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# Assessment of Yield Gaps in Main Staple Crops in Rwanda

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***Abstract:*** **This study analyzed the trends in yield of the stable food crops namely wheat, bean, maize, cassava, irish potato and rice in Rwanda and determined the gaps between current and potential crops yields of these crops. For the analysis of trends yield, crop yield time series covering the period from 2000 to 2013 have been used. For measuring the gaps, crops yield for 2013 year have been used. The findings of the study show that the crop yield is changed a lot from year to year and is in general increasing at declining rate for all crops. The gap between current and potential in yield is currently evaluated at 3.035 tons for maize, 1.839 tons for wheat, 3.266 tons for rice, 1.147 tons for beans, 31.999 tons for cassava and 30.562 for irish potato. In percentage terms and using the upper boundary of potential yield, the gap range from 60.7%, 45.97%, 36.28%, 71.68%, 63.99% and 76.40% respectively for maize, wheat, rice, bean, cassava and irish potato. These figures show that there is a room to increase the yield for all crops and therefore increase the agricultural production in order to improve the food security particularly for farmers who rely almost on income from selling the agricultural production. Therefore, the Government of Rwanda should continue to adopt programs and strategies to increase the agricultural productivity and production.**

***Keywords:*** **Crop Yields, Yield Gaps, Staple Crops, Rwanda**

## 1. INTRODUCTION

Rwanda's national economy is based on agriculture. About 75% of the total Rwandan population is dependent on agriculture sector for their living (MINAGRI, 2013). Agriculture contributes to development as an economic activity, as a livelihood, and as a provider of environmental services, making the sector almost a unique instrument for growth and poverty reduction in the country (MINAGRI, 2013). Theagriculture sector is providing about 31, 9% of GDP (CIA, 2014). Yet, it remains less productive and largely at subsistence level. While in the 1950s more than 50% of the people worked on more than 2 ha today more than 60% have less than 0.5 ha (MINECOFIN, 2007). Consequently, a substantial number of rural families who subsist on agriculture own less than 0.5 hectare, which is too small to earn a better living (MINECOFIN, 2007). Hence, the government of Rwanda aims to transform agriculture from subsistence farming to market oriented modern farming in order to transform Rwanda's economy into a middle income country (per capita income of about 900 USD per year) and raise the living standards in the country (MINECOFIN, 2000 and 2007).

Rwanda vision 2020 acknowledges that the most important issue retarding Rwanda's agricultural development is not land size, but low productivity associated with traditional peasant-based subsistence farming (MINECOFIN, 2000). Consequently, the vision 2020 sets the increase in agricultural productivity as a priority for realising the minimum growth rate of 4.5% per year for agriculture to be able to back the growth of the whole national economy. Therefore, CIP, one of the strategies of modernizing and developing the agricultural sector, attempts to address the concerns reflected in Vision 2020 on the reduction in productivity due to lack of simultaneous application of fertilizer use of modern inputs (fertilizers,pesticides and improved seeds) by emphasizing that intensification should be accompanied by the use of appropriate inputs (Cantore, 2010 and Musahara, 2014). The Crop Intensification Program (CIP) ultimate goal is to increase agricultural productivity of high-potential staple food crops and ensuring food security and self-sufficiency through sustainable intensification processes (IFDC, 2010). It focuses on six priority crops namely maize, wheat, rice, irish potato, bean and cassava. According to IFDC (2010), the use of fertilizers under CIP program has increased averagely from 8 kg/ha in 2007 to 23 kg/ha in 2010. The agricultural statistics shows a sharp increase in production for the crops prioritized by CIP program. The increase accounts for 73.56%, 56.83%, 84.78%, 24.93% and 64.87% between 2007 and 2013 respectively for cassava, potato, maize, bean, rice (paddy) and wheat.

However, even if the agricultural production has increased, the agricultural productivity is still low in the country (MINAGRI, 2009). The low agricultural productivity is mainly due to weak agricultural production systems resulting from the combination of factors including (i) fragmentation of small farms into ever-smaller plots, (ii) low rural income levels which make farmers reluctant to shift from subsistence agriculture to commercial agriculture. (iii) low levels of market integration in most farming areas, (iv) low levels of inorganic and organic fertilizer application, owing mainly to lack of purchasing power of most farmers but also due to other factors such as lack of sufficient awareness of fertilizer's benefits, lack of proper development of the distribution system, lack of availability of the most appropriate fertilizer mixes, poor planning and timing in placing orders for fertilizers, (v) lack of access and limited capacity to acquire improved seeds (vi) inadequate relation between research and extension services leading to poor technology transfer to farmers, (vii) difficulties in accessi- ng loans for input purchase for the majority of farmers and (viii) insufficient training in

product quality and post-harvest handling operations, and insufficient infrastructure for post-harvest handling systems. Therefore this study aims to analyze the trends in yield and to determine the gaps between current and potential yield of stable food crops prioritized by CIP program.

## 2. Literature Review

The Government of Rwanda aspires to fundamentally transform Rwanda into a middle income country (per capita income of about 900 USD per year). (MINECOFIN, 2000). With average annual GDP growth rate of 8 percent and 5.2 percent for agricultural GDP from 1999-2012, Rwanda's recent growth is a historical record. The poverty headcount fell from 59 percent in 2001 to 45 percent in 2011, and agriculture continues to be one of the main drivers of growth and poverty reduction in Rwanda, significantly lifting rural households out of poverty (World Bank, 2014). The country's economy need to grow at a rate of above 7% to accomplish this goal. To realize this vision, the government embarked on modernizing and transforming agriculture sector into a productive, high value, market oriented agriculture sector with forward linkages to other sectors of national economy (industry and services) (MINECOFIN, 2000 and Musahara, 2014). A minimum growth rate for agriculture through increase in productivity is evaluated at 4.5% per year for backing the growth of the whole national economy (MINECOFIN, 2000). Consequently, the government adopted different agricultural policies, strategies and programs in order to facilitate the intensification of agriculture sector.

*1. Strategic Plan for Agricultural Transformation (PSTA):*

The PSTA seeks to facilitate the development of Rwanda's agriculture through an approach based on resource management, human capacity and private sector driven value chains. The strategic focuses on both increased production of staple crops and livestock products and greater involvement of the private sector investment to increase agricultural exports, processing and value addition (MINAGRI, 2013). It is built upon four main agricultural programs:

- The program of agriculture and animal resource intensification through soil conservation and land husbandry, agricultural mechanization development, inputs use to improve soil fertility and management, seed development and livestock development.
- The program of research, technology transfer and professionalization of farmers which concentrate on research and technology transfer, extension and proximity services for producers, farmer cooperatives and organizations.
- The program of value chain development and private sector investment focuses on establishing an environment to attract private investment, encourage entrepreneurship and facilitate market access, development of priority value chains (food crops, dairy and meat, fisheries, apiculture), agricultural finance, and market-oriented infrastructure.
- The program institutional development and agricultural cross-cutting issues which concentrates on institutional capacity building, decentralization in agriculture, legal and regulatory framework, agricultural communication, statistical systems, Monitoring and evaluation and management information systems, gender and youth in agriculture; and environmental mainstreaming in agriculture.

*2. Crop Intensification Program (CIP):*

The CIP program introduced in 2007 aims at increasing agricultural productivity in high-potential staple food crops and ensuring food security and self-sufficiency through sustainable intensification processes (IFDC, 2010). Currently, the CIP program focuses on six priority staple food crops namely maize, wheat, rice, irish potato, bean and cassava. For agricultural intensification, the CIP program puts emphasis on land use consolidation, increasing the effectiveness use of the farm inputs, shifting focus from supply to enhancing the demand for inputs by farmers and market driven forces within the marketing system, strengthening the smallholders' links to inputs and outputs markets through improved access to finance and market information, minimizing the post-harvest losses and facilitation of linkages to value chain upstream (MINAGRI, 2011).

Under CIP program, the farmers using improved seeds increased from 3% in 2007 to 40% in 2010 and the use of inorganic fertilizer increased averagely from 8 kg/ha in 2007 to 23 kg/ha in 2010 (IFDC, 2010). In addition, Encouraging farmers to use improved seeds has substantially increased the local demand and the capacity for seed production. With the exception of hybrid seeds, the open pollinated varieties of maize and self-pollinated varieties of wheat, rice and beans are multiplied by RAB (Rwanda Agricultural Board) and entrepreneurial farmers in the country.

*3. Land Use Consolidation (LUC):*

LUC in Rwanda is nested in the structure and evolution of land and agriculture especially in the period after independence (Reitsima 1982, Clay *et al.,* 1996, Bizimana *et al*., 2004). Land Consolidation is generally considered as putting together small plots with the aim of making them viable and more productive per unit of investment, through economies of scale (Zhou, 1999). Land consolidation is an answer in societies where there has been significant land fragmentation (Okezie *et al.,* 2012). The proximate cause of land consolidation in Rwanda is found in land fragmentation (Musahara, 2006; Musahara and Huggins, 2005 and GoR, 2004). The consolidation of land use involves successfully rearranged land parcels to consolidate the use of farm holdings. Under the land consolidation policy, farmers in a given area need to grow specific food crops in a synchronized fashion that will improve the productivity and environmental sustainability. It facilitates the achievement of a unified farming production system characterized by collaboration in types of crops grown, sale or processing of agricultural products and/or distribution and marketing of agricultural products (MINAGRI, 2012).

At the beginning farmers were reluctant to adopt the la-

nd consolidation use. However, CIP program successfully convinced farmers by explaining the various advantages of land consolidation as it reduces volume/cost ratio, logistics and transportation costs of inputs and outputs, increases accessibility of inputs, by providing a focused market for farm inputs as the agro dealers can have a larger coverage, facilitates a concentrated market for farm produce, provides increased coverage of pro-ximity extension services enables equitable distribution of natural resources such as soil and water and increases land- and crop productivity and protection, erosion control under radical terracing schemes, rainwater harvesting and management and hillside irrigation., crop protection. Since its introduction in 2008, the total area under land use consolidation has increased by 18-fold from 28,016 ha in 2008 to 602,000 ha in 2012. However, Huggins (2012) argues that land consolidation in Rwanda is consolidation power in hands of a centralized authoritarian sate which will make Rwandan peasants proletarians. Musahara et *al.* (2013) noted that the study of Huggins (2012) fits well into the discourse on land grabbing in Africa which does not fit the Rwandan case.

*4. Mechanization, irrigation andterraces schemes strategies:*

It is envisioned that by 2017 about 25% of agricultural farm operations will become mechanized in Rwanda. This implies that out of four farmers, one farmer will either use or hire mechanization services by 2017. The mechanization efforts aim to raise the power inputs of farming activities, thereby putting more land into production, decrease drudgery in field operations, thereby enhancing quality of life of rural people, improve the timeliness and efficiency of field work, carry out tasks that are otherwise difficult to perform without mechanical means, advance the quality and value of agricultural produce and processed products of Rwanda, provide entrepreneurship opportunities and sustainable rural livelihoods, and facilitate crop processing and thereby improve rural economic opportunities. In 2013, only 13.5 % of farm operations were mechanized including land preparation, planting, crop treatment, harvesting, post-harvesting and agro-processing (MINAGRI, 2013).

*5. National Post-Harvest Staple Crop Strategy (PHSCS):*

The PHSCS aims to develop an efficient post-harvest system driven by private sector to ensure food security in the county through delivering staple crops. It has to assist with strengthening the harvesting, post-harvest handling, trade, storage, and marketing within staple crop value chains in Rwanda in order to improve markets and for farmers' linkages, and reduce post-harvest losses (MINAGRI, 2011). .For improving the crops value chains the PHSCS focuses on different elements which include (i) rendering basic market data available to public and private stakeholders, (ii) placing transport infrastructure that could support movement of staple commodities, (iii) facilitate appropriate technologies at the production and aggregation points along the value chain, (iv) engaging the private enterprises through facilitation of training and infrastructure, (v) increase the investments and financial services, (vi) improve the structures and grading of farm outputs, and (vii) leverage the management of strategic grain reserve to create a fair and transparent market for staple crops in the country (MINAGRI, 2011). From National Agriculture Extension Strategy, all agricultural technologies and practices recommended can give better results only if they are communicated properly to the farmers. Within that framework, the Rwandan extension strategy envisages ensuring ideal conditions for the dissemination and exchange of information between producers, farmer's organizations and other different partners in order to transform and modernize the agricultural sector (MINAGRI, 2009). The main axes of national extension strategy include (i) promotion of partnership between public sector, private sector, local and international NGOs, farmer organizations, research and education agricultural institutions; (ii) experimentation in farmer's fields and establishment of a network of farmer researchers, (iv) promotion of voluntary farmer's extension services providers (iii) promotion of rural innovation community centers, (iv) progressive disengage- ment of public sector from extension service delivery in favor of private extension service delivery (MINAGRI, 2009).

## 3. METHODOLOGY

This study relies on secondary data. The methodology used is the review of existing documents in order to have an insight of the evolution of recent Rwandan agricultural policies, programs and strategies and data on potential and current crops yield for determining the gaps in crops yields. The review of existing documents focused on strategic plan for agriculture transformation, the Rwanda Vision 2020 the documents on the use of modern inputs in agricultural sector and the mechanization and irrigation, post-harvest and extension strategies. The data on current and potential yields of crops were retrieved from the documents reviewed. These data have been analyzed for determining the trends in crop yields and compared for determining the difference between potential and current crop yield.

## 4. FINDINGS OF THE STUDY

*1. Analysis of crop yields trends:*

Using the data starting in 2000 which corresponds to the introduction of main agricultural policies, programs and strategies to modernize and transform agricultural sector, the following figure does show the trends of yield of main crops prioritized by CIP program. The sharp increase in yield is observed since 2007 year which corresponds to the introduction of CIP program. As a result, from 2006-2012, the food crop value-added growth rate of 6.2% per year is higher than the growth rate for the overall agricultural GDP. Between 2001 and 2011, agriculture remained the main occupation for over 70% of working Rwandans (World Bank, 2014). However, the yield is decreasing since year 2011 for all crops except for cassava and potato

(irish potato) for which the decrease started in 2012. In addition, the crop yield is in general changing from year to year and is increasing at declining rate for all crops. Consequently, there is again a possibility to reinforce the existing agricultural programs and strategies for avoiding the decline in crop yields and the agricultural production.

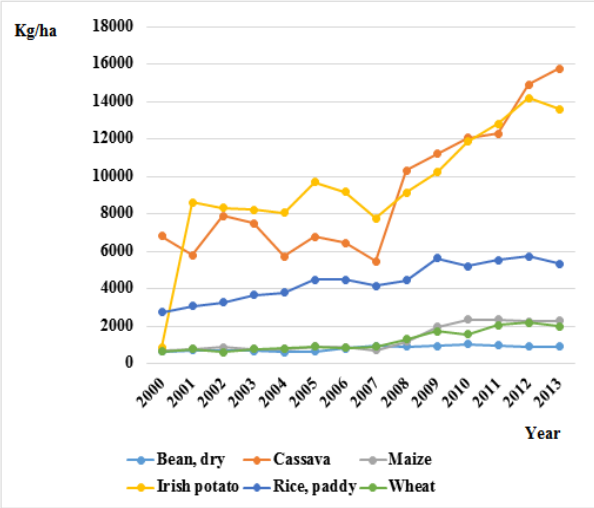


Fig.1. Trends in Yield (kg/ha) of Crops Prioritized by CIP Program

*Source: Authors on the basis of data on crop production and area cultivated from FAO STAT and MINAGRI.*

*2. Assessment of yield gaps:*

Even if the yield has been increasing since 2000, the available data show that there is again a room to improve the yield of crops since the potential yield is not yet reached. The following table shows the gap between the current crops yield and the potential yield.

Table 1.Gap Between Potential and Current Yield

| Crop | Potential yield[1] in tons is between | Current yield[2] in tons | Gap[3] in tons | Gaps in % using the upper boundary of potential yield |
|---|---|---|---|---|
| Maize | 2-5 | 1.965 | 3.035 | 60.70 |
| Whea | 3-4 | 2.161 | 1.839 | 45.97 |
| Rice | 3-9 | 5.734 | 3.266 | 36.28 |
| Beans | 1.2-1.6 | 0.453 | 1.147 | 71.68 |
| Cassa | 20-50 | 18.001 | 31.999 | 63.99 |
| Irish | 9-40 | 9.438 | 30.562 | 76.40 |

*Source: Authors on the basis of data from ministry of agriculture (MINAGRI) farmer's dairy and 2012/2013 year report.*

1Potential yield is taken from the farmer's diary of MINAGRI (2010) except for beans for which the potential yield is computed on the basis of data from the farmer's diary of MINAGRI (2010)

2 Current yield is the crop yield in 2013B season crop, MINAGRI Annual report for year 2012/2013

3 The gap computation assumed the highest potential yield

For all crops there is a possibility of increasing the yield and therefore the production. Using the upper boundary of the potential yield, the gap in percentage terms range from 60.7%, 45.97%, 36.28%, 71.68%, 63.99% and 76.40% respectively for maize, wheat, rice, bean, cassava and irish potato. These figures show that there is a big room for all crops to increase the yield and therefore increase the agricultural production in order to improve the food security particularly for farmers who rely almost only on the income from selling the agricultural produce. Therefore, the GoR should continue to adopt and reinforce policies, programs and strategies to increase the crop yield and agricultural production.

## 5. Conclusion and Recommendations

This study analyzed the trends in yield of the stable food crops under CIP and determined the gaps between current and potential crops yields for main staple food crops (maize, wheat, irish potato, cassava, rice and bean) prioritized by CIP program. The findings of the study show that the crop yield is changing a lot from year to year and is in general increasing at declining rate for all crops. The gap between current and potential crop yield is currently evaluated at 3.035 tons for maize, 1.839 tons for wheat, 3.266 tons for rice, 1.147 tons for beans, 31.999 tons for cassava and 30.562 for irish potato. In percentage terms and using the upper boundary for potential yield, the gap range from 60.7%, 45.97%, 36.28%, 71.68%, 63.99% and 76.40% respectively for maize, wheat, rice, bean, cassava and irish potato. These figures show that there is a big room for all crops to increase the yield and hence the agricultural production. Therefore, the GoR should continue to adopt and reinforce programs and strategies leading to the increase in crop yield and production.

The increase in crop yield and production should be possible since the data show that the agricultural productivity has been increasing since the adoption of important agricultural programs and strategies as well as policies in order to fully modernise and transform the agricultural sector. Within that framework, the GoR should reinforce the linkages between research and extension services in order to more respond to local requirements and needs targeting self-reliance standards for agro inputs particularly improved seeds through multiplication processes and trials before distributing them to producers, define clearly the agro ecological zones as in their context in terms of suitability for fertilizers and improved seeds and their respective application rate to different crops. Further there should be the reinforcement of the promotion of using organic fertilizers in combination with inorganic fertilizers in order to promote the sustainability of the farming land use and therefore contributing to sustainable agricultural chains development. The government should continue to intervene in land use consolidation where possible. Parallel to land use consolidation program, adapting the existing improved agricultural technologies to the size of farms should be focused on as farmers are facing the difficulty to invest in

agricultural technologies requiring the big farms while they possess small farms.. Also parallel to adapt technology to farm size, the government should continue to create windows for developing other jobs in order to reduce the number of people engaged in agriculture. This should result in the creation of big farms for which the use of common agricultural technologies could be easily possible.

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