characteristics of the whole population (Mugo, 2002). The two districts of Rulindo and Gakenke as well as the four cooperatives chosen Terimbere Muhinzi, Inkingiyurugo, Kundumulimo and Turwanyubukene respectively were selected

through convenience sampling.

Convenience sampling is a non-probability sampling technique where subjects are selected because of their convenient accessibility, proximity and suitability to the researcher. This study has covered all members of the four cooperatives. This method has advantage of simplicity of sampling and ease of research, data collection can be facilitated in short duration of time and it is cost effective (Dudovskiy, 2014).

This is the reason why this was used because all farmers in four cooperatives were invited for participating as follow: farmers were further organized into four cooperatives, two in each district.

Turwanyubukene and Kundumulimo cooperatives are located in Gakenke district and they have 51 members in total while Terimbere Muhinzi and Inkingiyurugo cooperatives are located in Rulindo district and they have 42 members in total.

Thus, all these 93 farmers participated in the survey process and provided all needed and expected information concerning the research. However much, the size of the sample remained highly representative as long as it represents 73.8 percent of the total population.

3.3. **Data Collection Methods and Tools**

Both primary and secondary data were used. Primary data were collected via the use of questionnaires in order to collect standardized data from all respondents in the same way and in a statistical form; the use of structured interviews which consisted of asking the respondents the same questions in the same way and the use of focus groups.

The focus group discussion has been used because this study aimed at requiring a collective discussion in order to understand the circumstances, behavior or opinions.

The primary data were both quantitative and qualitative which is could prove that the information is richer and has a deeper insight into the phenomenon under study (http://libweb.surrey.ac.uk/). Secondary data, mainly quantitative, were sourced from the records kept by the four cooperatives but where necessary other sources such as government records were considered.

3.4. **Validity and reliability tests**

To ensure reliability and validity of the data, the researcher ensured that the used questionnaire, interviews and focus groups discussion questions were well structured and questions formulated

devoid of ambiguity, incompleteness or irrelevancy. A pilot study was carried out to test the reliability of the data collection instruments, and relevant adjustments were made. To conduct this test, interview during structured questionnaire, was conducted under farmers growing sweet potato in our one Rulindo sector which is neighboring the farmers' cooperative.

3.5. **Data processing**

Data were firstcleaned, mainly to eliminate outliers, organized and tabulated into tables, taking into account the different sets of data forthe purposes of presentation and analysis. Data were analyzed using SPSS as statistical program. Analysis of the summarized data from the spread sheets were done by simple descriptive statistics including frequencies, mean and percentage

4. Presentation and Discussion of Findings

The tabulation, analysis and interpretation of data have followed a sequence in which the researchers separately present analysis and findings in respect of each study objective. Before embarking on each of the objectives, it's important, however to understand demographic background of the target population.

4.2 **Proportion of the households' land under Orange-fleshed Sweet potato farming**

As earlier mentioned in this study, the first objective was to assess the average proportion of the households' land that is under Orange-fleshed Sweet potato farming compared to the other varieties/ crops/livestock in Rulindo and Gakenke districts.

Table 1 below shows the total size of land allocated to Sweet potato farming, and in particular how much of it was allocate the total size of land allocated to other crops. It is obvious that households would not allocate their scarce resources to what they don't consider important. The land allocation can,

therefore, be used as an indicator of how important a crop (or any other farming undertaking) is to the farmer. The calculation of land percentage allocated to sweet potato type and other crops is analyzed based on total land combined. The total combination of all the agricultural practices farmer chooses to engage in essentially defines the farmers approach to food security.

Table 2: Land allocated to Orange fleshed Sweet potato compared to other varieties and crops.

Land allocation	***Gakenke***	***Rulindo***	***Mean***
Total land allocated to SP (m^2)	2843.9	2324.8	2552.3
% of total land allocated to SP	43.7	51.4	47.6
Land allocated to White & Yellow SP(m^2)	1293.1	643.6	928.3
% of total land allocated to White & Yellow SP	19.9	14.2	17.1
Land allocated to Orange SP(m^2)	1550.8	1681.2	1624.0
% out of total allocated to Orange SP	23.8	37.2	*30.5*
Average Land allocated to other crops (m^2)	3668.0	2193.8	*2833.1*
% of total land allocated to other crops	56.3	48.6	*52.5*

Source: Field data, July 2014.

The importance of Sweet potatoes in the food chain of the two districts is clearly evident from the table above where an average of 47.6% of total land is allocated to Sweet potato compared to 52.5% allocated to all other crops.

Orange fleshed Sweet potato has been allocated an average of 30.5% compared to 17.1% allocated to white and yellow fleshed Sweet potato, thus, this clearly shows how Orange fleshed Sweet potato is more preferred than white and yellow fleshed Sweet potato based on total land allocated to that type of sweet potato.

It is evident that Orange fleshed Sweet potato is a highly regarded crop hence a vital component of the food security basket in the two districts.

Since the introduction of orange sweet potato varieties, farmers have started to decrease slowly the land allocated to yellow and white sweet potato varieties and increase the land allocated to orange. As explained by farmers during interviews, one said "*these new varieties have high yield compare to the ordinary varieties and our household income has been increased due to sales of high quantities of yields*".

The market of orange production is guaranteed and due to that, the farmers are more secure in food security than previously. This was justified by the contract signed between Urwibutso Enterprise and farmers' cooperatives for both districts.

Average of total land allocated to sweet potato in Rulindo is higher than Gakenke (51.4% against 43.7) as well as orange sweet potato (37.2% against 23.8) while the percentage is high in Gakenke for white and yellow varieties. This situation is due mainly to Urwibutso Enterprise which is located in Rulindo and it is the main buyer of orange fleshed sweet potato. Thus, farmers in Rulindo feel comfortable than farmers in Gakenke.

4.4. **Consumption**

Table 3: Sweet potato Consumption at household level

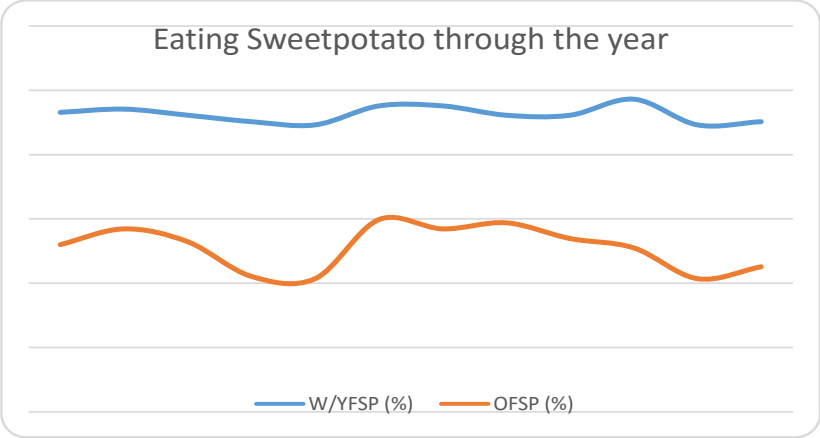
Days per week	*During SP production*		*During SP scarcity*		*Consumption of OFSP*	
	Frequency	*%*	*Frequency*	*%*	*Frequency*	*%*
0	0	0	1	1.3	15	20.5
1	0	0	4	5.8	7	9.5
2	0	0	12	16.4	11	15
3	4	5.5	12	16.4	8	11
4	4	5.8	22	30.1	6	8.2
5	8	11.0	16	21.9	8	11
6	8	11.0	1	1.3	3	4.1
7	49	67.1	5	6.8	15	20.5

Source: Field data, July 2014

It is viewed in the above table that the percentage of sweet potato consumption is high according to the numbers of days per week during the period of production and period of scarcity means when the production is low or even nothing for both orange sweet potato and other type of sweet potato.

Briefly, the same percentage (20.5) is applied for the farmers who don't eat orange sweet potato and the farmers who eat orange sweet potato seven days a week. 9.5% eat orange roots one a week while 8.2% eat orange roots four days a week. From detailed information, consumption graphs were developed to depict the patterns. The resulting patterns to that are shown in figure 3 below.

Figure 3: Frequency of eating Sweet potato through the year



Source: Field data, July 2014.

The orange line represents the frequency of eating OFSP while the blue line represents the frequency of eating white/yellow fleshed Sweet potatoes for the year. It should be noted that the reason why it appears that consumers consume more of white/ yellow fleshed than OFSP is because they preferred to sell most of OFSP in order to earn income for other needs.

The market of orange sweet potato is guaranteed to the farmers especially the market linked to the project while other types of sweet potato are sold mainly at the local markets. In addition to that, the price allocated to orange sweet potato is always high than the price of white/ yellow sweet potato.

A small quantity of orange is consumed at household level. There is also a problem of behavior change where farmers have eaten white and yellow roots for longtime. Sometimes, they think that orange roots are reserved only for children and pregnant women who may be at high risk of malnutrition.

Additionally it is worth noting that there are many varieties of both the OFSP and the White/Yellow Sweet potatoes hence there is need to show a sample of their respective preferences. Table 4 below shows the preference levels of the various types of both OFSP and the White/Yellow fleshed Sweet potatoes.

Tables 4: SP varieties preferences

SP varieties preferences	District		Mean (%)	Rank (5 most important
	Gakenke (%)	Rulindo (%)		
Selling				
Benye	0.00	9.76	5.48	5
Cacearpedo	***18.75***	***4.88***	***10.96***	4
Gihingumukungu	***43.75***	***31.71***	***36.99***	1
Karebe	3.13	0.00	1.37	
Magabari	0.00	2.44	1.37	
Nyiragiteke	0.00	2.44	1.37	
Tura	12.50	21.95	17.81	3
Ukerewe	12.50	24.39	19.18	2
Urunyumba	6.25	0.00	2.74	
Other	3.13	0.00	1.4	
Consumption				
Benye	0.00	2.44	1.37	5

Cacearpedo	***3.13***	***4.88***	***4.11***	4
Gihingumukungu	***9.38***	***19.51***	***15.07***	2
Tura	25.00	7.32	15.07	2
Ukerewe	59.38	65.85	63.01	1
Urunyumba	3.13	0.00	1.37	5

Source: Field data, July 2014.

The varieties shown in *italics* and bolded fonts above are OFSP varieties and it is possible to notice that on average in the two districts, 10.96% and 36.99% of the households respectively preferred to produce and sell Cacearpedo and Gihingumukungu varieties, while 4.11% and 15.07% of the households respectively preferred to produce and consume Cacaerpedo and Gihingumukungu varieties.

Once again this demonstrates the important role the OFSP played (or continues to play) in the day to day decisions of the households. It's a further demonstration of the significance of the OFSP in the food chain of the two districts.

The analysis and discussion so far on this section has focused on the role of OFSP in enhancing food security in the two districts of Gakenke and Rulindo. The 30.5% (37.2% for Rulindo and 23.8 for Gakenke) proportion of land on average allocated to the OFSP farming in the two districts has served to demonstrate the significance with which it's regarded by the households. Gihingumukungu, one

of orange varieties comes to the first position in terms of preferred varieties in general for both districts (43.7% and 31.7% for Gakenke and Rulindo) while it takes the second position in terms of preferred varieties for consumption after Ukerewe with 63.01% as the mean for two districts. Ukerewe is yellow and it has been released at the same time with orange varieties.

On the other hand, the analysis of nutrients value carried out in this section has demonstrated that central role that OFSP plays in providing the human body with some of the most essential nutrients, and at higher quantities compared to other food sources.

Given that food security is a function of both quantity and quality (nutritional value), it is reasonable to conclude that OFSP varieties fulfils the two functions. This is because they are both high yielding and nutritious. The analysis and the subsequent findings have fulfilled the first and the second specific research objectives as earlier stated in this study. The next section attempts to answer the third specific research objective by demonstrating the role of OFSP in enhancing farmer incomes.

4.5 **Average income earned from OFSPby farmers compared to those earned from other types of sweet potato varieties**

The third specific research question of this study sought to review the average proportion of income earned from Orange-fleshed Sweet potatoby farmers compared to those earned from other varieties/crops grown/livestock kept by the households in Rulindo and Gakenke districts.

Tables 5 and 6 below show the average quantities sold of OFSP, White/Yellow fleshed and other crops. It also shows the prevailing prices at the time of this study as well as the average income received by a single household during the period under consideration.

Table 5: Average quantity of Sweet potato sold per district

Quantity (kg)	*Gakenke*		*Rulindo*	
	W/YFSP (%)	**OFSP (%)**	**W/YFSP (%)**	**OFSP (%)**
<100	46.6	44.3	37.5	26.7
101-300	39	32.1	48.3	49.4
301-600	8.2	14.3	14.2	14.3
601-900	6.2	3.1	0	7.2
901-1200	0	3.1	0	2.4
1201-1500	0	3.1	0	0

Source: Field data, July 2014.

From the table above, the trend for the quantities sold at different ranges was roughly the same but it's important to notice that beyond the range of 900kg, only OFSP dominated the quantities sold for the range. The impression created by this revelation is that households preferred to cultivate OFSP for sale in large quantities (for those with high production) as well as smaller quantities (for those with fewer factors of production).

It is clearly observable that OFSP is highly regarded by the households as an income earner.
The famers sell their roots at farm gate, at local market, at urban markets, at collection center, at SINA Gerard/ Urwibutso Enterprise market and at other institutions like schools etc. Urwibutso Enterprise market comes at the first position (53.6%) followed by local market (51.2%) in Rulindo while in Gakenke urban market comes first (34.3) and followed by collection center (32.1%) and local markets (18.7%). Selling sweet potato at farm gate occupies the third position for both districts with 19.5% & 16.3% respectively.

The most reasons of selling are: Buy other household items and buy food items totalling 40.6% in Gakenke and 46.2% in Rulindo districts. Other reasons are paying school fees for children and because the crop

is mature. Table 6 below presents Orange Sweet potato income compared to other type of Sweet potato and other food crops for the period of one year July 2013 to June 2014. The quantity sold per crop is average of all respondents.

Table 6: Orange Sweet potato roots income compared to other type of Sweet potato and other food crops.

Type of crop	*Average quantity sold (kg)*	*Price (Rwf/kg)*	*Total income (Rwf)*	*% of Total income*
Sweetpotato				
Y/W SP	155	119	18445	9.4
Orange SP	245.5	150	36825	18.8
Other crops				
Maize	344.5	199	69668	35.6
Bean	140.7	247	30832	15.8
Cassava	90	170	15300	7.8
Sorghum	25	500	12500	6.5
Banana	100.0	120	12000	6.1
Total average income for all			***195,570***	**100**

Source: Field data, July 2014.

On the view of this table, quantities sold for each of the Sweet potato categories (White/Yellow fleshed and OFSP) have been shown for the period of this study per household. The prevailing prices per kg during the period of the study have also been shown and consequently the total income received by a

single household on average has been calculated, as well as the amount of each income bracket as a percentage of the total income. From this table, therefore, it is noticeable that Orange fleshed Sweet potato was only second at (18.8%) to maize with (35.6%) in ranking the greatest contributor to the household income. Maize is understandably the most common staple food crop in Rwanda as well as in Gakenke and Rulindo districts. Thus, no exception to the dominance of maize in their food chain.

A crop that contributes an average of 18.8% is no doubts a farmer's chicken that lays the golden egg. This section has, therefore, demonstrated the critical role that OFSP plays in enhancing household's income, hence a fulfilment of the third specific objective of this study which was to review the extent to which OFSP contributes to households' incomes. The findings are that it does contribute overwhelmingly to the households' overall income.

As shown in table 7, farmers do not get income from orange sweet potato roots only but also they earn money from sales of orange sweet potato vines compared to the money earned from vines of yellow/ white varieties where the price is almost low compared to orange varieties.

Table 7. Income from sales of orange sweet potato vines

District	*Farmer's cooperative*	*Cuttings*	*Earn (Rwf)*
Gakenke	Turwanyubukene	134065	610542
	Kundumulimo	50800	219500
Rulindo	Inkingi y'urugo	170400	801000
	KOTEMU	164800	730000

Source: Field data, July 2014.

As described in the table above, for only one year of our research 2,262,042 Rwf has been earned from the sales of vines. Two cooperatives in Rulindo (Inkingi y'urugo and Kotemu) have earned 1,531,000 Rwf against 830,042Rwf earned by cooperatives in Gakenke. That total amount of vines was bought by several buyers but mainly by International NGOs like Caritas, World Vision and CRS. Individual's farmers have also bought some vines for their home consumption.

The use of orange sweet potato is not only limited to the sales flesh roots and vines but also farmers in three of four cooperatives have managed to process roots into some of bakery products especially Mandazi and crisps. Turwanyubukene and Kundumulimo cooperatives have opened a shop for selling bakery products from Orange sweet potato in Gakenke while Inkingiy'urugo sells doughnuts

especially during the market days. So far, these cooperatives in Gakenke have sold Mandazi and earned 1,650,000Rfw for only six month while Inkingiy'urugo has earned 785,000Rwf from only sales of orange sweet potato doughnuts.

5.CONCLUSION AND RECOMMENDATIONS

5.1 **Conclusion**

In concluding this study, it's important to once again remind of what was the main focus of the study which was to assess the role of Orange fleshed Sweet potatoes (OFSP) with regard to its contribution to the households' income and food security. The role of OFSP is clear everywhere and secure food availability, accessibility and utilization.

The sheer amount of nutrients found in this food crop further confirms its contribution towards the general health of the consumers. OFSP is particularly endowed with high amounts of β-carotene, more than 150 times compared to the amount of the same found in the White/Yellow fleshed Sweet potatoes. β-carotene is known to contain high amounts of antioxidants which guard against the destruction of body cells by free radicals.

It's also widely also acknowledged to be a great source for vitamin A hence helping overcome the Vitamin A deficiency (VAD) which has by the time of this study been identified by the United Nations (UN) as a major challenge to growing children, pregnant and breast feeding mothers. All these

characteristics combined prove that the OFSP is an incredible component of the food chain and by large food security for Gakenke and Rulindo districts of Rwanda.

5.2. **Suggestions**

As the main purpose of this study was to assess the role of orange sweet potato to the food security and household income in Gakenke and Rulindo districtsof Rwanda, the findings so far generated from this study have brought us to formulate the following recommendations:

1. To the farmers, to adopt with determination the cultivation of Orange-fleshed Sweet potato due to its high values.

2. To the local government, to put more efforts in extension of the crop so that they can increase the level of local production.

3. To the government, private sector and non-governmental organizations to educate the public on the nutritional and income benefits of the Orange fleshed Sweet potato.

4. To the businessmen and research organization, to develop more value food chain additions, such transformation into other valuable products be emphasized so as to widen the importance of Orange fleshed Sweet potato.

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