ECONOMIC SCIENCES

THE AGRICULTURE SECTOR IN RWANDAN ECONOMY: AN EMPIRICAL IMPACT ANALYSIS

Dr. Hashim Al-Ali
Chief Technical Advisor (CTA)/Senior Macroeconomic Development Planning Advisor, UNDP/ Ministry of Economy and Planning (MEP), Riyadh, Kingdom of Saudi Arabia
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Abstract
The agriculture sector in Rwanda with its five component sub-sectors, namely; food crops, cash crops, livestock, fisheries, and forestry, is one of the leading sectors in the economy. It contributed more than 33.2 percent to Rwandan gross domestic product (GDP) in 2014 and is a pivotal sector in employing the largest proportion of the national labour force and absorbing as well as sustaining the living of the majority of the Rwandan population. The main objective of this practical study is to analyze the role of the agriculture sector, with its various subsectors, in the Rwandan national economy, and by various activities. Notwithstanding, here we are not only examining the agriculture role in the economy using the conventional standard approach, rather in addition, a more structural and developmental approach has been devised and applied. This adopted structural approach has been based on an input-output (I/O) techniques, in which a deeper analysis is carried out to study and quantify the direct and indirect as well as induced impact of the agriculture sector and its main components, on the economy as a whole and by various activities and sectors of the national economy of Rwanda. Thus, this would assist in, empirically assessing the role of agriculture, by its main sub-sectors, in the development of the Rwandan economy and on different aspects and dimensions.

Keywords: Agriculture, Rwanda, Development, Analysis, Diversification, Input-Output, Modelling.

1 Introduction

The main objective of this practical study is to analyze the role of the agriculture sector, with its various subsectors, in the Rwandan national economy, and by various activities. Notwithstanding, here we are not only examining the agriculture role in the economy using the conventional standard approach, rather in addition, a more structural and developmental approach has been devised and applied. This adopted structural approach has been based on an input-output (I/O) techniques, in which a deeper analysis being carried out to study and quantify direct and indirect as well as induced impact of agriculture sector and its main components, in the economy as a whole and by various activities and sectors of the national economy of Rwanda. Thus, this would assist in, empirically assessing the role of the agriculture, by its main sub-sectors, in the development of the Rwandan economy and on different aspects and dimensions. The obtained results, nonetheless, would support the decision makers in devising and selection the most feasible development strategies and policies, to be practically adopted for achieving agriculture sector growth objectives, as specified in the development vision 2020, and their implications, in a feasible, optimal and effective manner.

2 Statistical Data Sources

The statistical bases of this empirical study are the official statistics that collected, processed and disseminated, by National Institute of Statistics of Rwanda (NISR), department of economic and social statistics.

As it is a fact that NISR has published, in July 2014, the supply and use table (SUT) for Rwanda for 2011. The SUT was conducted and completed in quite professional manner and with international standard, though it was highly aggregated, by activities, on the uses side. This is quite natural for the purpose of producing SUT and then national accounts (NA) for the nation. With the full cooperation of the Director of Economic and Social Statistics Department and the specialist in charge on national accounts, the author has obtained some additional information where the published SUT has been drawn from.

Using such background data, the published SUT and the published national accounts data, we have managed to build an input-output table (IOT) for Rwandan economy at 2011, and for the first time. However, due to the structural nature of the input-output tables and their high demands on highly disaggregated and detailed statistical data, the available data in Rwanda at present, cannot, satisfactorily, be enough to produce a highly disaggregated IOT. Accordingly, at this first attempt, we were able to build and produce a table with less than otherwise desired disaggregated activities within the economy. Accordingly, the constructed input-output table for Rwanda for 2011 is of size 16 by 16 sectors for inter-industrial block with agriculture sector being disaggregated into five main sub-sectors, four final demand components and three primary input categories. Notwithstanding, these efforts have been achieved by further digging into the background data, supplemented with some applicable data simulation methods.

3 Brief Highlights on an Input-Output Table (IOT)

W. Leontief pioneered the building of Input-Output tables and their transformation into an economic model and a tool for its analysis in America during the 1930s. It has developed thereafter at both the national and regional levels. An Input-Output table, by and large, is a statistical description of the functioning of an economy. This function description has a time period dimension usually twelve months. It is primarily deals with the methods of analyzing the inter-dependency between sectors of the economy, and measuring as well

as defining the various sectors interrelationships and their inter-linkages within the national economy. Hence, how the different sectors of an economy can be developed to establish a coherent and integrated domestic economy. An input-output table, however, records the sales or purchases between all sectors in an economy, usually within a particular year. Typical tables identify several dozen such sectors and show the structure of an economy in a precise and detailed way. There are several types of tables each showing a different aspect of the economy, e.g. the pattern of purchases, sales, capital investment and imports.

In constructing and examining these tables it is necessary to make a distinction between commodities and industries. A commodity is an artefact, substance or service, while an industry produces various commodities and is defined by its principle commodity, and thus the cooking oil chiefly makes oil. An industry may also make other secondary commodities, for example, the cooking oil industry also makes and repairs small number of plastic products such as bottles and containers. Thus, while the commodity in an absolute concept; an industry may vary in time or from one country to another by virtue of having different secondary commodities.

The input-output tables serve both statistical and analytical purposes. They provide a framework for checking the consistency of statistics on flows of goods and services obtained from different kinds of statistical sources -industrial surveys, household expenditure inquiries, investment surveys, foreign trade statistics, agricultural survey etc. The input-output tables in particular, serve as a coordinating framework for economic statistics, both conceptually to ensure the consistency of the definitions and classifications used and as an accounting framework that ensures the numerical consistency of data drawn from different sources.

The input-output framework is also appropriate for calculating much of the economic data contained in the national accounts in addition to detecting its weaknesses. This is particularly important for the decomposition of values of flows of goods and services into prices and volumes for the calculation of an integrated set of price and volume measures. As an analytical tool, input-output data are conveniently integrated into macroeconomic models in order to analyze the link between final demand and industrial output levels. Input-output analysis can serve a number of other analytical purposes and uses.

The main structure of the input-output table (IOT) and techniques based on the main quadrant divisions of the input-output matrix. These quadrants are illustrated in the figure below:

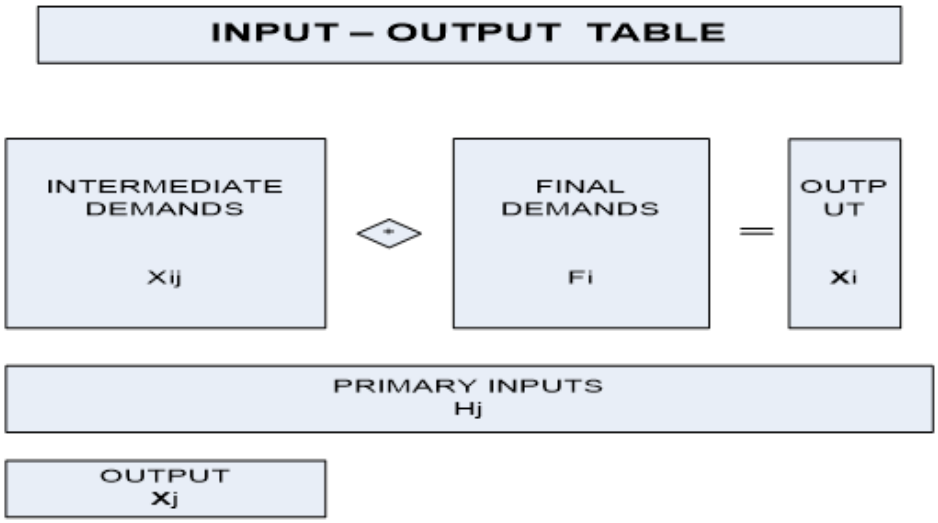


Figure 1: The Main Quadrants of the Input-Output Matrix

However, such characteristics and quadrants can be shown through the appropriate input-output systems of equations, as:

1) $\mathbf{X_i = \sum_j x_{ij} + \sum_k f_{ik}}$

2) $\mathbf{X_j = \sum_i x_{ij} + \sum_h p_{hj}}$

The Direct Coefficients are a_{ij} where:

3) $\mathbf{a_{ij} = x_{ij} / X_j}$

By Substitution in (**1**):

4) $\mathbf{X_i = \sum a_{ij} X_j + \sum f_{ik}}$

In Matrix-Vector notations, the Input-Output (I/O) relationships can be rewritten as:

5) X = AX + F

6) F = IX – AX

Hence:

7) F = (I – A) X

X : column-vector of gross output (n by 1)

A : a direct coefficients matrix (n by n)

F : a column-vector of total final demand

$\mathbf{F = \sum_k f_{ik}}$ **…… (n by 1)**

and I : is an identity matrix (n by n).

Therefore:

8) $\mathbf{X = (I – A)^{-1} F}$

where: $\mathbf{(I – A)^{-1}}$ **is known as Leontief Inverse**

However, the production structure and components of the input-output table (IOT) and its relationship for generating the gross domestic product (GDP) are illustrated in the below chart.

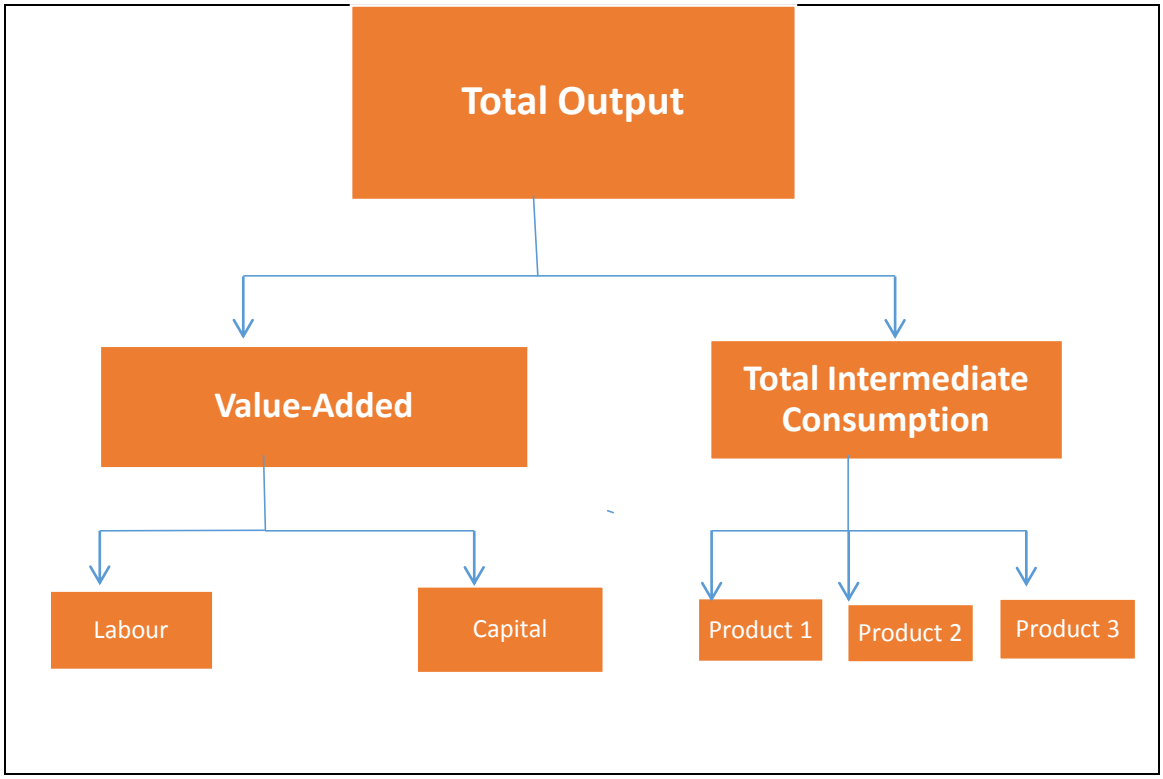


Figure 2: IOT Production Component and GDP

However, the last block of the above chart, the labour factor and labour compensations, which is considered to be part and parcel of the value-added, and hence, of the IOT primary inputs data, is missing in Rwanda supply and use table (SUT) for 2011 produced and published by NISR. That said, we have estimated the sectoral employment using the households income and expenditures survey (HIES) results for 2011. We also have simulated the 2011 employment compensation portion of the value added, and have split the other value-added row into two rows, namely; compensation of employment and operational surplus. The sectoral ratios that used to split total other value-added of SUT, have been simulated and driven using, amongst other things, the households income and expenditure survey (HIES) results, experts' view and some results of similar countries in the region with proper available input-output table, such as Uganda, Kenya, and few others.

4 The Agriculture Sector in Rwandan Economy: An Overview

In this section, an attempt has been made to assess the role of the agriculture sector and its principal sub-sectors, within the Rwandan national economy. Such an assessment and overview can be highlighted by quantifying and examining the following basic economic parameters.

Real compound growth rate: Agriculture sector has continuously generating positive growth rate within Rwandan economy, despite limited resources and prevailing of various external and national constraints. Notwithstanding, the sector has achieved a compound growth rate of (4.1) percent per annum during the period 2006-2013. While the main agriculture sector's sub-sectors achieved mixed trends of actual growth rates, during the same period. The graph below illustrates the achieved growth rates of the main five components of the agriculture sector in Rwanda.

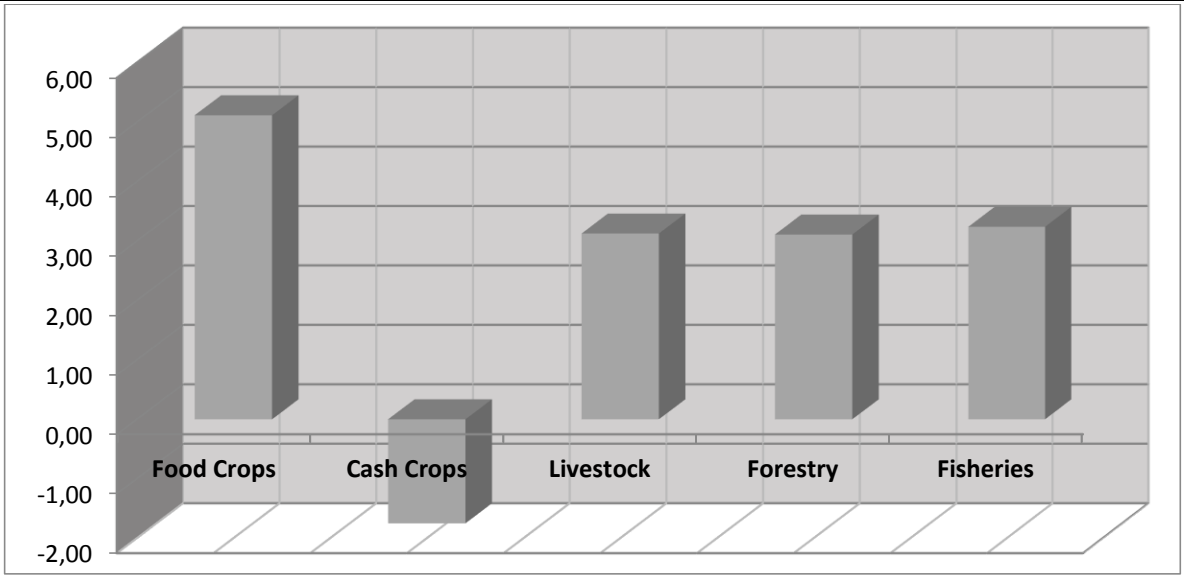


Figure 3: Percentage Compound Annual Growth Rates for Different Sub-Sectors of Agriculture Sector during the Period 2006-2013

This, by and large, shows that the food crops component of agriculture sector is the growth leading sub-sector of agriculture sector. While the cash crops sub-sector is declining during the same period, registering an overall compound growth rate of (-1.7) percent per annum.

Agriculture Sector's Contribution to the National Economy and the Share of the each of Sub-Sectors in the Agriculture Sector Products; The normal approach that usually used to measure the importance of a given sector to the national economy, is the share of that sector's product to the gross domestic product (GDP). Accordingly, agriculture sector contribution to total GDP in Rwanda has declined from 38 percent in 2006 to 33 percentage point in 2013. This is not surprising given the government efforts to diversify and developing the economy, as well as lessening the reliance of the economy on a single sector. It is a quantitative evident that such declining in agriculture contribution to total economy, is due to, among other things, successful process of the economy diversification policy, and increasing role and hence contribution of other sector of the economy, such as manufacturing industries, construction, trade, real estate and other personal services, overtime. Nonetheless, the contributions of the principal five sub-sectors, to the agriculture value-added were, somehow, mixed, though food crops taking the lead during the period of the analysis, and it is expected to continue unless more proactive and constructive integrated agriculture sectoral development strategic processes are adopted, and implemented.

The graph below depicts the relative importance of the main agriculture sub-sectors in the total sectoral products for the year 2006-2013.

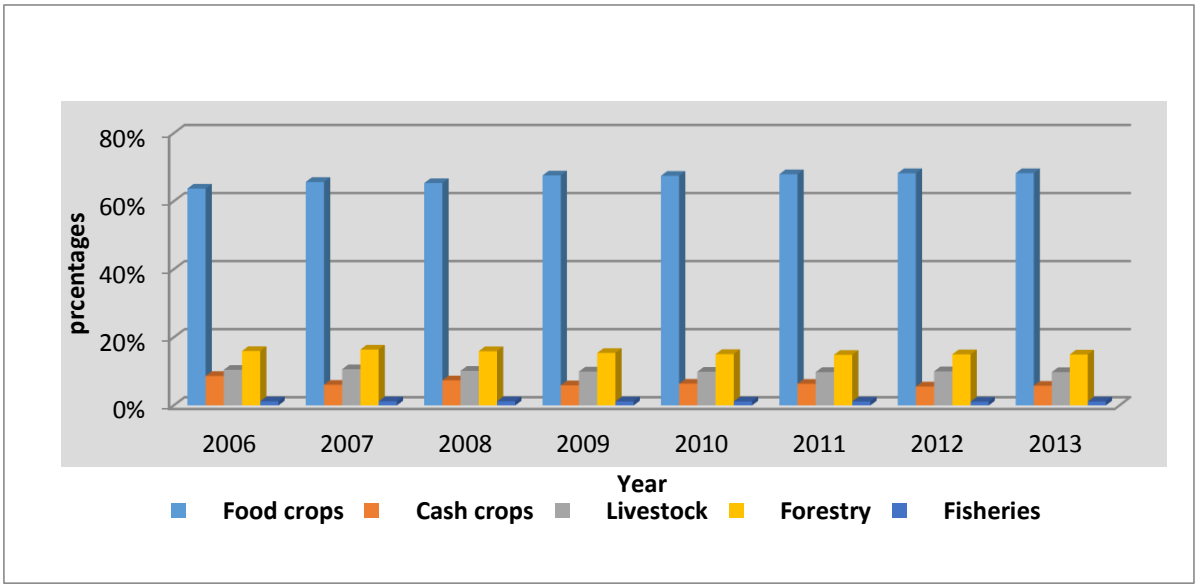


Figure 4: Agriculture Sub-Sectors' Contributions to Agriculture GDP during the period 2006-2013

Agriculture Sector and Rwanda Trade Balance; By and large, agriculture sector contribute, in average, by (14.8) percent to Rwanda total export in 2011. The main contributors to agriculture sector export was cash crops component, followed by livestock and livestock product. While the share of agriculture sector, at the same year, in total Rwanda imports was (4.6) percent, and this was mainly related to import of food crops sub-sector of Rwandan agriculture sector. The table below highlights structure of agriculture imports and exports by the main components in Rwandan economy.

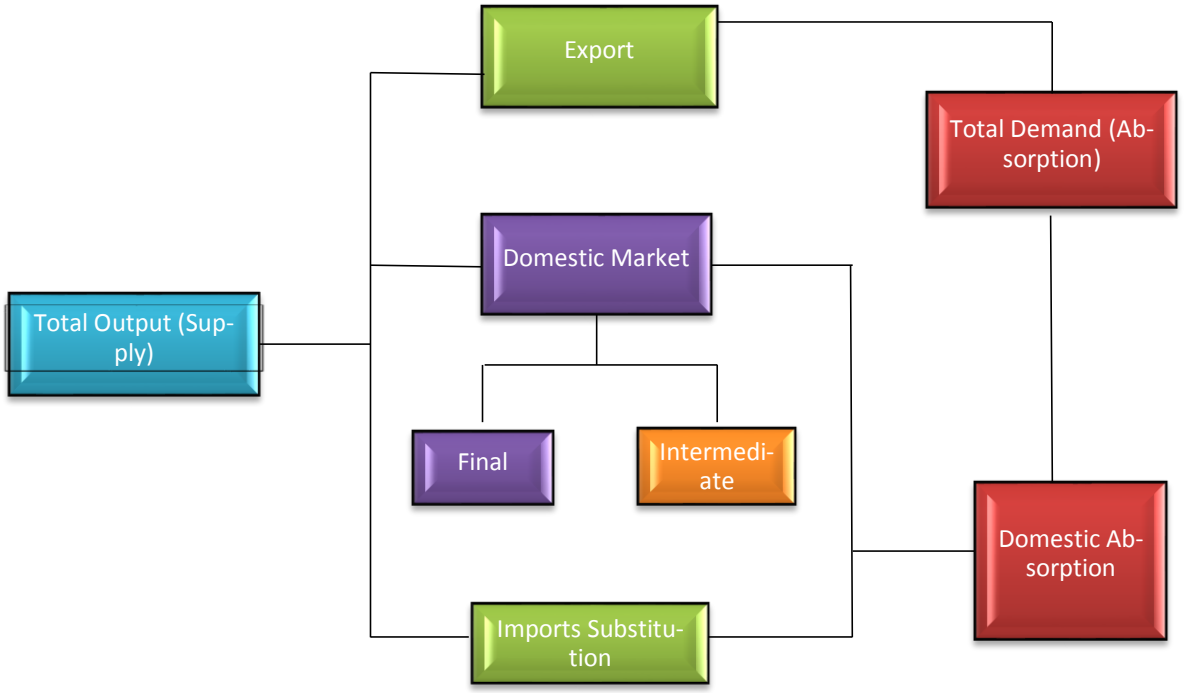
Table (1)

Agriculture Sector Components Contribution to Imports and Exports of the Economy in 2011

No.	Sub-Sector	Imports in RWF billion	% to total Imports	Exports in RWF billion	% to total Exports	Trade Balance
1	**Food Crops**	**43.8**	**3.85**	**11.0**	**2.08**	**-32.9**
2	**Cash Crops**	**3.7**	**0.32**	**45.5**	**8.67**	**41.9**
3	**Livestock & livestock products**	**3.6**	**0.32**	**19.4**	**3.70**	**15.8**
4	**Forestry**	**0.8**	**0.07**	**0.4**	**0.08**	**-0.4**
5	**Fishing**	**0.5**	**0.04**	**1.2**	**0.23**	**0.7**
6	**Total**	**52.4**	**4.60**	**77.5**	**14.76**	**25.1**

Agriculture production (supply) components and its absorption (demand) categories; it is an economic fact that sectoral activities, by and large, are growing and expanding as the same direction as the demand for their outputs. Agriculture output usually absorbed by domestic market or for export or both. The former, i.e. the domestic market demand is consisting of final consumption uses, intermediate uses as industrial feed-stocks, and for imports substitution. The depth and significant role of agriculture sector in the overall economic development of the nation depends on the sectoral full integration and inter-relationships within the economy and its different sectors, as well as it is role in promoting the country exports and hence improvement of current account balance and the balance of payments. This is of course coupled with reasonable satisfaction and meeting the domestic consumption demands. Such supply-demand relationship is depicted as in the chart below.

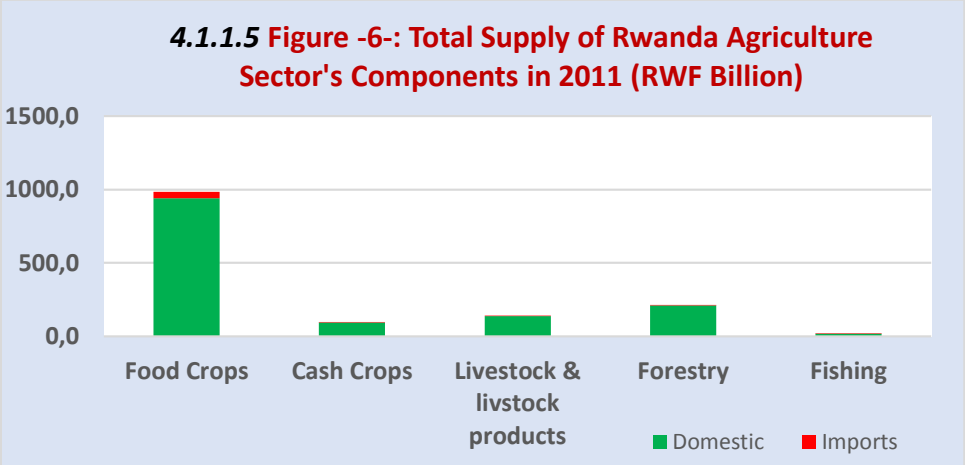
Figure -5-: Agriculture Sector's Supply-Demand Interactions



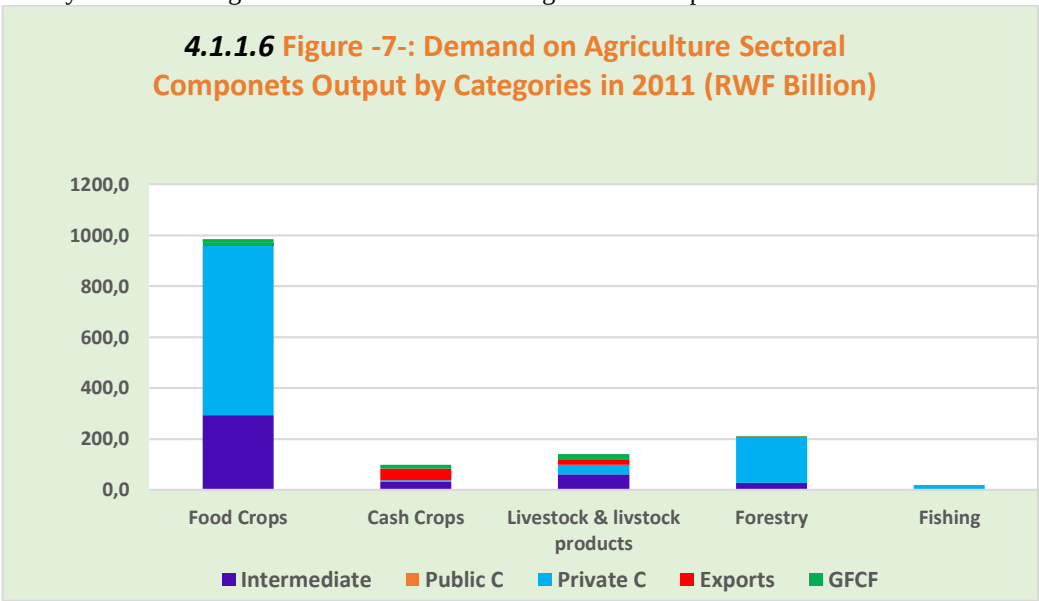
It is evident that the main absorbent of agriculture sector's output in Rwanda is the final consumption demand in the domestic economy. This consumption type demand absorb about three quarters of agriculture output. The remaining quarter of the production is absorbed by intermediate uses by other sectors of the economy, and very small proportion of the total production is exported to the rest of the world (ROW).

To identify, in quantitative manner, the total supply of each of the main agriculture sector components in Rwanda, and whether it is domestically generated or imported in order to meet the nation's demand, the

graph below illustrate the supply of each of the sector's components in the economy during 2011.



In contrast, the total demand on each of the agriculture sector's components, empirically, shown on the following graph. Such demand on the main components is identified by different categories of demand orientations and types. These categories of demand are; intermediate demand, government and non-government organizations demand, private sector household demand, gross fixed capital formation and demand for exports.



5. THE DEVELOPMENTAL ROLE AND IMPACTS OF AGRICULTURE SECTOR IN RWANDAN ECONOMY: Applied Modelling Approach

One of the most accurate approach to analyze and measure the role and impact of the main components of agriculture sector within the Rwandan socio-economic setting, is to quantify such role and measure the likely impact, by formulating and solving a specific and specially tailored modelling approach. Accordingly, and **given the fact that we have already constructed and built the first Rwandan input-output table (IOT) for 2011,** based on NISR published supply and use table (SUT), an analytical impact models, based on input-output techniques, have been formulated, structured and empirically articulated and solved, for Rwandan economy in order to measure the development role and importance of the main agriculture sector's components in the national economy. Hence, different and more applicable agriculture development strategic policies can be devised, recommended and implemented, at the nearest future.

Having said that, the analysis and measurement of the impact and role of agriculture sector and its various sub-sectors, would be focused on and addressed through solving for and calculating of the various economic multipliers and the level of the sectoral integration within the overall national economy and its relationships and linkages with other sectors that forming the total Rwandan economy. Accordingly, the input-output multipliers give a detailed picture of the impact of change in final demand on output, income and employment through the economy. They are now well established as indicators of the importance of particular sectors and the interdependence of the industrial structure and thus their meaning, uses and derivation are described within each derived type and nature of the economic multipliers worked out below.

6 The Agriculture Sectoral Output Multipliers in Rwanda

When the demand for the products of a particular sector (or industry) is increased then, in order to produce the additional output, the sector will need to purchase additional items from the rest of the economy. These purchases will stimulate further output which in turn will require further purchases and so on. Thus there is a sequence of diminishing requirements, the cumulation of which is measured by the output multipliers. These are called type I output multipliers.

Any increases in production, however, will also affect household income both through wages and salaries of employment and through elements of other value-added such as dividends. This increase in income will lead to increase in household consumption (demand) which in turn will stimulate further production and income. Accordingly, type II output multipliers can be defined which capture the additional effect of this household-consumption link. In order to do this, one need to define a consumption function which relates consumption to income and to decide the composition of marginal changes in this household consumption. In doing so, two simplifying assumptions have been made as the following: Firstly all wages and salaries are assumed to be channelled into consumption and thus no part of them is saved, whereas the income elements in other value-added (i.e. dividends/operating surplus) are assumed either to be saved or remitted outside Rwanda, and hence, not to affect consumption. Secondly the marginal household consumption is taken to be the same as the average, thus if on average households spend 30% of their income on food then it is assumed that 30% of each additional RWF1 will also go on food. These assumptions enable us to make a straightforward calculation of the type II multipliers by using the intermediate inter-industry transaction matrix augmented by column-vector of the purchases by households and a row-vector of wages and salaries. In effect this treats labour services as an additional industry and the pattern of consumption as the inputs necessary to make its 'product' labour. The calculations process is as for type I multipliers with using this new augmented matrix. The type II multipliers for each sector are higher than the equivalent type I, since the latter omit induced household effects, and the larger the difference between them the greater the amount of income which is channelled back into the domestic economy.

The **output multiplier** for sector j, however, measures the total direct and indirect output requirements from all the sectors (industries) in the economy in order to satisfy an increase of RWF1 in the final demand of sector j.

The **type I sectoral output multiplier** for sector J, k_j, is defined as:

$$k_j = \sum_{\mathbf{j}} r_{ij} \qquad \ldots\ldots\ldots (9)$$

The elements, r_{ij}^s are the coefficients of the Leontief Inverse of A, i.e. $(I-A)^{-1}$, where A is the matrix of the direct coefficients of the intermediate part of the inter-sectoral transaction table.

The **type II sectoral output multiplier** is defined similarly except that the intermediate part of the inter-sectoral transaction matrix is augmented by the household consumption column and the wages and salaries row. The values of both types of multipliers are shown in table (2), and the sectors have been ranked accordingly.

The Type I output multipliers range from 2.81 for air electricity and water sector to 1.16 for livestock and livestock products, however, closer examination reveals that more than half of the sectors have multipliers which are above the average multiplier value of 1.82. This also means that there will be a little difference in effect between alternative patterns of stimulating the demand in these sectors.

As the main purpose here is to analyze the agriculture sector role in the economy, it is quite clear that the five agriculture sector's components are all registered low output multipliers (type I). This is quite a natural and expected results as the agriculture sector's components are not fully integrated in reproduction structuring of the Rwandan economy. Hence, these agriculture components have no highly significant and strong inter-sectoral relationships with other non-agriculture sectors of the economy. This developmental fact is clearly reflected in the value of the type II output multipliers of the five agriculture sub-sectors. For this measurement and type of output multipliers, these agriculture sub-sectors formed the top ranks among other sectors of the Rwandan economy. This is economically highly plausible, as most of the output of these agriculture sub-sectors in Rwanda uses, at present, either for domestic consumption and/or for export which both of them are not part of industrialization and reproduction. Besides, this trend in agriculture sector development behaviour, has evidently and numerically proved that the value-added generated by the sector (particularly compensation of employees) is dominated its output. This is an obvious and expected outcome as these five agriculture sub-sectors have a relatively weak production and development relationships with other sectors of the economy, which drastically minimize the proportions used by these sub-sectoral of other industries and sectors' outputs within the national economy, as inputs for their production processes. Accordingly, the two influential factors for agriculture in Rwanda, nowadays, are the final consumption demand and the income generated within the farming communities, rather than inter-industrial developmental process and domestic economic integration. Nevertheless, if there is more and full inter-sectoral relationships and integration of agriculture sub-sectors within the Rwandan economy, a much higher proportion of the change in the final demand will be channelled back into the economy, and hence creating further growth, development and more national value-added.

However, and as stated above, the picture of agriculture sectors in the economy shifts quite radically when induced income effects are incorporated as shown in the type II multipliers, tables (2). The increased importance of all agriculture sub-sectors are apparent is due to their high income coefficients (i.e. value –added (wages)/output ratios), and development reasons stated above.

These high income coefficients, however, means that a high proportion of the inputs of these sectors are channelled into household consumption which in turn purchases a wide variety of products, and hence enhanced the multiplier effect of these sectors. It is worth mentioning that the type II multipliers are spread wider and more uniformly than type I (see table (2)).

Table 2

Sectoral Output Multipliers in Rwandan Economy

No.	Sectoral	Type I Multiplier	Rank	Type II Multiplier	Rank
1	**Food Crops**	1.17	15	7.06	4
2	**Cash Crops**	1.29	13	6.25	6
3	**Livestock & livestock products**	1.16	16	7.20	2
4	**Forestry**	1.22	14	7.45	1
5	**Fishing**	1.50	12	7.08	3
6	**Mining & quarrying**	2.00	6	5.74	9
7	**Manufacturing of food**	2.12	5	6.42	5
8	**Manufacturing of beverages & tobacco**	1.86	9	5.13	13
9	**All Other Manufacturing Industries**	2.32	2	4.69	15
10	**Electricity and Water**	2.81	1	5.62	10
11	**Construction**	2.32	3	4.70	14
12	**Trade and Transport**	1.64	10	4.23	16
13	**Hotels & restaurants**	2.19	4	5.19	12
14	**Public administration and defence**	1.93	8	5.85	8
15	**Education and Health**	1.97	7	6.15	7
16	**All Other Services**	1.53	11	5.22	11

7 The Sectoral Income Multipliers in the Economy

Any change in demand will affect not only output but also income and employment, and in fact these latter effects are usually of more interest than the former. Multipliers may be calculated to help assess theses effects. Firstly we examine the impact on income. The income generated in the economy by a RWF1 change in the final demand for industry/sector j, is found as:

$$\sum \omega_i * r_{ij} \ldots . (10)$$

Where ω_i is the labour income coefficient (i.e. the ratio of wages and salaries to gross output) for the ith sector, and a list of these sectoral labour income coefficients are given in section (10) of this report.

However, a more usual measure of the interdependency of the economy and a sector's ability to stimulate income in the rest of the economy is to look at the total direct and indirect income generated for every RWF1 of direct income generated.

Thus, the **type I income multiplier** for sector j, h_j , is defined as the ratio of the direct and indirect income divided by the direct income generated by the change of RWF1 in the demand for sector j output. That is:

$$h_j = \sum \omega_i * r_{ij} / \omega_j \ldots\ldots (11)$$

As before the coefficients of the Leontief inverse of the augmented matrix are substituted in the above equation in order to obtain the type **II** income multipliers. Both types of multipliers are shown in table (3).

Table 3

Sectoral Income Multipliers Type I and II in Rwandan Economy

No.	Sector	Type I Multiplier (hi)	Rank	Type II Multiplier (hi)	Rank
1	**Food Crops**	1.06	15	2.64	15
2	**Cash Crops**	1.11	13	2.75	13
3	**Livestock & livestock products**	1.07	14	2.65	14
4	**Forestry**	1.05	16	2.61	16
5	**Fishing**	1.15	12	2.85	12
6	**Mining & quarrying**	1.57	9	3.89	9
7	**Manufacturing of food**	10.62	1	26.36	1
8	**Manufacturing of beverages & tobacco**	6.67	3	16.56	3
9	**All Other Manufacturing Industries**	7.15	2	17.74	2
120	**Electricity and Water**	4.98	5	12.36	5
11	**Construction**	4.22	6	10.47	6
12	**Trade and Transport**	1.53	10	3.79	10
13	**Hotels & restaurants**	5.88	4	14.60	4
14	**Public administration and defence**	1.75	7	4.33	7
15	**Education and Health**	1.57	8	3.90	8
16	**All Other Services**	1.31	11	3.24	11

The variation in the **type II multiplier** here ranges from 2.61 for the forestry sector to 26.36 for food manufacturing sector. These multipliers can be used to assess the relative importance of secondary income gen-

eration in each sector (industry). For example, if the increase in final demand is such that, RWF1000 of income is created directly for workers in the food manufacturing sector, then in fact another RWF 9,620 will be created in Rwanda indirectly, while a further RWF 15,740 will be generated in the economy by the induced effects of the household income-consumption link, making a total income change of RWF 26,360.

Industries like food products have very high multipliers because of their significant domestic inter-industrial linkages and because their direct income coefficients are small. On the other hand forestry sector products although have some integration within the domestic economy, as evidenced by its high output multiplier, has a low income multiplier because of its large direct income coefficient in the denominator.

The rankings between income multiplier type I and type II are the same, and in fact the ratio between type I and type II income multipliers for each sector is a constant 2.48. This constant relationship has been demonstrated algebraically by Bradley and Gander (1969), and it indicates the proportion of income being retained within the domestic economy. The lower the ratio is the more open the economy. The examples of this ratio are: 1.32 for Scotland (Al-Ali and Burdekin, 1978), 1.15 for United Arab Emirates (Al-Ali, 1998), 1.26 for Jordan (Al-Ali and Sabbagh, 2014). It is interesting, accordingly, to note that Rwanda experiences a little leakage of household income outside the country. That said, it must be borne in mind that the comparison between different economies, particularly, where these ratios are based on different tables and for different years would lose the uniformity of comparison, this is besides that the definitions of income may also differ.

8 The Sectoral Employment Multipliers in Rwanda

The repercussions of a change in final demand, such as new investment, will generally have some impact on employment in the economy and the sector, although an increase in output level might be met by increases in labour productivity. Using the ratio of each sector's employment to its gross output in 2011 as a simple employment production function, the impact on employment of a RWF1 change in the final demand/investment for sector j is calculated as:

$$\sum_i \ell_i * r_{ij} \text{ ..... (12)}$$

Where, $\ell_i = E_i / X_i$ is the labour-output ratio for sector i

E_i is the employment in sector i, and

X_i is the gross output of the ith sector.

The employment figures were based on information provided by the household income and expenditures survey (HIES) results, modified and adjusted according to 2011 SUT of NISR and the constructed 2011 IOT adopted sectoralization scheme.

As in the case of the income multipliers, the employment multiplier is defined to be the ratio of the total change to the direct change in the Rwandan employment generated by a change of RWF1 in the final demand of a given sector or sectors of the economy.

The **type I employment multiplier**, e_j, is defined as:

$$e_j = \sum_i \ell_i * r_{ij} / \ell_i \text{ ..... (13)}$$

The coefficients of the Leontief inverse of the augmented matrix have used to derive the **type II employment multipliers**. The computed values of the employment multipliers are shown in table (4).

Table 4

Sectoral Employment Multipliers Type I and II in Rwandan Economy

No.	Sector	Emp. Multiplier Type I (ej)	Rank	Emp. Multiplier Type II (ej)	Rank
1	Food Crops	1.05	15	2.28	15
2	Cash Crops	1.08	13	2.36	13
3	Livestock & livestock products	1.06	14	2.30	14
4	Forestry	1.03	16	2.25	16
5	Fishing	1.09	12	2.43	12
6	Mining & quarrying	2.27	8	8.72	9
7	Manufacturing of food	22.66	1	52.42	1
8	Manufacturing of beverages & tobacco	13.62	3	32.31	3
9	All Other Manufacturing Industries	11.73	4	31.76	4
10	Electricity and Water	4.66	5	14.80	6
11	Construction	3.12	6	9.54	8
12	Trade and Transport	1.35	11	3.48	11
13	Hotels & restaurants	13.85	2	36.31	2
14	Public administration and defence	1.75	10	7.03	10
15	Education and Health	2.76	7	16.51	5
16	All Other Services	1.90	9	13.33	7

The employment multiplier (type II) of cash crops sector, for example, means that if an increase in final demand is such that employment in this sector increases by 100 then the total employment change in Rwanda, throughout all sectors, will be 236 of which 128 resulted from the inclusion of the household income-consumption link. While for food manufacturing products sector, such an increases in its employment of, say, 100 due to an increase in its final demand component including increase in investment, the resulting total employment opportunity in the economy, by all sectors,

will be 5242 of which 2976 opportunity due to inclusion of the household income-consumption link.

Once again the large indirect output requirement by food manufacturing sector, beverages and tobacco industry and other manufacturing industry sector from other sectors and industries in the economy, combined with their low labour-output ratio, due to their production technologies, means that these sectors, amongst others, also have the highest employment multipliers. As can be seen from table (4) the employment multipliers are distributed more homogeneously than for other two multipliers.

All above analysis have illustrated, using a strategic developmental techniques coupled with Rwandan actual and driven statistical data. Such realistic approaches and analytical developmental tools, have evidently, and in quantitative manner approved that agriculture sector and its sub-sectors components have no significant development and multiplier impact on other sectors of Rwandan economy and/or on the national economy at large, that can push economic development and growth of the economy forward. This has been empirically tested where all agriculture sub-sectors have ranked at the bottom of all sectors for all multipliers. An exception for that was the ranking of these agriculture sub-sectors in output multiplier type II which apparently to due to the final consumption column. This, however, is a vital evidence that the uses of agriculture productions at present stage of development in Rwanda is, mainly, for final consumption.

9 Agriculture Sector and Other Sectoral Development Linkages in Rwandan Economy

In order to describe the structural interdependence of the sectors/industries within the economy, particularly identifying the development importance of the agriculture sub-sectors, two measures have been devised. These are; the backward and forward linkages. The first of these indicates the relative ability of an industry or sector to stimulate output amongst the various sectors within the economy, and the other indicates the relative dependence of an industry or sector upon demand of its output by different sectors of the economy.

However, and for the purpose of formulating development growth strategy for the national economy, the linkages have been used to identify the key (leading) sectors in the economy for growth and development. The leading sectors are these sectors which are in a favourable position to induce the expansion and development of other sectors of the economy, and hence to accelerate the development process and stimulate growth in the national economy. These are a fundamental development measures and issues that we are restrict ourselves to follow in order to deriving the key sectors in the Rwandan economy.

9.1 The Backward and Forward Development Linkages

The **backward linkage**, b_j, is define, in an input-output context, as:

$$\mathbf{b_j = \sum_i r_{ij}} \quad \textbf{(14)}$$

Where, r_{ij}, is the elements (cells) of Leontief Inverse matrix $(I-A)^{-1}$. Thus b_j is the total change in the gross output of the economy brought about by one unit change in demand for sector/ industry j output.

The **forward linkage,** c_i, is defined as:

$$\mathbf{c_i = \sum_j r_{ij}} \quad \textbf{(15)}$$

This shows the output generated in sector i when final demand in each sector of the economy is increased by one unit.

9.2 The backward and Forward Development Linkages Index

Having derived the above, an index is constructed to measure the relative strengths of each of the linkages; by dividing each of b_j and c_i by their respective average backward and forward linkages for the Rwandan economy as a whole, that is:

$$\mathbf{v_j = \frac{\sum_i r_{ij}}{n} \Big/ \frac{\sum_i \sum_j r_{ij}}{n^2}} \quad \textbf{(16)}$$

Or using another methodological setting, this as:

$$\mathbf{v_j = n * b_j / (\sum_j b_j)} \quad \textbf{(17)}$$

With n as the number of the sectors in the economy, and (*) is sign for multiplication. While for the forward linkage indices (u_i), the calculation systems are:

$$\mathbf{u_i = \frac{\sum_j r_{ij}}{n} \Big/ \frac{\sum_i \sum_j r_{ij}}{n^2}} \quad \textbf{(18)}$$

Or in another way it can be calculated as:

$$\mathbf{u_i = n * c_i / (\sum_i c_i)} \quad \textbf{(19)}$$

Those sectors with a higher than average backward linkage index (i.e. $v_j > 1$) generate an above average response in the other sectors of the economy, and the status for the relative performance of different sectors is shown in table (5). These are driven from the total I/O coefficient Matrix (A).

A higher than average forward linkage index means that these sectors display above average dependence on the demand from other sector. By increasing the output of such sectors it is hoped that the industries which purchase them will be encouraged by the greater availability of supplies to increase their own output.

Table 5

Ward and Forward Sectoral Linkages and the Ranking in Rwandan Economy

No.	Sector	Backward	Rank	Forward	Rank
1	Food Crops	1.17	15	2.08	4
2	Cash Crops	1.29	13	1.14	13
3	Livestock & livestock products	1.16	16	1.22	9
4	Forestry	1.22	14	1.15	11
5	Fishing	1.50	12	1.00	16
6	Mining & quarrying	2.00	6	1.11	14
7	Manufacturing of food	2.12	5	1.24	8
8	Manufacturing of beverages & tobacco	1.86	9	1.43	5
9	All Other Manufacturing Industries	2.32	2	4.85	2
10	Electricity and Water	2.81	1	1.21	10
11	Construction	2.32	5	1.25	7
12	Trade and Transport	1.64	10	4.93	1
13	Hotels & restaurants	2.19	4	1.15	12
14	Public administration and defence	1.93	8	1.39	6
15	Education and Health	1.97	7	1.07	15
16	All Other Services	1.53	11	2.81	3

It is quite clear from the results above that agriculture sub-sector have the lowest linkages, both backward and forward, apart from some on other sectors of the economy on food crops sector due to some inputs used of some sectors particularly, food industry comes from food crops sub-sector. This is, by and large, a natural and accurate results, as agriculture sector, and as stated earlier, has very little relationship with the production processes of the rest of the Rwandan sectors. This is due to, amongst other things, the lack of integration of the agriculture sectors within the national economy's development processes and, more importantly, to the lack of industrialization and uses of various agriculture outputs, neither having domestic industries that supplying agriculture sectoral component with its, much needed and required inputs, within the domestic Rwandan economy.

The table below (table (6), shows the results of backward and forward linkages indices. These have been calculated in order to identify the key (leading) sectors in the Rwandan economy.

Table 6

Sectoral Backward and Forward Linkages Indices in Rwandan Economy

No.	Sector	Backward Linkages Index (v_j)	Rank	Forward Linkages Index (u_i)	Rank
1	Food Crops	0.65	15	1.15	4
2	Cash Crops	0.71	13	0.63	13
3	Livestock & livestock products	0.64	16	0.67	9
4	Forestry	0.67	14	0.64	11
5	Fishing	0.83	12	0.55	16
6	Mining & quarrying	1.10	6	0.61	14
7	Manufacturing of food	1.17	5	0.68	8
8	Manufacturing of beverages & tobacco	1.03	9	0.79	5
9	All Other Manufacturing Industries	1.28	2	2.67	2
10	Electricity and Water	1.55	1	0.66	10
11	Construction	1.28	3	0.69	7
12	Trade and Transport	0.95	10	2.72	1
13	Hotels & restaurants	1.21	4	0.63	12
14	Public administration and defence	1.06	8	0.77	6
15	Education and Health	1.09	7	0.59	15
16	All Other Services	0.84	11	1.55	3

However, it is quite obvious, and given what have been stated and analyzed above, none of agriculture components and sub-sectors, is emerged as leading sector in Rwanda (only other manufacturing Industries sector and, to lesser extent, trade and transport sector emerges as the two leading sectors in the economy). This is a credible result as most if not all of agriculture sectoral output and products of various crops and sub-

sectors are either used for final consumptions or, modest, portion of that products is went for exports to the outside world. Hence, minimal portion of the sector being used domestically for industrialization purposes and as inputs into other sectors within the Rwandan domestic economy, as economic development reality and comparative advantages should dictate.

10 Some Key Ratios and Sectoral Economic Indicators of the Rwandan Economy

The following are a list of some selective indicators based on the income coefficient (wage-output ratio), labour productivity (RWF billion of output per thousand workers) and labour-output ratio (thousands of workers per RWF billion of output) for the each of the industrial groups shown in the input-output tables, for the Rwandan economy. The sectors have also been ranked by the different ratios. However, it should be noted that the definition of industrial output, labour and/or wages used are all pertaining to 2011, the year for the structured input-output tables for the economy.

Table 7

Some Selective Sectoral Indicators in Rwandan Economy

No.	Sector	Income-Output Ratio	Rank	Labour Productivity	Rank	Labour-Output Ratio
1	Food Crops	0.81	2	0.39	14	2.57
2	Cash Crops	0.65	5	0.48	12	2.08
3	Livestock & livestock products	0.82	2	0.38	15	2.62
4	Forestry	0.86	1	0.36	16	2.75
5	Fishing	0.71	4	0.44	13	2.25
6	Mining & quarrying	0.35	8	3.20	9	0.31
7	Manufacturing of food	0.06	15	12.87	3	0.08
8	Manufacturing of beverages & tobacco	0.07	14	10.62	4	0.09
9	All Other Manufacturing Industries	0.05	16	15.76	1	0.06
10	Electricity and Water	0.08	11	6.70	5	0.15
11	Construction	0.08	12	5.01	8	0.20
12	Trade and Transport	0.25	10	1.53	11	0.65
13	Hotels & restaurants	0.07	13	13.89	2	0.07
14	Public administration and defence	0.33	9	2.50	10	0.40
15	Education and Health	0.39	7	6.11	6	0.16
16	All Other Services	0.41	6	5.75	7	0.17

11 Conclusions and Development Policy Implications

Given the above modelling approach and the empirical results of the role of agriculture sector in Rwandan economy, it is worth mentioning the following concluding remarks:

1. It has to be stated that this is the first attempt, in Rwandan economy, to have a complete construction of an input-output table (IOT) for the economy, and to carrying out empirical analysis of various agriculture sub-sectors in an inter-industrial/inter-sectoral developmental approach.

2. Most of the agriculture sub-sectoral outputs are used for final consumption. Relatively, little proportions of the agriculture production is used by other sectors of the economy as inputs, and quite a low percentage went for export, in 2011.

3. Accordingly, agriculture sector's impact on the production and growth regenerated cycle in the economy is minimal. Hence, very weak development linkages between agriculture sub-sectoral activities and productions with the other sectors productive activities, and with the rest of the domestic economy. This is very important for direction and implication for future development policies for the agriculture sector and its various components in Rwanda.

4. The increasing agriculture growth and production depends on whether additional product and produce would be marketed and absorbed efficiently, whether domestically for final uses, intermediate industrial uses, for export and to substitute the imports. This, by and large is essential for vegetables and fruits produced in Rwanda. To support farmers in this respect, it is imperative to improve the infrastructure and the market information. Such measures would, undoubtedly, facilitate the traders, manufacturers and post harvesting commercialization process.

5. To achieve the target delineated to agriculture sector thus far, agriculture productivity in food crops, cash crops and livestock sub-sectors should be the priority. To achieve that required improved agriculture technology (mechanization, and others) and management. These, however, includes improvement soil watering, irrigation efficiency, and implementation of modern irrigation technology and projects, that relying on solar energy (particularly, pumping, dripping and spray). For these supportive activities; private and cooperate sector should be encourage to involve deeply, using various stimulus including subsidies.

6. Also, the achievement of growth target for the agriculture sector requiring improving seeds and seed varieties, fertilizers and nutrient deliveries and management practices. Besides, acquiring and using new agriculture technology for preharvest, harvesting and postharvest processing. Again, for some of these activities private sector can be effectively motivated to handle in an efficient manner.

7. It is recommended that the analyzed five agriculture sub-sectors, have to be, statistically, disaggregated further, in the future, in order to have more comprehensive and wider coverage analysis of detailed agriculture products components and various types of crops.

8. It is envisaged that such an analytical and empirical approach, presented in this paper, would be extended, in the near future, so that planning and forecasting procedures and tailored-made methodologies can be structured and applied for agriculture sector, sub-sectors, which would including all developmental aspects and variables, particularly, investment requirements, priorities, impacts and tasks ahead for Rwandan agriculture sector. Hence, supporting agriculture development decision makers, with an appropriate and effective analytical tools and subsequent empirical results, to devise realistic, feasible and applicable development policies for agriculture sector in Rwanda.

9. Moreover, carrying out such an analysis and future forecasting of the likely and potentially agriculture sectoral development, will equip the decision making authority with better development perspective, based on a sold quantitative articulation. Thus enhancing the capability to determine agriculture sector growth trajectories, and crops development priorities as well as crops diversification and outlook strategies.

10. Nonetheless, it is planned to have more pertinent statistical data and further improvements and disaggregation of the IOT of Rwanda, particularly, when we manage to implement and successfully completing the agriculture sector's statistical templates that prepared earlier, at the Planning and Budgeting Directorate of MINAGRI.

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