EFFECTIVENESS AND EFFICIENCY OF FERTILIZER USE IN RWANDA

FINAL REPORT

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ACRONYMS

BCR	Benefit Cost Ratio
BRD	Development Bank of Rwanda
BNR	National Bank of Rwanda
BRP	Rwanda Peoples Bank
CAN	Calcium Ammonium Nitrate
CBA	Cost Benefit Analysis
CIP	Crop Intensification Programme
CSS	Credit Survey Scheme
DHS	District Health Services
EDPRS	Economic Development and Poverty Reduction Strategy
ENR	Local Fertilizer supply company
EICV	Socioeconomic Integrated Household Surveys
FAO	United Nations Food and Agriculture Organization
FGD	Focused Group Discussion
FFS	Farmer Field Schools
GDP	Gross Domestic Product
GHG	Green House Gases
GMPs	Good Management Practices
GoR	Government of Rwanda
ICT	Information Communication Technology
IAD	Institutional Analysis and Development
IDCP	Integrated Development Conservation Programme
IDPs	Integrated Development Programme public workers/development assistants at cell level
IFDC	International Fertilizer Development Centre
IPCC	Intergovernmental Panel on Climate Change
IPPC	International Plant Protection Convention
LCA	Life cycle analysis
MA	Millennium Ecosystem Analysis
MINAGRI	Ministry of Agriculture
MINECOFIN	Ministry of Economic Development and Finance
MINIRENA	Ministry of Natural Resources
NAP	National Agriculture Policy
NISR	National Institute of Statistics of Rwanda
NUE	Nutrient Use Efficiency
PEI	Poverty and Environment Initiative
PSC	Project Steering Committee
PSTA	Strategic Plan for Transformation of Agriculture in Rwanda
RAB	Rwanda Agricultural Board
RADA	Agriculture Development Authority
ROR	Republic of Rwanda
RARDA	Rwanda Agriculture and Rural Development Authority
REMA	Rwanda Environment Management Authority
RNRA	Rwanda Natural Resources Authority
ROHDA	Rwanda Horticultural Development Agency
SAS	Seasonal Agriculture Survey
SPAT	Strategic Plan for Agriculture Transformation
TUBURA	Local Acronym for 'One Acre Fund Organization
UNDP	United Nations Development Programme
USAID	United Stated Agency for International Development

EXECUTIVE SUMMARY

This is a final report of the study on effectiveness, efficiency and sustainability of fertilizer use in Rwanda, whose outcome is meant to assist the GoR to improve the cost effectiveness and ecological sustainability of inorganic fertilizer use from both farm level and national level perspectives. The study was undertaken between February and May, 2016, by Green World Consult Limited (GWCL) as a joint assignment by Rwanda Environment Management Authority (REMA) and the Rwanda's Ministry of Agriculture and Animal Resources (MINAGRI) funded under the UNDP-UNEP supported Rwanda Poverty and Environment Initiative (PEI) through the United Nations Development Programme (UNDP) Office in Rwanda. The study was based principally on data provided by MINAGRI and / or that was sourced from the National Institute of Statistics of Rwanda. However, because of the need to consider both the national and farmer level perspectives it was deemed necessary by GWCL to collect also primary data from farmers in representative districts, as the existing national data from both MINAGRI and NISR could not be easily assigned to specific farming households – a requirement for Cost Benefit Analysis from the farmers' level perspective.

The study was conducted as a descriptive evaluation assessment seeking to improve the cost-effectiveness and ecological sustainability of inorganic fertilizer use from both the farm and national perspective. The specific objectives of the study were to:

(i) Estimate the production (i.e. technical) use efficiency of inorganic fertilizer using available data for crops, fertilizer use by type, and agro-ecological zones. In addition, provide recommendations for improving such analysis in future.
(ii) Determine the benefit-cost ratio (BCR) of current inorganic fertilizer use from farm to national perspective. Summarise the future agricultural and economic productivity of this based on current trends, policies and markets. Provide recommendations for improving such analysis in future.
(iii) Identify the institutional (agricultural sector institutions, policies, laws, strategies, programmes, capacity, decision-making processes, including coordination mechanisms and methodologies, extension services, marketing and cooperatives, financial resourcing etc.) opportunities and constraints for improving efficiency and effectiveness at national and farmer level. Assessment of effectiveness is to include economic, social (distributional) and environmental factors.
(iv) Identify and outline future research priorities on fertilizer use in the context of Rwanda national development priorities and agricultural strategies. This should include social, economic and environmental research elements of fertilizer use.

Rwanda's fertiliser incentive programme seeks to reverse the low crop productivity experienced in the 1990s and the early 2000s, and appropriately targets food crops which contributed 86.2% of the agricultural GDP at the outset of the programme. The use of inorganic fertilisers was also justified by the high soil nutrient mining levels on farms in Rwanda, ranked highest in regards to phosphorus and potassium, and also included among the highest was the crop soil mining of nitrogen starting in the 1980s to the late 1990s.

The outlook of crop output and fertilisers between 2007 and 2014 suggested a positive and proportional relationship between increased inorganic fertiliser use and crop output. But a close examination of crop responsiveness through production and nutrient use efficiency based on a Cobb-Douglas production function suggested that the proportionality of the relationship was lower than expected. The coefficients showing the percentage increase in output for every one-percentage increase in fertiliser use 0.35%, 0.84%, 0.14% and 0.18% for aggregate crop total, maize, rice and beans respectively with weak significance for beans and rice. The response for Irish potato was negligible while that for wheat was not significant.

The results of the value cost ratio VCR were based on the rule of thumb that farmers would be more willing to use inorganic fertilisers if the additional value of crops produced exceed the cost of fertiliser used by a ratio of 3:1. Maize and rice provided the only profitable crops with fertiliser use while beans, Irish potatoes and wheat were not feasible. The VCR result also demonstrated the importance of the crop subsidy. Whereas rice and maize crops were profitable with subsidised fertiliser use this was not the case when the subsidy was not available. In sub-Saharan Africa, VCR is expected to be low often ranging between 2.0 and 3.0. Therefore, the lack of profitability for wheat, Irish potato and beans would not lead to their exclusion from further economic analysis due to the possibility of other effieiccy considerations additional to fertiliser use and the crop yield response. .

When the influence of social and environment factors on fertilizer use were captured in the CBA analysis using the Benefit Cost Ratio (BCR) approach, the results showed that both national level and farm-level use of fertilisers was under the viability threshold with BCR of 0.32 and 1.32, at the national and farm-level respectively. Even though, the BCR for the national level was quite low when the CIP fertiliser programme is implemented fully to cancel out the current soil nutrient depletion rate, the projected BCR would be 0.82. The use of fertilisers in the production of the initial five target crops of maize rice, beans, wheat and Irish potatoes was not viable at the national level but was viable at the farm level.

The BCR results at the national level were lower than expected. Even though, the sub-optimal result is also related to the smoothing of data between farmers implementing the CIP programme and those who do not implement the programme, it also aggregation of limiting factors such as environmental externalities from inorganic fertiliser pollution in water systems, the continuing soil nutrient depletion in the country where Rwanda has the highest depletion rates for nitrogen, phosphorous and potassium in the Sub-Saharan Africa, and the limited complementary within the CIP programme. The use of inorganic fertilisers, improved seed, organic manure and irrigation did not complement each other as set out in the CIP programme resulting in the poor performance observed as well as the projected environmental externalities.

At the sub-national level, the discretion of farmers allows them to use organic manure, practice crop rotation, intercropping and crop diversification beyond the targets of the CIP programme. As a resilience of the farm level production was higher than the national aggregate. The major limiting factor at farm level is the price of crops. The influence of crop price on farmers' willingness to use fertilisers was likely to be higher than the cost of the fertiliser and cost of other variable inputs. The subsidy itself was more important at the national aggregate level than at the national level.

The results of this study show that the implementation of the CIP programme needs to embrace a similar structure to that used at farm level; building on the resilience of complementarity of inputs by balancing inorganic fertiliser use with organic manure, improved seed and irrigation. The aggregate environmental externality related to soil erosion run-off of nutrients and the high rate of soil nutrient depletion needs to be dealt with through soil and water conservation measures which are also included in the complementary actions of the CIP programme. At the farm-level, the external inputs including fertilisers and improved seed are not a major limiting factor commodity prices are. Whereas the focus on value chain management and market structure stability is the main and immediate concern, the low responsiveness to the external drivers for externality is a concern. The relatively low access to agricultural extension may be an investment for increasing farmer willingness to use external inputs. The resilience at farm level suggests that production and productivity could be higher if appropriate knowledge, training and market support investments were available.

National level benefit cost ratio for inorganic fertiliser use in Rwanda and sensitivity analyses

	BCR		Sensitivity 1: Viability Threshold 1		Sensitivity 2: Viability Threshold 2		Sensitivity 3: Projected target of current BCR	
	Discounted costs	Discounted benefits	Discounted costs	Discounted benefits	Discounted costs	Discounted benefits	Discounted costs	Discounted benefits
	Million Rwf							
ECONOMIC			-	-			-	
Gross margins		620	-	671	-	819	-	671
Net nutrient loss	1,128							
ENVIRONMENTAL			-	-	-	-	-	-
Mineral run-off into water	779		631	-	779	-	779	-
SOCIAL			-		-	-	-	-
Fertiliser subsidy for farmers	40		40	-	40	-	40	-
Totals	1,946	620	670	671	818	819	818	671
BCR	**0.32**		**1.00**		**1.00**		**0.82**	

Benefit-Cost Ratio for fertiliser use for the farming household perspective

	Annual benefits	Annual costs
	(Rwf/ha)	
ECONOMIC		
Gross revenue for CIP crops (maize, beans potato, rice, wheat) due to fertiliser use	1,423,144	
Variable cost for CIP crops (maize, beans potato, rice, wheat) due to fertiliser use		725,327
ENVIRONMENTAL		
Impacts of nutrient run-off per season/ha		444,951
SOCIAL		
Farm-level subsidy benefit	21,924	
Total	1,445,068	1,170,278
BCR	**1.23**	

1. INTRODUCTION

1.1 Background

Rwanda's long-term development strategy "Vision 2020" seeks to fundamentally transform Rwanda into a middle - income economy by the year 2020. The six pillars of Vision 2020 are:

i. Good governance and a capable state;
ii. Human resource development and a knowledge-based economy;
iii. A private sector-led economy;
iv. Infrastructure development;
v. Productive and market-oriented agriculture; and
vi. Regional and international economic integration.

The cross-cutting areas are gender equality, protection of environment and sustainable natural resource management, and science and technology including Information Communication Technology (ICT).

The long-term aspirations of the Vision 2020 were developed further in the Economic Development and Poverty Reduction Strategies (EDPRS 1&2) at the national level and operationalized through sector strategies and district development plans. Rwanda's EDPRS 2 for 2013 – 2018 aims to contribute to Vision 2020 by accelerating economic growth to an average 11.5%/year, and reducing poverty below 30% while restructuring the economy towards service and industry sector. One of the six thematic areas under EDPRS 2 is rural development where realisation of sustainable agricultural sector growth is the critical long-term intervention targeted with the agricultural sector analysed to have the greatest potential to reduce poverty in Rwanda. Currently, agriculture is a major component of Rwanda's national economy with about 84% of the population, of which 52% are women, depending either directly or indirectly on agriculture for their livelihood.

The Ministry of Agriculture and Animal Resources (MINAGRI) developed the Strategic Plan for Transformation of Agriculture in Rwanda (PSTA) phase 1 (2004-2007), phase 2 (2008 – 2012), and phase 3 (2013 – 2018), as the sector's contribution to EDPRS I &II processes, as well as meeting its obligations towards implementation of the National Agricultural Policy. The Government of Rwanda (GoR), through MINAGRI, embarked on PSTA 3 to transform Rwanda's agriculture from a subsistence sector to a knowledge based sector and accelerate agricultural growth to increase rural incomes and reduce poverty. The strategy encompasses four broad program areas: Agriculture and animal intensification (where the aspirations of the crop intensification program (CIP) lie); Research, technology transfer and professionalization of farms; Value chain development and private sector investment; and Institutional development and agricultural cross cutting issues. The cross-cutting issues include environmental sustainability and gender, among others.

1.2 Brief understanding of the Crop Intensification Program

The CIP was launched in September 2007 as a flagship program of MINAGRI aimed at increasing the agricultural productivity in high potential food crops and ensuring food security and food self-sufficiency and reliance. This originally focused on six priority crops namely maize, wheat, rice, Irish potato, beans and cassava – with the first four benefitting from fertilizer use, while cassava and beans were rotation crops in alternate season mainly to gardens fertilized for maize production. The main activities under the program are:

(a) **Land use consolidation** where farmers grow one crop on one consolidated farm land but with each having right over his/her own plot and resultant production. Under land use consolidation, communities are encouraged to specialise in specific agricultural enterprises as producer groups or cooperatives and/or individual private land owners to boost access to quality inputs, allow for easier access to extension, and bulk production to attract better paying markets.
(b) **Improved seed and fertiliser use component** aimed at increasing farmer access to high quality inputs as a basis for increased productivity and boosting production for improved food security and incomes; CIP is taken as a package of land use consolidation and adequate use of fertilizer and improved seeds, facilitated by private distributors at affordable prices through district specific retail and distributor networks. The Rwanda Agricultural Board (RAB) of MINAGRI serves to monitor and ensure quality of inputs on market, allowing private sector to take the lead in provision of agricultural inputs. Currently GoR still subsidizes the prices of key inputs including fertilizers and in some cases seed, with farmers required to contribute a portion to the cost of the inputs through a voucher system.
(c) **Increasing proximity of extension service** aimed at augmenting the input availability and consolidated land use with ready access to extension services for farmers. District and Sector Agronomists are required to facilitate the process and make sure that farmers get timely services and guidance. Service Providers (SP) attached to RABare required to have at least one technician for each consolidated 500 Ha area. The job of Service Providers is to mobilize farmers to use inputs, prepare land at the right time, and to follow up with farmers in the field and guide on produce marketing.
(d) **Create mechanism for Service Providers** to provide extension, set out demonstration plots, and facilitate the process of seed distribution. Service Providers work with the sector agronomist and report to RAB. Zonal RAB offices have the focal points of CIP in each district.

Agriculture product marketing is a strategic objective of the PSTA process aimed at increasing the revenue that farmers obtain from their produce and product marketing in order to boost income. Other key activities under the CIP include changing farmers' behaviours from subsistence to market oriented production behaviour; promoting of Agro inputs dealer's network to increase the reach of input supplies; stimulate reliable, private-sector input and output markets; ensure household and national food sufficiency and food self-reliance of Rwanda.

The CIP program was originally almost entirely managed through public sector interventions by MINAGRI implemented and monitored by RAB. However, since 2010, MINAGRI is increasingly working with service providers who, on behalf of GoR and MINAGRI, import, distribute and retail agricultural inputs procured under the CIP program. Some of these service providers are also engaged in extension service provision and from time to time also undertake produce marketing and value addition activities. These actions, though by private sector, are undertaken in support of MINAGRI and RAB, which provides the backbone for CIP.

Strategically, CIP is expected to contribute to gross domestic product (national income) by boosting the income from agriculture, the country's core sector, and increase productivity of farmers through better modern land use practices, growing the bank portfolio to agriculture sector, and enhance protection against soil erosion with set targets as indicated in *Table 1*. CIP directly supports increased inorganic fertiliser use at farm level given the history of low agricultural productivity associated with low soil fertility, the high levels of soil nutrient mining, as well as the high nutrient loss/leakage linked to the soil erosion facilitated by rugged and hilly terrain of Rwanda, by promoting and supporting protection against soil erosion through soil and water conservation practices.

Table 1: Understanding targets under CIP

Indicators	**2000**	**2010**	**Actual June 2010**	**2020**
Agricultural GDP growth (%)	9	8	7.7%	6
Agriculture as % of GDP	45	47	33.8%	33
Land under modern agriculture (%)	3	20	18%	50
Fertiliser application (kg/ha/annum)	0.5	8	9.9kg	45
%banks portfolio to agriculture sector	1	15	Not available	20
Soil erosion protection (% total land)	20	80	80.9%	90

Source: MINAGRI (2013)

To support increased consumption of inputs, including quality planting materials and fertilizers under the CIP, the GoR through MINAGRI has been subsidizing the cost of fertilizers for a number of 'strategic' crops since 2007. The subsidy started at 50% for UREA and DAP and 20% for NPK for all the benefiting crops. With the purpose of getting the farmers to know the advantages of using fertilizer, Government is cutting back on the subsidy with goal of eliminating it totally in the medium to long term. The crops for which the cost of fertilizer was subsidized initially were maize, rice, wheat and potatoes. This list in the recent times has been expanded to include fruits, vegetables, beans, cassava and bananas.

1.3 Rationale

1.3.1 The Policy process

The GoR formulated a National Agricultural Policy (NAP) in 2004, with five areas of focus:

1. Food security and nutrition;
2. Modern, professional, innovative, and specialized agriculture – contributing income and profitable;
3. A market-oriented and social responsible agriculture;
4. Fair distribution of benefits of production and processing; and,
5. Integrated and diversified agriculture that is friendly to the environment.

MINAGRI developed the PSTA Phase 1 (2004-2007), Phase 2 (2008-2012) and Phase 3 (2013-2018) to implement the NAP.

With the exception of improvements in soil and water conservation structures on farms to reduce soil erosion, the documentary review suggests that environmental sustainability issues have not been comprehensively integrated into the programme nor is there any time-series data on environmental impacts of agricultural intensification programme. This is evident from MINAGRI (2013) reporting on the performance of CIP within PSTA II, which as indicated in *Table 2*, shows that contributions to GDP and agricultural exports increased

Table 2: Agriculture Sector Macro Performance Indicators for PSTA 2 related to CIP

Objective	target	Actual 2012)
Increase annual growth of real GDP for all crops and livestock products	6.5%	5.6% avg
Increase in investment as a percentage of GDP	23%	22.5%
Increase in off-farm employment as a share of total employment	30%	26.6%
Reduction of the share of the rural population living in poverty	52%	49%
Reduction share of the population falling below minimum food requirement	18%	21%
Share of female-headed household members living in poverty declines	48%	47%
Increase annual rate of growth of agricultural exports	8%	44% avg

The environmental sustainability indicators/factors as indicated in *Table 3*, which if not well managed, can increase environmental damage, which would endanger the sustainability of the economic gains made. Key concerns include the increased area of marshland under cultivation; the loss of nutrients due to inadequate safeguards against volatilization, runoff and leaching; the limited role of organic manure; and the inadequate provisions for environment management and lack of appropriate health and safety safeguards for fertilizer use at farmer level. The above concerns, especially with singular focus on productivity, could reverse the positive impacts of fertiliser use that has far been reported.

Table 3: Land intensification, inputs and land performance targets related CIP

Objective	Baseline	Target % of land to be protected	Actual (2013) land protected
Agriculture area protected against soil erosion increased	40%	100%	73%
Land protected by trenches and progressive terraces increases	504,000ha	860,000ha	802,292
Hectares of newly constructed terraces	0	32,000ha	46,246ha
Area of developed marshlands increased	0	20,000ha	23,000ha
Irrigated area on hillsides increased	0	13,000ha	2,490ha
Land area under consolidated use	28,788ha	No set targets provided	502,916ha
Application of inorganic mineral fertiliser increased	12%	25%	30%
Increase in tonnage of fertiliser imported (MT)	22,900	56,000	44,000

1.3.2 Effectiveness, Efficiency and sustainable aspects of fertiliser use under CIP

The Government of Rwanda (GoR) implements the Strategic Plan for Agricultural Transformation (SPAT) in line with the country's commitment to the Comprehensive Africa Agricultural Development Program (CAADP). CAADP aims to increase average growth of the agriculture sector of African Union countries to above 6%/year, and increase public finance allocation to 10% of national budgets (African Union 2003). Rwanda has had three SPATs in 2004, 2009 and 2012. The strategic plans emphasize effective implementation of the

National Agricultural Policy (NAP), market and export-oriented rural agriculture, increased in productivity through improved inputs including fertilisers. In 2007, MINAGRI developed the Strategy for Developing Fertiliser Distribution Systems (SDFDS) to increase fertiliser use to achieve a target of 7% agricultural growth and significantly reduce poverty in rural areas (IFDC 2014). The CIP program also launched in 2007 is closely interwoven into SPAT and the SDFDS in particular.

Rwanda has one of the lowest average nutrient balances in sub-Saharan Africa (SSA) (Alley and Vanlauwe 2009). In a 13 country study including other SSA countries (Benin, Botswana, Cameroon, Ethiopia, Ghana, Kenya, Malawi, Mali, Nigeria, Rwanda, Senegal, Tanzania and Zimbabwe), Rwanda has the most adverse indications on annual mineral mining for nitrogen, phosphorus and potassium at -60Nkgha^{-1}year^{-1}, -11Pkgha^{-1}year^{-1} and -61K kgha^{-1}year^{-1}, respectively. It was evident that major interventions are needed for the maintenance and improvement of soil productivity.

Estimates made in the early 2000s indicated that the country required drainage for the 5% of land, measures for erosion control in 53% of the country's steeper slopes, soil amendments and nutrients among others (Verdoodt and van Ranst 2003). The CIP fertiliser programme was aimed at not only minimising the annual soil nutrient losses but also allowing the soil to support production and productivity improvements (IFDC 2014).

The success of fertiliser use programs is based on three criteria of the effectiveness, efficiency and sustainability of fertilizer use to which the CIP fertiliser study was subjected in this study. Effectiveness addresses the question on whether fertiliser use achieved the full agronomic purpose for which they were applied (Dittoh et al. 2012). Rwanda has a total arable land of 2.3 million ha, with about 1 million ha cropped and 1.5 million small holder farms, more than 50% under 0.5ha, 80% under 1ha, and 25% under 0.2ha (IFDC 2014). Therefore, effectiveness in the case of Rwanda covers the effects on soils, the use and non-use of complementary inputs. This is because the crop response to fertilisers often extends beyond the fertiliser applied into the other complementary inputs used such as improved seed and irrigation water (USAID 2015). Efficiency refers to whether fertiliser use is profitable for farmers. This involves a combination of crop response rates, price movements of fertilisers and crops as well as production risks. On the other hand, sustainability is based on whether fertiliser use will ensure that agricultural production and productivity will be better or at least not worse in the long-term. Sustainability is also concerned with whether fertiliser use will increase production and productivity and still guarantee that the resource base will be protected for future generations (Dittoh et al. 2012).

1.4 Land use and agriculture in Rwanda

Agricultural production activities remain the major land use type in Rwanda, and cultivated land has been found to be increasing at the expense of pasture, fallow, marshlands and woodlots. The share of pasture and fallow decreased from 22 % in 1990 to 14% in 2002 and woodlots decreased from 11% in 1990 to 7% in 2002 (REMA, 2009). Currently arable land is estimated to be 46.32% of the land surface; with permanent crops cultivated on 9.49% of the land. Rwanda had about 1.4 million hectares of land under cultivation by

2008, which was 52% of the surface area of the country at the time. According to REMA (2009) the land under cultivation had increased to 1.6 million with another 0.47 million ha considered as being under permanent pasture. This implied that over 70% of the country's total land surface was exploited for agriculture. According to Economic Development and Poverty Reduction Strategies (EDPRS I) estimates of 2009 Rwanda had about 165,000 ha of marshlands of which 93,754 ha (57%) at the time was under cultivation. REMA also noted that of the cultivated marshlands only 5,000 ha had been developed and could be cultivated throughout the year while the rest was arbitrarily cultivated by peasants grouped in organizations or by cooperatives without any technical study (ROR 2008). More recently the MINAGRI (2015), reports that the total agricultural land under cultivation is now 1,806,102.9 ha based on satellite imagery, and the land is currently stratified as indicated in *Table 4*.

Table 4: Stratification of agricultural land use in Rwanda

Stratum	Description	Total (Ha)	Percent
1.1	Intensive agriculture land (Season A – Sept to Jan; and Season B – Feb to June, Season C – June to August)	1,479,081.4	81.9
1.2	Intensive agriculture land (Season A and B, with potential for Season C)	48,388.2	2.7
2.1	Other marshlands	95, 820.7	5.3
2.2	Marshlands potential for rice	20, 200.9	1.1
3.0	Rangeland	133,848.5	7.4
10.0	Tea plantation	28,763.1	1.6
Total agriculture land		**1,806,102.9**	**100**

Source: NISR - 2015 Seasonal Agriculture Survey

1.5 Key socioeconomic and environmental issues for the agricultural sector

a. Socioeconomic issues

Rwanda is relatively a small rugged country (hilly) with one of highest population densities globally, and is mostly dependant on agricultural production with over 80% of population engaged in agricultural production activities. The high dependence on agricultural production coupled with high population density poses a challenge of high soil nutrient mining and need to replenish the soil nutrients on a regular basis, while enhancing the sustainability of agriculture, including increasing nutrient use efficiency. This situation also poses a challenge of sustainably utilizing the natural resources and managing the environment for continued production of food. In spite of being highly dependent on agriculture, Rwanda is classified among the food deficit countries by FAO (2014), and is still faced with the challenge of high levels of malnutrition and stuntedness especially among children under five and lactating mothers. The other challenges for agriculture sector include:

- The limited industrialization and inability to transform or process agricultural produce into better paid industrial products;
- the land-locked nature and long distance from seas which adds to the cost of production and marketing given the high cost of moving imported inputs such as fertilizers and moving unprocessed agricultural products to the international markets; and,
- limited Research, technical and human capacity – which has led to deficiency in science and technology to guide the set agricultural policies in meeting stated objectives.

b. Environmental issues

The major issues putting pressure on agricultural productivity include high population density that is heavily dependent on the limited land resource, and the ecological sustainability of increased agricultural production. This has led to land fragmentation and reduction of farm sizes with continuous cultivation of land with little or no fallow. This situation coupled with soil erosion facilitated by the rugged nature of the country has had environmental consequences including high nutrient mining by crops and loss of nutrients driven by leaching and runoff. This is feared to have led to the increase in nutrient enrichment of the aquatic environment causing pollution and reducing the ability of soils to support sustainable food production. Such situation is exacerbated by the weak extension and research services and the increasingly erratic weather linked to climate change with frequent floods in some areas of the country and or prolonged drought with occasional heavy rains in other areas. The other environmental issue is the increased focus on wetlands (marshlands) in search for cultivable land in the country. This eliminates or reduces the ecological role of the wetlands in maintaining and renewing the production capacity of farmed land. Also the need to bring all stakeholders in the agricultural production value chain on board as regards the role of natural and agro-ecosystems in sustaining production, and what the respective stakeholders can do to manage the ecosystems better, is a critical environmental issue for efficient and effective fertilizer use in Rwanda.

1.6. Purpose and objectives of the assignment

Purpose

- Overall purpose of this consultancy is to undertake a study to assist the GoR to improve the cost-effectiveness and ecological sustainability of inorganic fertilizer use from both the farm and national perspective.

Objectives

1. Estimate the production (i.e. technical) use efficiency of inorganic fertilizer using available data for crops, fertilizer use by type, and agro-ecological zones. In addition, provide recommendations for improving such analysis in future.
2. Determine the benefit-cost ratio (BCR) of current inorganic fertilizer use from farm to national perspective. Summarise the future agricultural and economic productivity of this based on current trends, policies and markets. Provide recommendations for improving such analysis in future.
3. Identify the institutional (agricultural sector institutions, policies, laws, strategies, programmes, capacity, decision-making processes, including coordination mechanisms and methodologies, extension services, marketing and cooperatives, financial resourcing etc.) opportunities and constraints for improving efficiency and effectiveness at national and farmer level. Assessment of effectiveness is to include economic, social (distributional) and environmental factors.
4. Identify and outline future research priorities on fertilizer use in the context of Rwanda national development priorities and agricultural strategies. This should include social, economic and environmental research elements of fertilizer use.

2. METHODOLOGY

2.1. General Approach to the Study

The Consultancy was a descriptive evaluation study in the order of a technical review of the inorganic fertilizer use from both the farm and national perspective. It was a retrospective review of inorganic fertiliser use and aimed at developing a projection about future implementation of the programme. Although the Consultancy was initially coined as primarily desk work exercise, it was found necessary to combine desk work with field work so as to acquire the missing data needed for farm level perspective analysis of the fertilizer use programme to meet the set objectives. These two methods were used together with technical consultations with key players in the fertilizer use programme under CIP so as to elucidate the salient issues especially the fiscal, managerial, policy and regulatory matters that guide the implementation of the fertilizer use programme. Desk work concentrated on acquisition and collating of the secondary data used in assessing the Benefit Cost Ratio of the fertilizer use, and for in-depth analysis and illustration of the fertilizer use value chain starting right from decision making at policy level to the importation and throughout the distribution and supply chain of mineral fertilizers ending with the farmer application. The Desk work also included reviewing and contrasting GoR policies, legislations and management practices with others from the region and outside Africa, as well as comparing local agronomical practices to established standard protocols and norms to what is commonly considered as the best management practices for fertilizer use. Desk work also included review and analysis of the importation, distribution, supply and marketing of fertilizers in Rwanda; and, contrasting of local practices and norms with established Good Management Practices (GMPs) pertaining to fertilizer use, especially in relation to environmental management. The desk work also involved analysis of the funding, funding arrangements, the benefits and associated environmental and socioeconomic costs of fertilizer use, and leading into the Cost and Benefit Analysis as to the efficiency and effectiveness of fertilizer use in Rwanda.

Field work was undertaken to assess the implementation of the fertilizer use programme at farmer level with areas of study purposively chosen to allow assessment where the fertilizer use programme was being implemented as per the guidelines from MINAGRI. The study included direct interviews and assessment of farm level activities for 180 farmers from six districts with effort made to have a representation of all regions. The assessment was aided by specially designed checklist (*Annex* 3). The data was collated and coded, and analysed with aid of the Statistical Package for Social Scientists (SPSS) computer programme.

The consultative meetings with key stakeholders and technical managers of the fertilizer use programme centred on highlighting and analysing the existing and required innovations for addressing socioeconomic and environmental challenges faced in the fertilizer acquisition, distribution and supply as well as in the application by the end users. During the consultations, stakeholders (see *Annex* 8) were requested for their views, information in their possession or for which they had knowledge of, their opinions and access to relevant datasets that can assist in assessing the efficiency and effectiveness of fertilizer use.

2.2 Assessment methods

2.2.1 Participatory and Consultative Approach

This study was based on a participatory and consultative approach, in accordance with the mission and philosophy of GWCL, and as a means of fostering a buy-in by the target audience for this study as defined by REMA and MINAGRI. However this approach to the study was greatly constrained by the lack of funding for primary data collection and the tight timeframe of only two months for implementation of a project of this magnitude. Stakeholders were consulted during the planning, design and implementation phases of the project, notably through:

i. Consultative meetings and personal exchanges with members of REMA and MINAGRI and responsible technical officers in the study area, respectively;
ii. Regular consultation with technical officers and experts in Rwanda within Government Ministries, Universities and with non-government institutions including TUBURA, and fertilizer importers such as ENR; UN agencies
iii. Review and discussion by MINAGRI, REMA (including the technical advisor) and PEI specialist from UNDP of the inception, draft and final reports;
iv. Review and consultation with farmers, cooperative leaders and members, farmer promoters, FFS facilitators, and agro-dealers.

2.2.2 Review of Fertilizer Supply Chain and Experts Opinion

This review was aimed at drawing a general comprehensive understanding of the fertilizer use value chain while highlighting the innovations that have been developed to enhance the efficiency and sustainability of the programme, and pointing out the challenges still faced by the programme in terms of effectiveness of the fertilizer use programme. For this purpose, a review of existing information in the country on the supply and distribution chain of fertilizers was undertaken including Government of Rwanda (GoR) programs related to fertilizer use and management. The programs reviewed included: the Crop Intensification Program (CIP) in general at MINAGRI, 'Twigire Muhinzi' and the Farmer Field School (FFS) system of extension by MINAGRI and SPAT2 respectively; the farmers promoters mineral fertilizer uptake promotion programme and support to agro-dealers by TUBURA; and the use of demonstrations by IFDC and RAB. In addition, views and opinions of experts working in the area of fertilizer use in the country were collected and analysed to complement written reports and publications. The assessment of views and opinions of public technical managers was based on a checklist shown in *annex 4*; while that for service providers was based on checklist shown in *annex 5*; and that for agro-dealers was based on checklist shown in *annex 6*. It should be noted that 'Twigire Muhinzi' extension system is a farmer to farmer extension system developed in Rwanda to ensure that all farmers have access to advisory services. It is a combination of the FFS and farmer promoter system where the extension providers are well trained and facilitated, and ideal conditions created for transfer of targeted technology.

2.2.3 Production (i.e. technical) use efficiency of inorganic fertilizer

The production and nutrient use efficiency of inorganic fertilizer was estimated principally from the primary data gathered from farmers but in combination with secondary data from MINAGRI by constructing a production function for different crops using aid of the Excel solver. Data for constructing of the production function was adduced as follows:

1) *Primary Data Source*

Primary data sources included but not limited to the following:

a) Farmers in purposively selected six districts, where successful implementation of the CIP was said to have been achieved (*Table 5*), were interviewed for this study. A total of 179 farmers were interviewed and their farm activities related to CIP were assessed using specially designed questionnaire (*Annex*) in lieu of the fertilizer use programme.

b) Key Informant Interviews Schedule i.e. administered to fertilizer use programme managers in MINAGRI; fertilizer importers and distributors; service providers and partners of MINAGRI (FAO, TURBURA); the management of Chamber of Commerce responsible for Agriculture and Livestock; and Integrated Development Programme (IDPs), cooperative leaders, farmer promoters and FFS facilitators in sectors of the sampled districts, were undertaken.

Table 5: Source of primary sample data on fertilizer use

Province	District	No. respondent
Eastern	Bugesera	30
Western	Karongi	30
Southern	Muhanga	30
Northern	Musanze	29
Eastern	Nyagatare	30
Southern	Nyanza	30

The effectiveness of primary sources depended on the design of interview research questions. All interview schedules/checklists are attached.

2) *Focus Group Discussions (FGDs)*

A focus group discussion was held with four senior managers of MINAGRI working with RAB under the fertilizer use programme to clarify and provide more information on issues highlighted by farmers in the field, and what the Consultant viewed as a gap or innovation that needed elaboration. In addition, the FGD was used to draw upon respondents' attitudes, feelings, beliefs, experiences and reactions on what is required to enhance the effectiveness, efficiency and sustainability (especially the ecological and environmental aspects) of the fertilizer use programme.

3) Key Informative Interviews

An interview schedule was designed for the different categories of respondents (*Table 6*) as follows: the fertilizer use programme managers and scientists (MINAGRI, MINIRENA, MINECOFIN); farmers and cooperatives; NGOs, Service providers and partners of MINAGRI (FAO, USAID, IFDC and TURBURA); and fertilizer importers in Rwanda. Key informants were interviewed and selected on the basis of their roles as leaders, specialized knowledge and experience on the fertilizer use programme. Key informants were approached with a standard key informant interview schedule presented in Annexes (*Annex 4* to *6*) intended to elicit information on the previous and current state of fertilizer use including potential, problems, issues, challenges and alternatives.

4) Secondary Sources

These included: existing data on fertilizer use and technical reports/documents, and policy and legal documents on fertilizer use in Rwanda, and selected papers from East Africa and the region as a whole.

5) Analysis

Production and Nutrient-Use Efficiency

Production and nutrient-use efficiency analysis was conducted using three basic techniques: crop response to fertilisers was analysed using ordinary least squares (OLS) analysis for a Cobb-Douglas production function, and estimation of the value cost ratio (VCR).

The Cobb-Douglas production function describes the relationship between the dependent variable of output (or production) and the independent variables typically capital and labour represented by two Xs (equation 1). The β represent the parameter estimators β1 is the intercept variable, while the parameter estimators of the relationship between the Xs and the dependent variable – output.

$$Y = \beta_1 X_{2i}^{\beta_1} X_{3i}^{\beta_3} e^{u_i} \quad (1)$$

The Cobb-Douglas production function was used to analyse the response relationship between crop output (Y) the dependent variable and fertiliser use (F) and improved seed used (S) the independent variables. The natural log (ln) is used to convert the cobb-Douglas function in equation 1 into a linear function in equation 2.

$$InY = \beta_o + \beta_1 InF + \beta_2 InS + u_i \quad (2)$$

In the decomposed linear Cobb-Douglas relationship employed for the study was to analyse the relationships between the aggregate output for all five crops (maize, wheat, rice, beans and Irish potato) and aggregate fertiliser and aggregate improved seed used as the well as the relationships between individual crop output and the corresponding inorganic fertiliser and improved seed used.

The Cobb-Douglas relationships were analysed using STATA software, where the R^2 statistic was used to assess the explanatory power of the relationship between the independent variable for the observed values of the depend variables. The proximity of the R^2 to 100% indicated the strength of the explanatory power of the independent variables for the observed values of the dependent variable. The parameter estimates observed were recorded for the coefficient value, and the probability values ($p < 0.05$) 5% level of significance of the observed parameter estimates. The parameters in the relationship are described by sign of positive or negative and the 5% level of significance used for agricultural experiments was adopted. Nonetheless, results with weaker significance at 10% and up to 15% levels of significance were considered where the R^2 value exceed 50% (Gujarati 1995; Gujarati and Sangeetha 2007; Maniriho and Bizoza 2015; Mulinga et al. 2016).

The value-cost ratio (VCR), which is the ratio of the technical response to fertilizer use and the nutrient/output price ratio (Morris et al. 2007). A widely held convention is that the VCR should be greater than 2 in a developing economy to provide incentives for fertilizer use to overcome risks and costs of capital (CIMMYT 1988). In especially risky production environments, a minimum VCR of 3 or 4 may be needed to provide sufficient incentives for adoption (Morris et al. 2007). The VCR was calculated as:

$$VCR = \frac{Added\ crop\ output\ from\ fertiliser\ applied * crop\ price\ (\Delta Crop\ Revenue\ due\ to\ fertiliser)}{Amount\ of\ fertiliser\ applied * price\ \ (Total\ fertiliser\ cost)} \qquad (3)$$

2.2.4 Cost Benefit Analysis

The purpose of the cost benefit analysis was to achieve a basis for describing the net benefit of a policy decision. In the case of the benefit-cost ratio (BCR) criteria the cost-benefit analysis ratio determines the ratio of discounted benefits of using fertilisers under the CIP programme for the five identified crops to the discounted cost of using the fertilisers. The BCR was determined as

$$BCR = \frac{\sum_{it}^{IT} Eb_{it} + Enb_{it} + Sb_{it}}{\sum_{it}^{IT} Ec_{it} + Enc_{it} + Sc_{it}} \qquad (3)$$

Where BCR is the benefit cost ratio; (i, ,I) and (t, ,T) are from variable option i to I, i.e. for the different types of Economic benefits (Eb) or Economic costs (Ec), Environmental benefits (Enb) and Environmental costs (Enc) and Social benefits (Sb) and social costs (Sc). While t, to T shows the timeline of projection from 2007 to 2013. The benefits and costs under consideration are the additional benefits and costs associated or attributed to using fertilisers.

Sensitivity analyses were conducted to assess the robustness due to changes in economic, social and environmental variables. The sensitivity analyses provided an indication of policy decisions that can be taken given the BCR results obtained.

Several derived variables were generated using STATA software analysis. Considerable secondary data was also used to support both the BCR analysis and the production and nutrient use efficiency analyses.

2.2.5 Institutional opportunities and constraints for improving efficiency and effectiveness at national and farmer level

This involved review of the agricultural sector institutions, policies, laws, strategies, programmes, capacity, decision-making processes, including coordination mechanisms and methodologies, extension services, marketing and cooperatives, financial resourcing and others meant for proper functioning and implementation of the fertilizer use programme. The assessment of effectiveness included the illustration of the impact of the economic, social (distributional) and environmental factors on the success or failure of fertilizer use programme in meeting the stated outputs and envisaged impacts.

The 'Institutional Analysis and Development (IAD) Framework' was used in illustrating the effectiveness of the different components of the institutional processes and mechanisms for the fertilizer use program. The IAD allowed for fair elaboration of the contribution of the different players and gaps therein in the management of the fertilizer use program.

2.2.6 Future research priorities on fertilizer use in the context of Rwanda national development priorities and agricultural strategies

Identification and outline of future research priorities on fertilizer use in Rwanda involved extensive literature review and document examination; collation and synthesis of notes and observations from key informant discussions, stakeholder meetings and feedback from the planned workshops for the assignment; assessment and review of the national priorities, targets for poverty reduction and CIP programme based on consideration of the available data and information on performance and impacts of CIP, fertiliser use; and expert review and judgement.

2.2.7 Drawing on Good Practices

The study also conducted an extensive review of fertilizer use programmes elsewhere including from countries in the region such as Ethiopia, Malawi, Egypt, Kenya and South Africa where fertilizers are a significant component of their agricultural production systems. From review of impact studies done there and global literature, the study has extracted the most appropriate and recommended approaches for Rwanda's scenario and characteristic terrain and socioeconomic status.

3 PRODUCTION AND NUTRIENT USE EFFICIENCY

3.1 Evolution of fertiliser use in Rwanda

Agricultural production and productivity in Rwanda was quite low in the 1990s. The decline in production and productivity is thought to have been due to a reduction in the average farm size, reduced use of anti-erosion barriers, and low fertiliser use including both organic and inorganic fertilizer (Kelly et al. 2001). As the average farm size declined from 1.06 to 0.7ha, use of anti-erosion barriers and manure declined from 93% and 76% of cultivated area to 65% and 59%, fertiliser use declined from 5% of cultivated area (7% farms) to 3% cultivated area (5% farms) leading to a noticeable decline in production between 1996 and 2000.

Between 1996 and 2000, the Rwandan economy recovered from a low economic base, the country's real GDP grew by 10% per annum expanding beyond agricultural production. In the subsequent period of 2001 to 2006, real GDP grew by 6.4% where agriculture remained the key sector of the economy contributing 36.4% to the GDP but down from 37.7% (MINECOFIN 2007). The major component of agricultural GDP in the 2001 to 2006 period was the food crop sub-sector with a GDP contribution of 31.4% overall, or 86.2% of the GDP for the agricultural sector. The government's efforts to overcome the low agricultural production were through the CIP as indicated above with increasing inorganic fertiliser use in food crop production as a key ingredient of the programme.

Initially, the government decided to bulk procure fertilisers and distribute the fertilisers to farmers while building the capacity of private sector to ensure sustainability of the process. However, in April 2013, fertiliser importation and distribution was opened up and left to the private sector after Government argued that it had created "effective" fertiliser demand to attract able private businesses in the importation and distribution of inorganic fertilizer. Fertiliser use differs across the country and is dependent on the major crops in specific districts. In some Districts such as Nyabihu, Rubavu and Musanze, NPK accounts for the largest proportion of fertilisers used. In these districts, NPK is used for Irish potato production, in Burera and Ngororero Districts, inorganic fertiliser is used for maize, wheat and Irish potato production. At the beginning of the CIP programme in 2007, average fertiliser use on food crops was 4.2kg/ha and this has since increased to over 32kg/ha (MINAGRI, 2015).

3.2 Trends of fertiliser use

The trends (*Figure 1*) of fertiliser use in Rwanda indicate a strong increase in fertiliser use for NPK (17:17:17), di-ammonium phosphate (DAP) and Urea over the period between 2007 and 2014. Fertiliser use in the early 2000s for food crop production of maize, wheat, rice, Irish potato and (bush) beans was dominated by NPK with negligible amounts for Urea and DAP. Prior to the CIP period NPK fertilizer importation was in steady decline. Conversely, the use of DAP peaked higher than NPK in 2013 although it declined after. The CIP earlier emphasized importation of NPK which increased greatly over this period. Recently, following the RAB/IFDC study on nutrient distribution across the country, MINAGRI has diversified the nutrient types opening up the importation of fertilizers to include micronutrients and other mineral amendments.

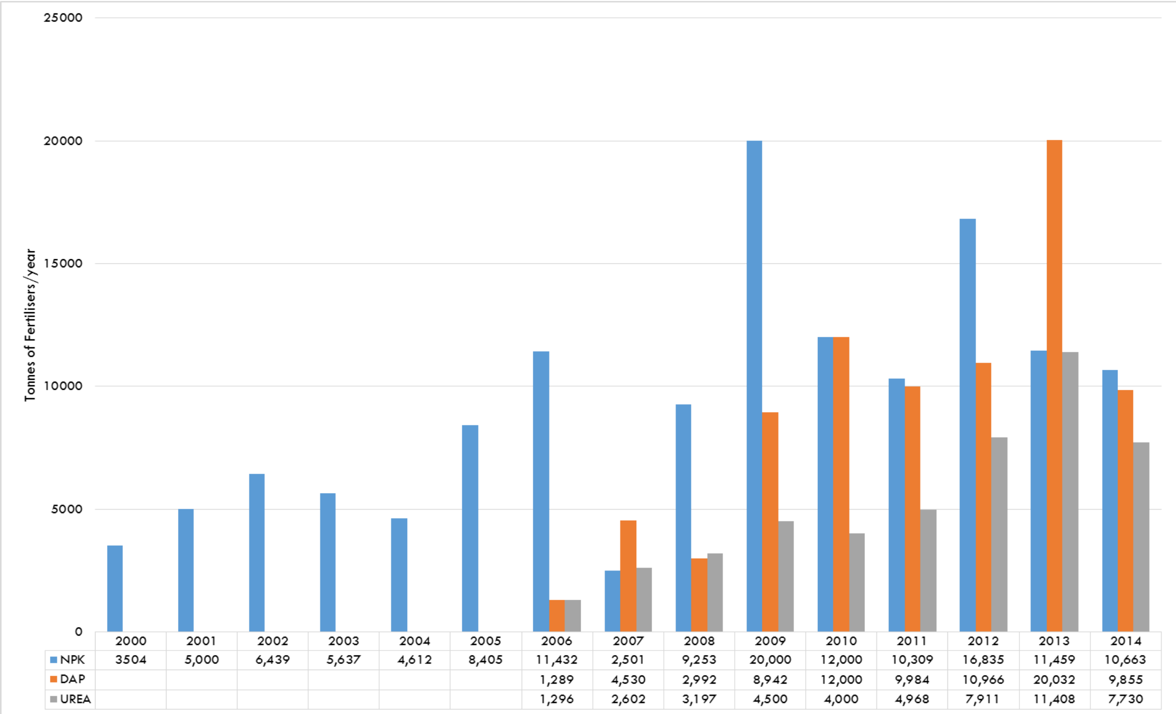


Figure 1: Fertiliser use for food crops: Maize, Bush Beans, Rice, Wheat and Irish potato
Source: adapted from RAB/MINAGRI and NISR databases

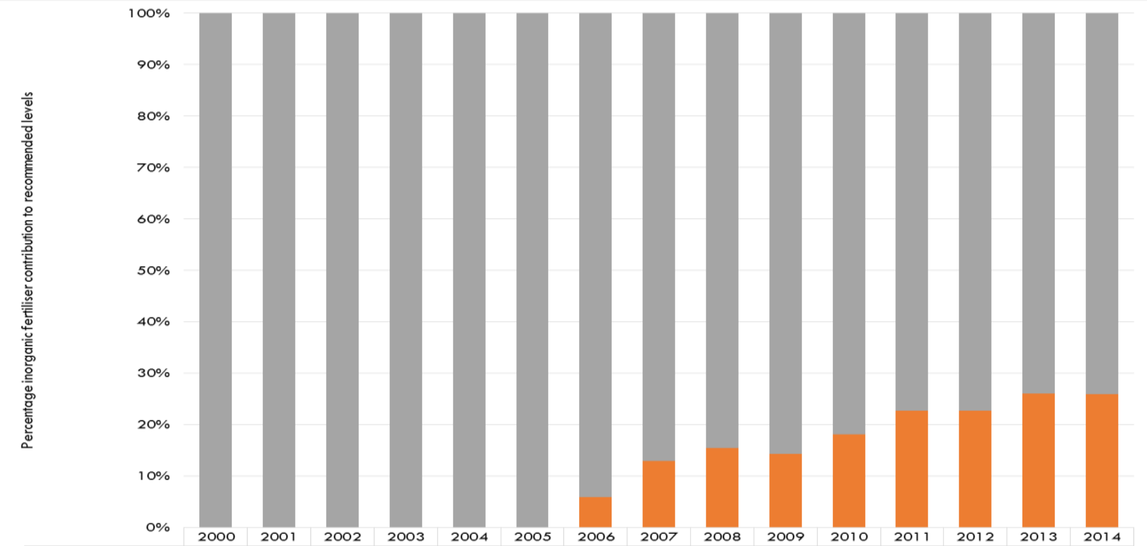
A review of fertiliser application rates as compared to the actual fertiliser supplied at farm level showed that fertilisers may not be uniformly available for the target farmers on the 356,000 ha under the CIP programme. An assessment conducted by Nitiyanga et al. 2015 indicated that application rate of NPK fertilisers for maize and rice may have exceeded the recommended rate in 2011 (*Table 6*). On the other hand, *Figures 2 – 4* showed that only in the case of phosphorous based fertilisers did the applications in 2010, 2011 and 2013 exceed the recommended levels. The findings of *Figure 3* concur with those in *Figure 1* suggesting application of fertilisers was in reaction to indicative performance of previous seasons.

Table 6: Fertilizer application rates and deficit quoted for CIP period, 2011

Type of fertiliser	Crops	Estimated application rate (Kg/ha)	Recommended rate (Kg/ha)	Deficit in use (Kg/ha)	Deficit by %
Urea	Irish potato	0.04	070	0.66	94
	Beans	0.02	0.05	0.03	60
	Rice	0.10	0.10	0.00	0
	Wheat	0.04	0.10	0.06	60
	Maize	0.04	0.10	0.06	60
DAP	Irish potato	0.05	0.11	0.06	54
	Beans	0.03	0.10	0.06	54
	Rice	0.07	0.10	0.03	30
	Wheat	0.06	0.10	0.04	40
	Maize	0.07	0.10	0.03	30
UREA	Irish potato	0.15	0.30	0.15	50
	Beans	0.18	0.25	0.07	28
	Rice	0.16	0.25	-0.09	-36
	Wheat	0.04	0.25	0.21	84
	Maize	0.44	0.25	-0.19	-79

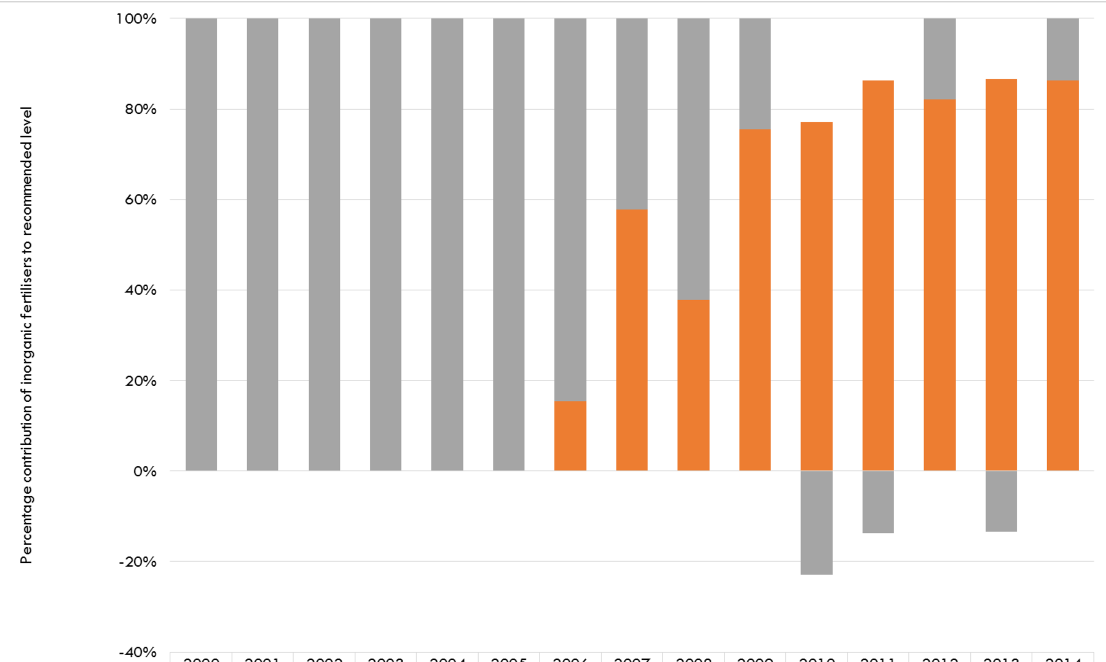
Source: Nitiyanga et al. 2015

The levels of urea applied were much lower than those recommended, even though a noticeable increase was observed as shown in *Figure 2*, while the application of NPK was also lower than the recommended rate. However, there was indication that the fertiliser management approach looked at the two fertilisers as compliments and the recent increase in urea use has coincided with a slowdown in the use of NPK.



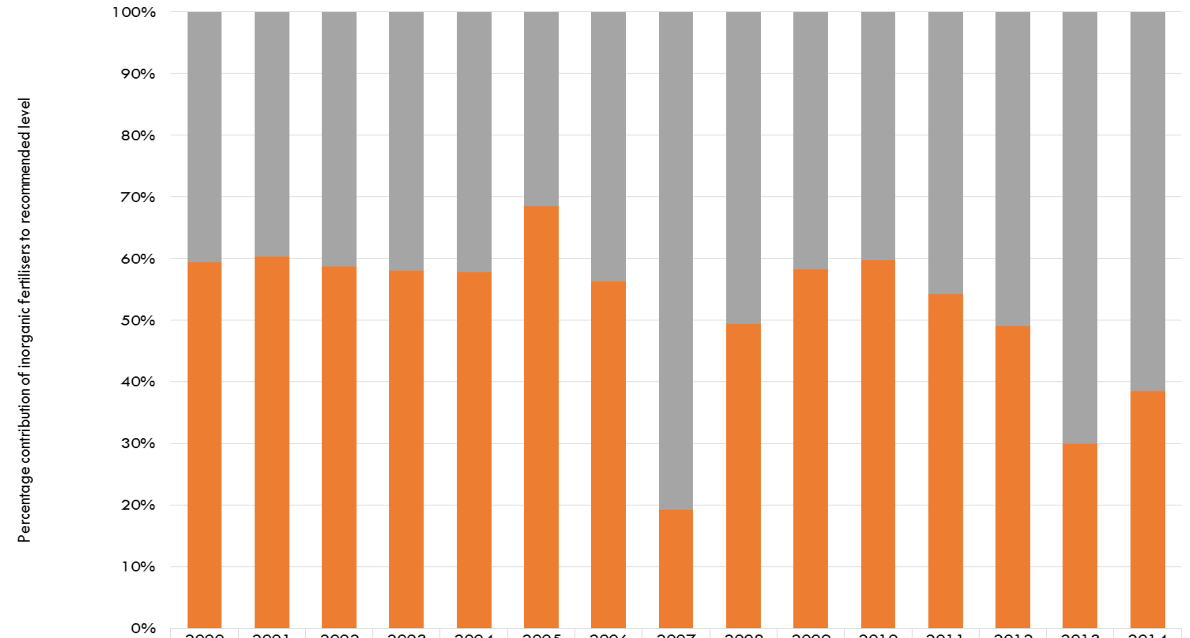
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
UREA (tons) Deficit	6,222	8,236	10,819	9,520	7,583	11,991	20,899	17,533	17,520	26,905	18,058	16,909	27,025	32,442	22,052
UREA (tons) Applied							1,296	2,602	3,197	4,500	4,000	4,968	7,911	11,408	7,730

Figure 2: Trends of UREA application and the nutrient deficit from production area



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
DAP (tons) Deficit	2,312	3,066	3,988	3,539	2,815	4,465	7,075	3,313	4,913	2,892	-3,562	-1,594	2,398	-3,099	1,574
DAP (tons) Applied							1,289	4,530	2,992	8,942	12,000	9,984	10,966	20,032	9,855

Figure 3: Trends of DAP application and the nutrient deficit from production area

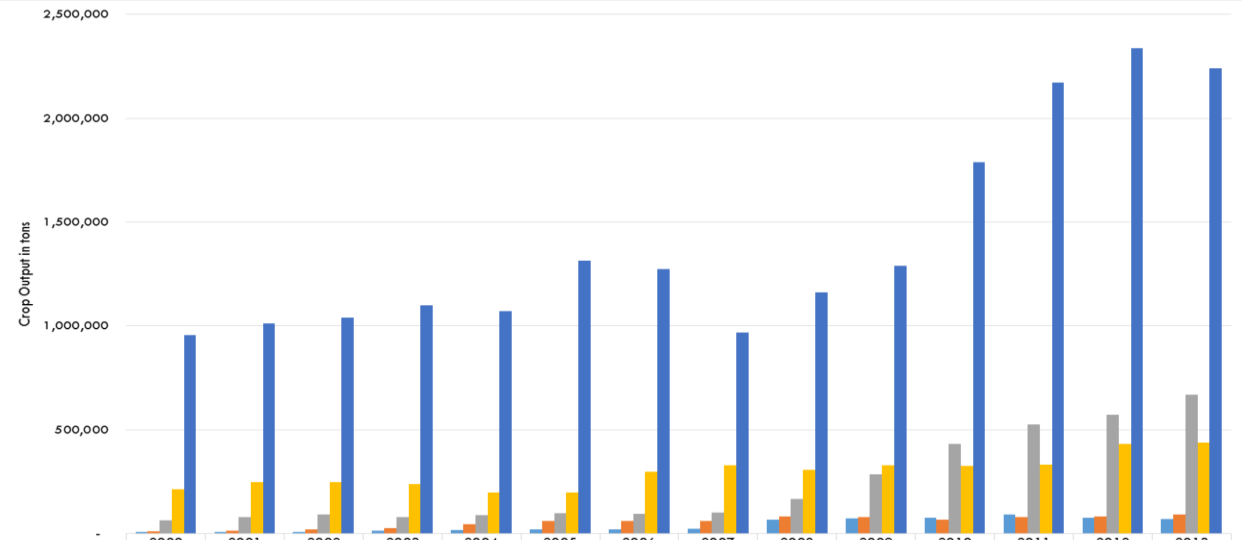


	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
NPK tons Deficit	2,400	3,289	4,526	4,090	3,370	3,876	8,868	10,470	9,489	14,361	8,077	8,707	17,532	26,786	17,111
NPK tons Applied	3504	5,000	6,439	5,637	4,612	8,405	11,432	2,501	9,253	20,000	12,000	10,309	16,835	11,459	10,663

Figure 4: Trends of NPK application and the nutrient deficit from production area

3.3 Crop output and fertiliser responsiveness

Trends of crop production indicated a positive response of crop output to fertiliser application between 2007 and 2014. While the trend for maize, beans, Irish potato shows genuinely large increases, the increases for rice and wheat though significant were generally modest (*Figure 5*).



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
wheat	6,444	8,209	7,434	15,305	16,772	21,942	18,978	24,195	67,869	72,479	77,193	90,684	75,913	70,129
rice	11,654	15,610	20,976	28,191	46,191	62,193	60,446	61,797	82,025	81,081	67,253	80,541	84,079	93,746
maize	62,796	80,979	91,686	79,124	88,209	97,251	96,662	101,659	166,853	286,946	432,404	525,679	573,036	667,834
beans	215,347	248,157	246,906	239,697	198,224	199,648	296,724	328,811	308,563	327,728	327,497	331,166	432,857	438,236
irish potato	957,198	1,012,26	1,038,93	1,099,17	1,072,77	1,314,051	1,275,586	967,283	1,161,943	1,289,623	1,789,404	2,171,517	2,337,706	2,240,715

Figure 5: Trends of crop output for Rwanda between 2000 and 2014

An ordinary least squares regression for a Cobb Douglas production function with two variable aggregates for seed and fertilisers shows that use of fertilisers significantly contributed to the aggregate crop output realised for the five CIP crops. The coefficient of the total fertiliser variable indicates that a 1% increase in total fertilisers leads to a 0.35% increase in total output (*Table 7*).

The test of significance shows that fertilizers, and seeds are statistically significant at 5% level of significance. The adjusted R^2 estimated was 0.938, showing the independent variables of inorganic fertilisers and improved seed has a 93.8% explanatory power for the observed aggregate output.

There was a significant relationship between aggregate crop output and inorganic fertiliser use at a 5% level of significance. A 1% increase in inorganic fertiliser use resulted into a 0.35% increase in aggregate output of crops. The crop output response to fertiliser use was in a ratio of 2.85:1; suggesting that 2.85 tonnes of fertiliser was needed to achieve a 1 tonne increase in aggregate crop output. The results suggest a low but significant crop output response to fertiliser

Table 7: Estimates of national crop production aggregates with fertilisers and improved seed

Dependent variable	lnTotoutput			
Variable	**Coef.**	**Std. Err.**	**T**	**P>|t|**
lnTotferts	0.3520662	0.0782175	4.50	0.011
lnTotseed	0.2601067	0.0525333	4.95	0.008
_cons	8.983901	0.6768017	13.27	0.000
Number of obs		=	7	
F(2, 4)		=	46.57	
Prob > F		=	0.0017	
R-squared		=	0.9588	
Adj R-squared		=	0.9382	
Root MSE		=	.08597	

The estimation for relationship between maize production, fertiliser and seed was significant at 5% level of significance for fertilisers, and just over 10% level of significance for seed, even though the intercept result was not significant (*Table 8*). The significance could have been improved with a larger sample set. However, the results showed with significance that a 1% increase in fertiliser applied led to a 0.8% increase in the maize output. The increase in maize crop output with fertiliser applied was much higher than the average aggregate for all the study crops.

Table 8: Estimates of maize crop production and responsiveness to fertilisers and improved seed

Dependent variable	lnMZoutput					
Variables	**Coef.**	**Std. Err.**	**T**	**P>t**	**[95% conf. Interval]**	
lnMZseed	0.2102729	0.0994336	2.11	0.102	-0.065799	0.4863447
lnMZfert	0.8376969	0.2548686	3.29	0.030	0.1300683	1.545326
_cons	2.084727	2.244721	0.93	0.406	-4.147619	8.317072
Number of obs	=	7				
F(2, 4)	=	32.10				
Prob > F	=	0.0034				
R-squared	=	0.9413				
Adj R-squared	=	0.9120				
Root MSE	=	0.20843				

The estimation of the relationship between rice production, fertiliser and seed was only significant at 12% level of significance for fertilisers, while that for seed was significant at a 13% level of significance, while the intercept was significant at 5% (even 1%) level of significance (*Table 9*). The weak significance is plausible given the small data set of aggregate data use for analysis. However, the results showed with significance that a 1% increase in fertiliser applied led to a 0.14% increase in the rice output. The increase in rice output like that for maize output when fertiliser applied was lower than the average for all aggregate crops.

Table 9: Estimates of rice crop production and responsiveness to fertilisers and improved seed

Dependent variable	lnRCoutput					
Variables	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
lnRcTotfer	0.136867	.0674815	2.03	0.112	-0.0504916	0.3242257
lnRcseed	-0.0789227	.0415468	-1.90	0.130	-0.1942751	0.0364296
_cons	10.46301	.6780816	15.43	0.000	8.580357	12.34567
Number of obs	=	7				
F(2, 4)	=	6.21				
Prob > F	=	0.0593				
R-squared	=	0.7564				
Adj R-squared	=	0.6346				
Root MSE	=	0.08574				

The estimation of the relationship between beans output, fertiliser use and use of improved seed was only significant at 16% level of significance for fertiliser use and insignificant for improved seed use, while the intercept was significant at 5% (even 1%) level of significance (*Table 10*). The weak significance for bean seeds was likely due to small sample size of derived data used for analysis. However, the results showed with weak significance a 1% increase in fertiliser applied led to a 0.18% increase in the beans output. Even though magnitude of responsiveness for beans to fertilisers was higher than that for rice the level of significance was weaker than the latter. The R^2 value of 50% suggests that the results are also marginally agreeable.

Table 10: Estimates of beans crop production and responsiveness to fertilisers and improved seed

Dependent variable	lnBnsoutput					
Variables	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
lnBnsTotfer	0.1819083	0.1049835	1.73	0.158	-0.1095727	0.4733892
lnBNseed	0.0132377	0.0486922	0.27	0.799	-0.1219535	0.1484289
_cons	11.47213	0.6599375	17.38	0.000	9.639852	13.30441
Number of obs	=	7				
F(2, 4)	=	2.00				
Prob > F	=	0.2495				
R-squared	=	0.5005				
Adj R-squared	=	0.2507				
Root MSE	=	.1258				

Whereas a 1% increase in fertilisers seemed to lead to a 0.39% increase in output, higher than beans and rice, the result was not significant at a 5, 10 or 15% level of significance (Table 11). The significance was too weak to consider the current result without additional data correction to improve confidence of the results. Nonetheless, the result is worth looking at again. The R^2 results also confirms the low confidence of the result in relation to the data.

Table 11: Estimates of wheat output and responsiveness to fertilisers and improved seed

Dependent variable	lnWhToutput					
Variables	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf. Interval]**	
lnWHTseed	0.0786649	0.218858	0.36	0.737	-0.5289824	.6863122
lnWhTTotFert	0.3885676	0.3183346	1.22	0.289	-0.495271	1.272406
_cons	7.957655	2.51039	3.17	0.034	0.9876934	14.92762
Number of obs	=	7				
F(2, 4)	=	0.79				
Prob > F	=	0.5142				
R-squared	=	0.2829				
Adj R-squared	=	-0.0756				
Root MSE	=	0.45586				

The test of significance shows that fertilizers, and seeds are statistically significant at 5% level of significance. The R^2 estimate showed that 78.6% of variations in Irish potato output, from the relationship developed, were explained by seed and fertilisers (*Table 12*). While the result for fertiliser use was just significant at 5% level of significance even though was significant at just over 5% level of significance. Nonetheless, had a very marginal but positive impact on the output of Irish potato. However, seed had a larger 0.55% increase in output for a 1% increase in improved seed used. The adjusted R^2 value of 67.95% suggests other variables such as organic manure, farmer management practices, among other could also account for increases in potato yield observed over time.

Table 12: Estimates of Irish potato output and responsiveness to fertilisers and improved seed

Dependent variable	IrishPoutput					
Variables	Coef.	Std. Err.	T	P>t	[95% conf. Interval]	
lnIRPTotFert	$8.68x10^{-6}$	$3.12x10^{-6}$	2.78	0.050	$2.24x1^{-8}$	0.0000173
lnIRPseed	0.5497635	0.2001166	2.75	0.052	-0.0058492	1.105376
_cons	9.629713	1.523745	6.32	0.003	5.399118	13.86031
Number of obs	=	7				
F(2, 4)	=	7.36				
Prob > F	=	0.0457				
R-squared	=	0.7863				
Adj R-squared	=	0.6795				
Root MSE	=	.20201				

The aggregate increase in crop output realised can be explained by use of fertilisers. The strongest response was noticed for maize, followed by beans and rice. The responsiveness for Irish potato was quite small while that for wheat was not significant.

The results are able on average aggregates over the seven years of the CIP projection, therefore the results in some years may average out others. The typical production function would experience increasing returns, constant, decreasing and declining returns and all these could have been realised leading to averaging out of results. Nonetheless a seven-year period would still be considered a medium period and current declines may be related to efficiency and externalities e.g. phosphorous binding, leaching, acidification, run-off and poor fertiliser application practice, among others.

3.4 Value cost ratio

The VCR shows that with the exception of Irish potato, the other crops fertilisers provide enough incentives to cover for risks and costs of capital from fertiliser use. The minimum VCR of greater than 3.0 would cover the risky production environment to allow for adoption of fertiliser incentives (CIMMYT 1988; Morris et al. 2007). The VCR ratios for unsubsidised prices showed that farmers would be less incentivized to use fertilisers in risky environments when fertilizer prices are not subsidized even where significant response in output was observed as was the case for rice and maize, but would be highly incentivized to use fertilizers for such risky environments under subsidy (*Table 13*). The VCR seems to suggest that the use of fertiliser subsidies has been worthwhile to reduce the risk faced by farmers. At the same time, the margin of the VCR ratio for rice and maize means that protection against risk is quite marginal. In case of Irish potatoes, the crop output response to fertilizer is very minimal and would benefit more from environment management than use of synthetic amendments. In the absence of the subsidy, production with fertilisers might not be recommended for farmers based on the results of the VCR.

However, the results for wheat and beans would not stand given the non-significance and the weak significance respectively. On the other hand, Irish potato fertiliser subsidy may be the most effective approach to reduce farmers' production risk with improved seed as has been shown based on the analysis above. Additional factors such as organic manure and farmer practice may be suitable alternatives for influence on potatoes production, and are also likely to be a good alternative for improved output performance for wheat and bean as well.

Table 13: VCR estimates for subsidised and unsubsidised fertiliser prices

Output	Mean ('000tons)	Output response to fertilisers	VCR at subsidised fertiliser prices	VCR at unsubsidised fertiliser prices
Wheat	68,352	0.39	29.00***	19.39***
Rice	78,646	0.14	3.33	2.18
Maize	393,487	0.84	3.05	2.28
Beans	356,408	0.18	48.78**	36.31**
Irish potato	1,708,313	8.68×10^{-6}	0.0001	0.0001

** weakly significant; *** not significant

3.5 Review of current fertiliser needs and use by province and ecological zone

Whereas MINAGRI through the CIP programme sought to promote and increase fertilizer use in agriculture sector, the coffee and tea industry was already consuming comparatively a high quantity of fertilizer imported and distributed purposely to farmers of these two cash crops. It was established that whereas the fertilizer under CIP has gone up significantly, still about 50% of the fertilize use in the country is accounted for by application in tea and coffee shambas. Tea and coffee and other non-food crops have an independent arrangement outside CIP although MINAGRI in effort to increase production of coffee and tea is in the process of finding ways to boost inputs including fertilizers and planting materials for such cash crops (Naramabuye et al. 2008).

The decision on the advice to private sector on what type, form and volume of fertilizer should be imported under CIP programme was reported to be a function of the envisaged or planned area for production of the priority crops including cash crops as indicated by the District Agronomists and collated by RAB under the fertilizer use programme. An example of such information is provided in *Table 14* below. The quantity needed varies from season to season due to impacts such as nutrient mining, determined by type of crops and intensity of use, and loss of nutrients to environment through soil erosion, leaching+ and volatilization. The new information on the actual soil fertility levels and desired nutrient levels for the particular crops produced in different areas is currently guided by research findings of RAB working together with IFDC, which has enabled better selection of the nutrient mixes and informed the setting of application rates away from the previously used one rate fits all areas.

Table 14: Fertilizer needs for year 2009 Season A for different crops grown in different Districts

	Province	District	Type	Crop	Area (ha)
1	East	Kirehe	DAP + Urea	Maize	10,827
		Gatsibo	DAP + Urea	Maize	5,500
		Nyagatare	DAP + Urea	Maize	6,600
		Rwamagana	DAP + Urea	Maize	?
2	West	Rusizi	DAP + Urea	Maize	7,000
		Nyamasheke	DAP + Urea	Maize	1,049
		Rubavu	DAP + Urea	Maize	540
		Nyabihu	DAP + Urea	Maize	100
			NPK 17-17-17	Wheat	430
		Ngororero	NPK 17-17-17	Wheat	525
3	North	Gicumbi	DAP + Urea	Maize	3,000
			NPK 17-17-17	Wheat	?
		Musanze	DAP + Urea	Maize	500
			NPK 17-17-17	Wheat	163
		Burera	DAP + Urea	Maize	607
		Gakenke	DAP + Urea	Maize	656
		Rulindo	NPK 17-17-17	Wheat	1,000
4	South	Huye	DAP + Urea	Maize	880
		Nyaruguru	DAP + Urea	Maize	1,000
		Muhanga	DAP + Urea	Maize	624
		Kamonyi	DAP + Urea	Maize	1,050
		Nyamagabe	NPK 17-17-17	Wheat	500

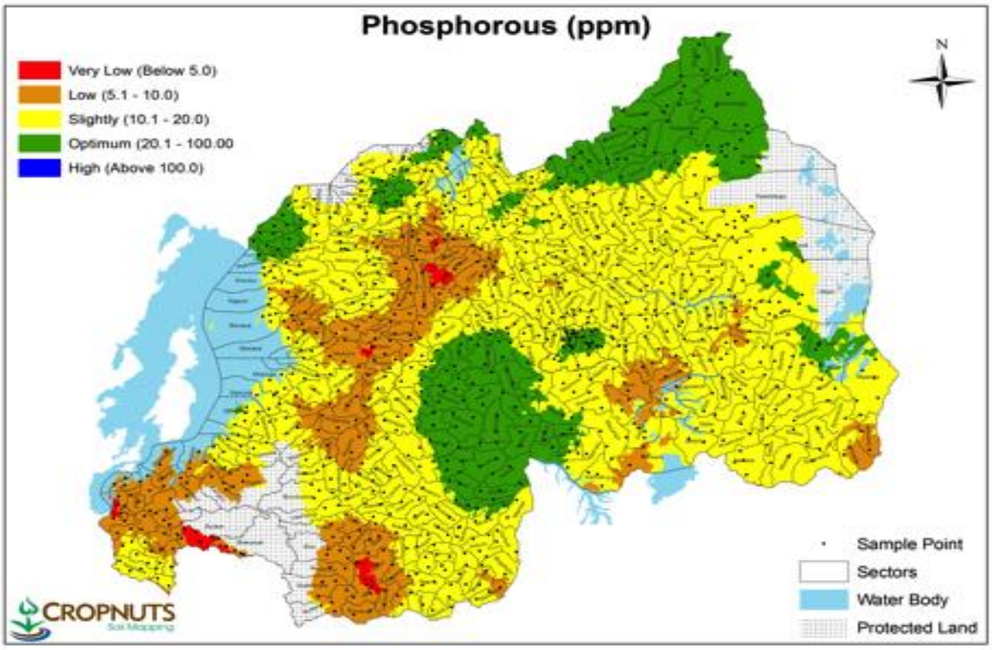


Figure 6: Soil nutrient map for levels of phosphorous

Recent collaborative work between RAB and IFDC have produced soil nutrient maps providing crucial information in what nutrients are actually required for the different areas of the country shown as examples in *Figure 6* to *Figure 11*. The different colours in the maps also indicate not only types but levels of nutrients needed to guide the setting of the application rates in the specific areas on the maps. This is indeed is a significant departure from the previous approach which was one formula for each type of fertilizer applied uniformly for all farmlands under CIP across the country

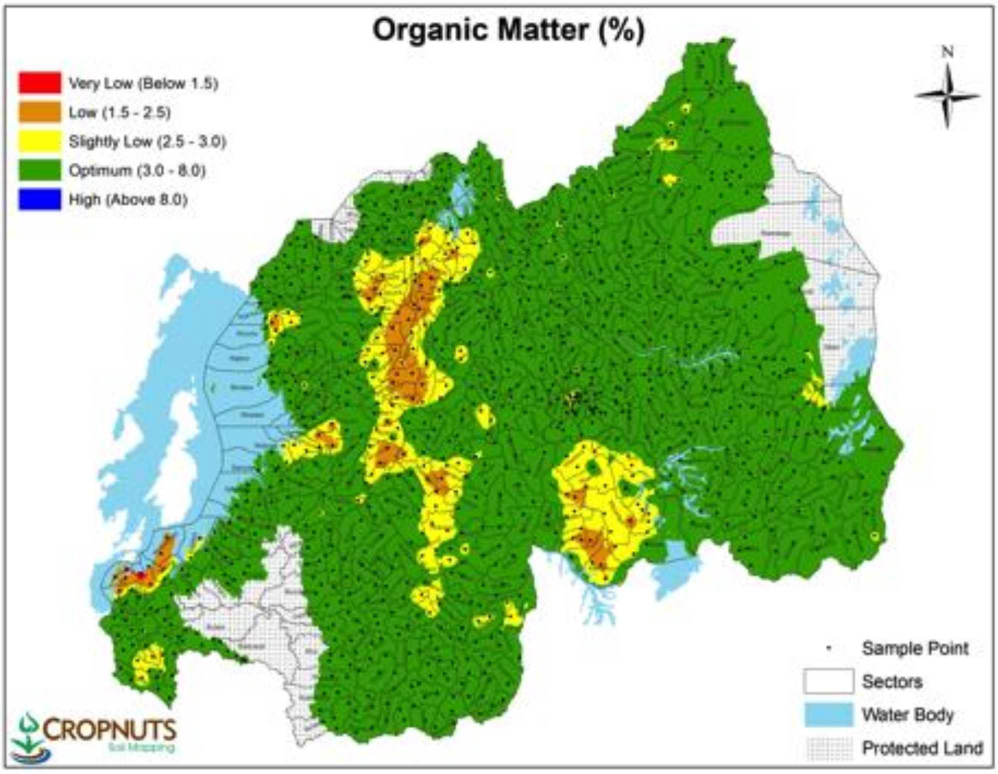


Figure 7: Soil nutrient map indicating levels of organic matter

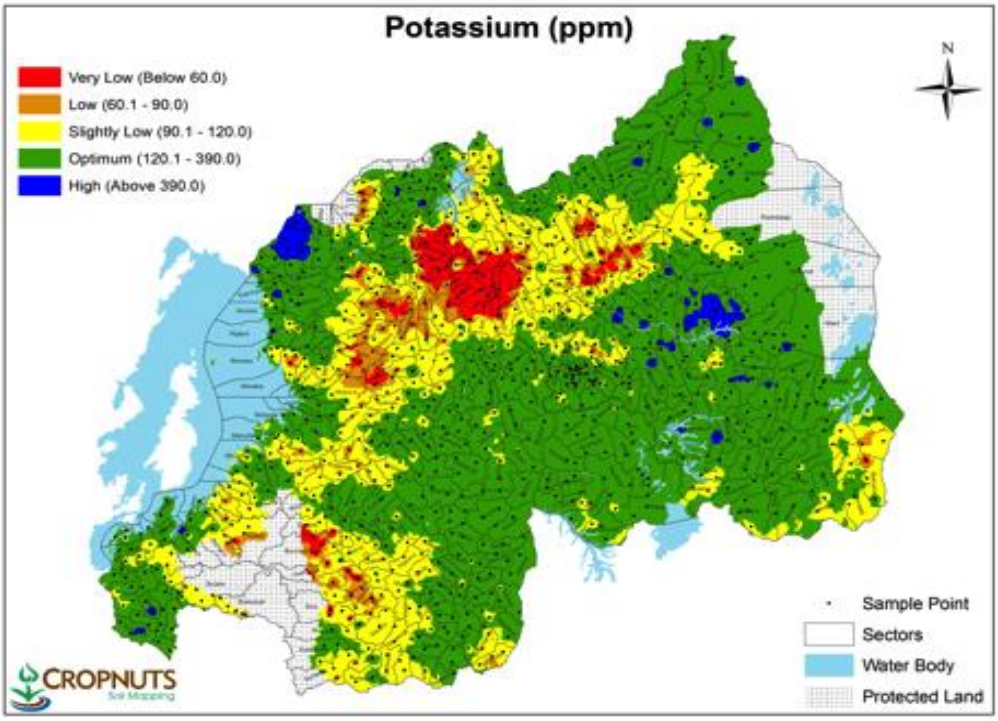


Figure 8: Soil nutrient map indicating the levels of potassium

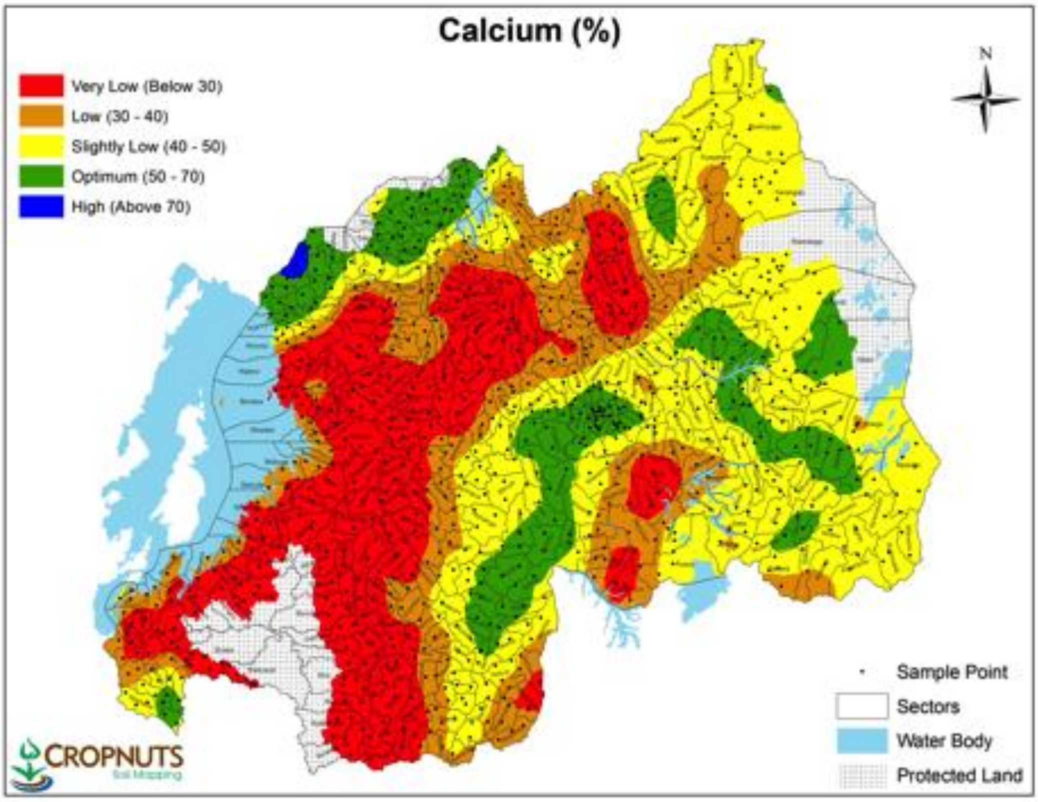


Figure 9: Rwanda soil nutrient map for levels of calcium

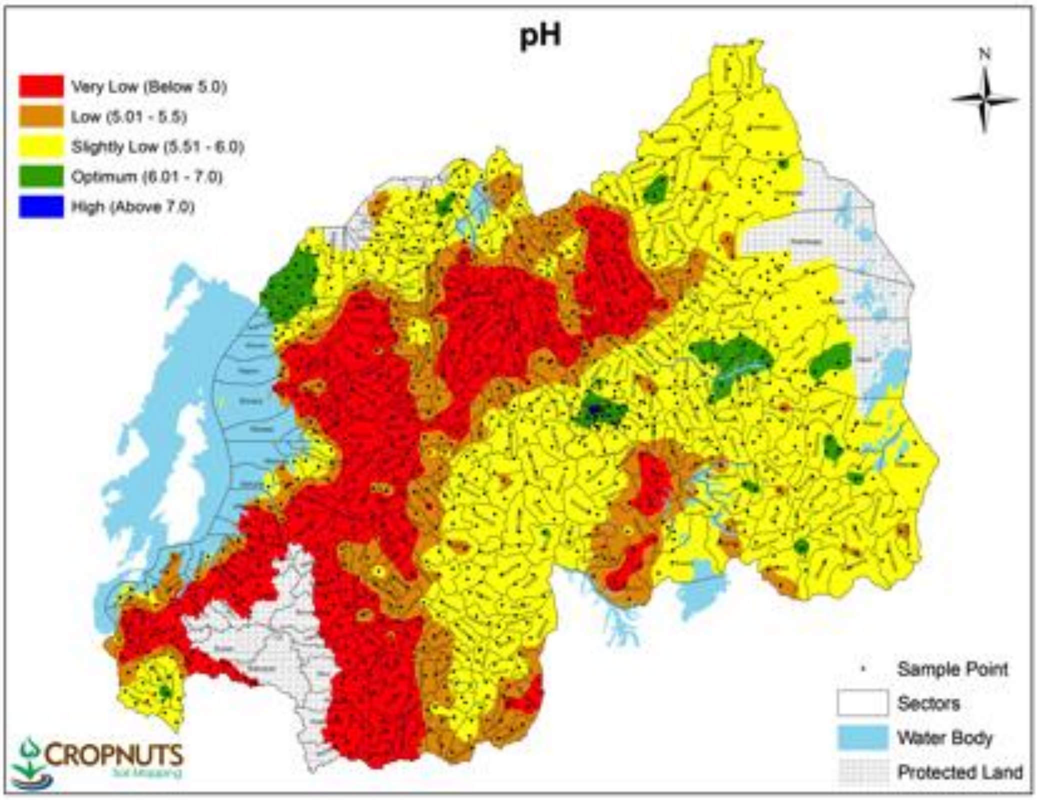


Figure 10: Rwanda Soil Nutrient map indicating the pH (acidity) levels

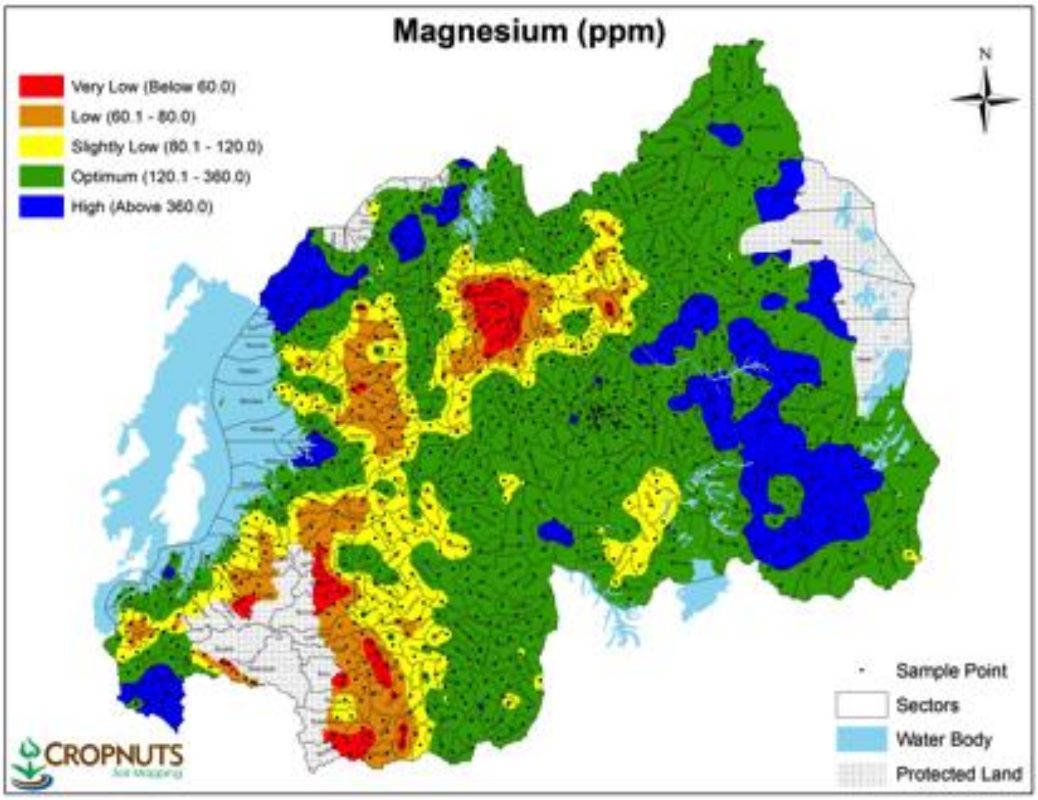


Figure 11: Rwanda Soil Nutrient map showing levels of micronutrient -magnesium

4. COST BENEFIT ANALYSIS OF FERTILISER USE

4.1 National level Benefit-cost ratio

The national level BCR was determined from the aggregate yield responses, and the associated economic, environmental and social costs and benefits. The economic, social and environmental impacts may occur as externalities or as intended impacts of the fertiliser incentive.

4.1.1 National gross margins from fertiliser use

The discounted gross margins for inorganic fertiliser use for the five crops (maize, beans, wheat, Irish potato and rice) were positive indicating a gain in income due to fertiliser use. The total revenue from increased fertiliser use and the associated improved seed, labour costs and cost of fertilisers when discounted at a 3% discount rate was estimated at Rwf 620 million. The overall increase in gross margins based only on the significance of the yield response to fertilisers showed a fairly modest gain given that in 2014 the fertilisers imported were estimated at Rwf 12.9 billion. However, the figures tallied with the findings from the production efficiency to fertilisers which was also relatively modest (*Table 15*).

The gross margin was positive over the projection period except for 2009 where there was a negative gross margin. Where the cost of labour, and seed exceeded the increase in yield associated with fertiliser use.

Table 15: Discounted gross margins for rice, maize, beans, wheat and potatoes.

Years	Total revenue	Total seed cost	Total labour cost	Total cost of fertiliser	Gross margin	Discounted gross margin
			Million Rwf			
2007	249	12.6	95.1	4.63	137	111
2008	327	10.4	188	8.41	121	101
2009	410	20.2	406	16.2	-32.5	-28
2010	467	42.3	307	11.1	107	95.1
2011	595	160	274	12.2	149	136
2012	807	181	404	17.9	204	192
2013	853	386	426	28.5	13.5	13.1
	Total				**699**	**620**
	Mean				**99.86**	**88.6**

4.1.2 Cost of fertiliser subsidy

The fertilizer subsidy is an instrument used to promote fertilizers and increase its use. MINAGRI is implementing an exit strategy from subsidies that have been implemented since 2007 when CIP began. After, 6-7 years of subsidies of 50% for DAP and UREA and 20% for NPK, the subsidies have now reduced to about 35% for DAP, 30% for UREA and 15% for NPK. The increase in the market fertilizer prices is a combination of the increase in market prices and reduction in subsidies (Murekezi 2015). The discounted value of the subsidy was estimated at Rwf 40 million aggregated for the period between 2007 and 2013 (*Table 16*). The subsidy was estimated based on the actual benefit based on reported subsidised and unsubsidised prices for the fertilisers.

Table 16: Total value of subsidy

Years	Total fertiliser cost subsidised	Total fertiliser cost unsubsidised	Fertiliser subsidy
		Rwf million	
2007	2.85	4.90	2.05
2008	6.61	9.61	3
2009	13.20	18.70	5.5
2010	7.46	12.00	4.54
2011	8.10	13.20	5.1
2012	12.70	19.80	7.1
2013	17.40	29.70	12.3
Total	**68.32**	**108.00**	**39.59**
Mean	**9.76**	**15.40**	**5.66**

4.1.3 Impact of fertilisers on surface water resources

The environmental cycle of the cost-benefit analysis comprises of assessment of evidence of impact of fertiliser use on water resources. The impacts of pollution on water include; drinking water quality (surface and ground water), recreational value due to worse water quality, freshwater eutrophication, bathing water quality, rover ecosystems and natural habitat impacts, and wetland ecosystem and natural habitat impacts (Defra 2014). Review of assessments conducted for Rwanda show that the crop fertiliser uptake under good performance may reach 50% of the fertilisers applied (Kotsch 2015). About 30% is stored in the soils, based on properties of the soils i.e. organic matter and capacity to retain nutrients, while 20% is accumulating as acidification and also leaching to lower layers and subsequently into ground water systems (Kabirigi et al. 2016; Nduwumuremyi 2013). There is limited assessment on ground water impacts even though there have been proposals for efforts to be undertaken to establish these impacts (Cantore 2011). Nonetheless, there is a growing elaboration of soil erosion run-off (UNEP 2011).

Rwanda has a surface water area of 135,000 ha comprising of 101 lakes and 861 rivers (RADA 2005 and REMA 2010). The key environmental concern associated with inorganic fertiliser use is pollution from soil erosion run-off into surface water. Kagera river basin, Rwanda's major catchment covers 67% of the country. The river basin is a key focus of estimates of accumulation of soil run-off from erosion on farmlands and others land use systems (MINIRENA 2011). Estimates indicated accumulation of 6.5 million kg of Nitrates, 114,116kg of ammonium-based nutrients and 205409kg of phosphates for an agricultural area of 22,823 km^2 (Wali et al 2011).

The run-off from farms is generally collected into Rwanda's river system and transported into the lakes. The estimation of the cost of nutrient pollution into the river system was based on shadow prices of chemical treatment costs and pollution impacts for nitrogen and phosphorus based fertilisers. Wali et al. 2015 adopted UNEP (2015) shadow prices for environmental impacts of nitrogen and phosphorus based nutrients in river systems were estimated at €16.3 and 30.9 per kg of nutrient in the river system (UNEP 2015 and Wali et al. 2015). However, the immediate risk area is only 25% of the mean risk value at Rwf 779 million based on estimates of phosphorus and nitrogen fertiliser pollution in the river system from application of Urea, NPK and DAP (*Table 17*).

Table 17: Cost of pollution from soil erosion run-off in Rwf

Years	Total Area	Actual values	Discounted values	Value for the area under risk (25%)
		Values in Rwf (millions)		
2007	125439.8	5,150	4,187	1,055,171
2008	248239.5	10,191	8,535	2,150,777
2009	535195.9	21,972	18,953	4,776,112
2010	404848	16,620	14,767	3,721,268
2011	361678.6	14,848	13,588	3,424,199
2012	532766.6	21,872	20,616	5,195,298
2013	561410.6	23,048	22,376	5,638,859
Mean		**16,243**	**14,718**	**3,709**
20% of soil erosion run-off into surface water system				**779**

4.1.4 Impact of fertilisers through acidification

Whereas fertiliser use could contribute to acidification of soils, current factors suggest that the contribution of inorganic fertilisers cannot be considered for this assessment. First, the baseline conditions for assessment of acidification are confounded by the on-going research work under the Rwanda Agricultural Board through research that carried out liming with the support of the Alliance for Green Revolution in Africa (AGRA) (Nduwumuremye et al 2013). Indeed, RAB indicated in the 2012/2013 Annual report that a combination of limestone, farmyard manure and inorganic fertilizer generated two-three times yield as compared to the yield obtained from farmer practice treatment that was mainly comprised of farmyard manure from home gardens. The basis for the lime application was that soils in the northern and western provinces of the country were generally acidic and needed liming to complement inorganic and organic fertilisers. Simulations can be considered with additional datasets.

Secondly, several research studies seem to suggest that soil nutrient depletion is a major problem in Rwanda (Chianu and Mairura 2012). Indeed, studies conducted in the early 2000s showed that out of 13 African countries on which case studies were done, including Botswana, Kenya, Tanzania, Ethiopia and Malawi, among others, Rwanda had the highest nutrient mining rate for phosphorous and potassium. In the case of potassium the soil mining of Rwanda was the highest since the early 1980s (Roy et al. 2003). Moreover, recent nutrient balance assessments conducted in Cyabayaga watershed in Nyagatare district, Eastern province of Rwanda support the earlier studies. Partial nutrient balances showed negative nitrogen and potassium balances at -67.5 kg N/ ha/ season and −7.7 kg K/ ha/ season respectively) whereas phosphorous (P) balance was positive (17.4 kg P/ha/season. The studies seemed to affirm nutrient depletion as a problem in the country. Even though no further assessment is undertaken on inorganic fertiliser use and soil acidification at this stage it will be wise that a system is put in place to monitor this problem as it can have large effects on cost of fertiliser, reduce willingness to use and perhaps more importantly have long-term impacts on soil fertility/productivity and ground water quality.

4.1.5 Impact of fertiliser use on GHGs

Greenhouse gas emissions associated with fertiliser use have been indicated in the Rwanda Nationally Determined Contributions (NDCs) towards mitigation under the United Nations Framework Convention on Climate Change (UNFCCC). The presence of emissions can also be an opportunity for generating enterprises for GHG emissions reductions. At this stage; however, they are considered as an environmental cost associated with fertiliser use. The value of greenhouse gases (GHG) generated from the fertiliser imports since 2000 are estimated to have cumulatively reached 2.67 milliontCO_2 by the end of the 2013 farming seasons (*Table 18*). The price used was US$6/t$CO_2$ which was equivalent to Rwf 3,608/tCO_2 based on the average exchange rate for the US$ to Rwf 602 between 2007 and 2013 (World Bank 2014; National Bank of Rwanda 2016). In monetary terms, GHG emissions were the equivalent a discounted value of Rwf 8.16 billion (*Table 18*). It should be noted here that there is a wide variation in cost, some as low as US$3/t$CO_2$ whereas others use rates as high as US$12/t$CO_2$. Moreover, the NDCs for Rwanda have already earmarked mitigation actions for inorganic fertilisers, which would neutralise the emissions. Therefore, the emissions were considered in the BCR analysis.

Table18: Value of GHGs generated as a result of fertiliser use for CIP crops

Year	NPK	UREA	tCO_2	Value in Mill. Rwf	Discounted value mill. Rwf
2007	2,501	2,602	157,623	518	421
2008	9,253	3,197	211,528	690	578
2009	20,000	4,500	317,900	1,085	936
2010	12,000	4,000	265,880	939	834
2011	10,309	4,968	316,943	1,146	1,048
2012	16,835	7,911	505,909	1,859	1,752
2013	11,459	11,408	692,499	2,670	2,593
Total			**2,468,283**	**8,906**	**8,162**
Mean					**1,166**

4.1.6 The cost benefit analysis for the national perspective

Benefit cost ratio at the national level including the environmental social and economic benefit described above was estimated at 0.32 (*Table 19*). Given the viability threshold for BCR is 1.0, it does seem that the current fertiliser programme has not yet attained viability. There are three main limiting factors to the viability of fertiliser use; the net soil nutrient depletion rate for the country, the environmental soil of inorganic fertiliser nutrient run-off into water systems, and gross margins earned from fertiliser use. Rwanda still suffers a net nutrient depletion especially for nitrogen and potassium fertilisers (Chianu and Mairura 2012). The value of net nutrient depletion was Rwf 1.128billion while the cost of pollution from soil erosion into surface water systems was estimated at Rwf 779 million.

Even though mineral fertiliser use carries the risk of environmental impact, there is a need to overcome the net nutrient depletion deficit and inorganic fertilisers provide the most immediate opportunity for its attainment. However, as sensitivity analysis I shows, for viability to be attained, the increase in crop gross margins from fertiliser use along with the recovery of economic losses from nutrient depletion would not be enough to attain viability. A reduction in fertiliser pollution into surface systems of at least 19% is needed to go over the BCR viability threshold of 1.0.

On other hand, if the gross margins from crops with fertiliser use increased by 22% beyond the projected increase associated with estimated crop responsiveness to fertiliser, it would be possible for viability to be achieved (Sensitivity 2). Viability would be achieved, by only increasing inorganic fertiliser use until the annual net nutrient depletion is overcome, as long as the gross margins increase beyond projected fertiliser responsiveness (sensitivity 3). Fertiliser responsiveness is dependent on complementary inputs such as improved seed, organic manure and irrigation, among others (Morris et al. 2007). Evidence from the Seasonal Agricultural Surveys (SAS) shows that improved seed use in Rwanda peaked at only 17.9% between 2007 and 2013 (NISR 2014). Between 82-92% of Agricultural Operators (small scale farmers less than 10 hectares of farmland) used traditional seeds and 8-18% traditional seed. Rwanda large scale farmers (LSF), with over 10ha of farmland, who used traditional seeds were 66.5 % while those that used improved seed were 33.5 %. Between 48-71% of small scale farmers used organic fertilizers and only 17% to 20% inorganic fertilizers. Among LSF, 62.3 % used fertilizers and 37.7 had not already used fertilizer (NISR 2013). In addition to the low usage of improved seed and modest use of organic manure the use of inorganic fertilisers is not uniformly spread to cover one-fifth of the farmers.

Table 19: National level benefit cost ratio results and sensitivity analyses

	BCR		Sensitivity 1: Viability Threshold 1		Sensitivity 2: Viability Threshold 2		Sensitivity 3: Annual nutrient depletion cancelled out	
	Discounted costs	**Discounted benefits**	**Discounted costs**	**Discounted benefits**	**Discounted costs**	**Discounted benefits**	**Discounted costs**	**Discounted benefits**
				Million rwf				
Economic			-	-			-	
Gross margins		620	-	671	-	819	-	671
Net nutrient loss	1,128							
Environmental			-	-	-	-	-	-
Mineral run-off into water	779		631	-	779	-	779	-
Social			-		-	-	-	-
Fertiliser subsidy for farmers	40		40	-	40	-	40	-
Totals	1,946	620	670	671	818	819	818	671
								-
BCR		**0.32**		**1.00**		**1.00**		**0.82**

4.2 Farm-level CBA

4.2.1 Overall gross returns with fertilisers

Gross revenue of crop enterprises with fertiliser application show that the highest returns per hectare, among the study districts, for farmers in fertiliser using both inorganic fertilisers and organic was highest in Nyagatare District in the Southern Province followed by Musanze District in the Northern Province with Muhanga and Karongi Districts also performing strongly. For a farmer with a one-hectare farm with enterprises for maize, rice potato, wheat, and beans and vegetables the highest gross revenue realised was RWF 6.9 million/ha/year. However, as observed in *Table 20*, the farmers in Nyagatare obtained the higher gross revenue per hectare based on the performance of maize, rice, beans and vegetable enterprises. Musanze had the highest returns from beans and vegetables. Across all six districts the revenues per crop enterprise were staggered suggesting no specific advantage for any one crop enterprise, instead different enterprises exhibited differing suitability based on gross margins earned. This means no district had a specific advantage over others but there were differences in performances within districts for the five crops in regards to crop output response to fertilizer use and gross margins earned.

Table 20: Gross revenues for crop enterprises for farmers using inorganic fertilisers'

Crop	Gross revenues per hectare per year					
	Eastern Province		Southern Province		Western	Northern
	Bugesera	Nyagatare	Muhanga	Nyanza	Karongi	Musanze
Maize	225,340	3,288,346	377,270	251,359	244,582	524,819
Rice	83,893	2,188,413	213,818	-	-	-
Potato	-	-	1,570	274,254	239,024	474,211
Wheat	200,000	-	-	37,500	277,500	625,000
Beans & vegetables	450,904	1,470,036	687,915	83,985	251,980	2,498,342
Grand total	960,137	6,946,795	1,280,572	647,098	1,013,087	4,122,371

4.2.2 Enterprise specific performance for crops

Tables 21 to *25* provide the detailed estimation of the gross revenues from the crop enterprises in the six sample Districts. The performance is based on respondent farmers and is attributable to use of both inorganic fertilisers and organic manure as far as soil fertility is concerned.

Nyagatare District showed very strong performance for maize and rice enterprises while Musanze District exhibited strong performance for the beans and vegetable enterprises followed by Nyagatare District. Generally maize performed best of all crops and there was income realised from maize production in all districts, which is representative of the production across the country.

Wheat, rice and potato production was lower than expected. Rice growing enjoys continuous supply of water throughout the production cycle as it is mainly carried out in marshland areas and has a regional concentration in the southern and eastern parts of the country with averagely better rainfall. The low crop output response to fertilizer use for wheat and potatoes needs further research especially given the fact that potato farmers apparently are purchasing fertilizer more regularly and in higher quantities even with the reduced subsidy. Only 1.1% of arable land across the country is marshlands suitable for land production, and for this reason MINAGRI and RAB have had an increased focus in utilising suitable marshlands for rice production under CIP.

Service providers such as One-Acre Fund, and RAB itself, have not had a strong involvement in the promotion of wheat and this could have affected the performance at farmer level. According to the National Institute of Statistics of Rwanda (NISR) Seasonal Agricultural Survey (SAS) for 2015, 3.9% of the arable land in Rwanda is under potato (Irish potato) production. The area of production for potato is lower than that for beans (bush beans, 10.6%) as well as other crops such as cassava (22.6%) and cooking bananas (7.9%), which have taken precedence in a small sample survey of farmers with small land holdings.

Table 21: Gross Revenues for maize production

District	Province	Season B 2014/15					Season A 2015/16					Annual Total GR/ha
		Mean output (kg)	Farm gate price (RWF/kg)	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	
Bugesera	Eastern	128	157	0.3433	372.43548	58,457.47	154.1667	156.96	0.145	1063.2186	166,882.79	225,340.26
Karongi	Western	347	212	0.3614	959.69369	203,205.54	92	211.74	0.4708	195.41206	41,376.55	244,582.09
Muhanga	Southern	168	237	0.1669	1005.0929	238,347.72	100	237.14	0.1707	585.82308	138,922.09	377,269.81
Musanze	Northern	1296	163	0.4783	2709.918	441,337.25	175	162.86	0.3414	512.5952	83,481.25	524,818.50
Nyagatare	Eastern	9219	180	0.934	9,912.6344	1,784,274.19	1169.8333	180	0.14	8,355.9521	1,504,071.39	3,288,345.58*
Nyanza	Southern	95	235	0.4639	204.06704	47,853.72	926.6667	234.5	1.0678	867.82796	203,505.66	251,359.38

Table 22: Gross Revenues for rice production

District	Province	Season B 2014/15					Season A 2015/16					Annual Total GR/ha
		Mean output (kg)	Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	
Bugesera							100	250	0.298	335.57	83,892.62	83,893
Muhanga	Southern	187	250	0.219	855.27	213,818						213,818
Nyagatare	Eastern	8271	274	1.035	7992.45	2,188,413						2,188,413*

* Outlier values from the average

Table 23: Gross Revenues for potato production

District	Province	Season B 2014/15					Season A 2015/16					
		Mean output (kg)	Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Annual Total GR/ha
Karongi	Western	300	140	0.41	731.71	102,439	400	140	0.41	975.61	136,585.37	239,024
Muhanga	Southern	1570	150	0.37	10.47	1,570						1,570*
Musanze	Northern	1588	135	0.45	3512.67	474,211						474,211
Nyanza	Southern	2450	150	1.34	1828.36	274,254						274,254

* Outlier values from the average

Table 24: Gross Revenues for wheat production

District	Province	Season B 2014/15					
		Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Annual GR/ha
Bugesera	Eastern	80	500	0.2	400	200,000.00	200,000
Karongi	Western	150	370	0.2	750	277,500.00	277,500
Musanze	Northern	1250	500	1	1250	625,000.00	625,000
Nyanza	Southern	15	500	0.2	75	37,500.00	37,500*

* Outlier values from the average

Table 25: Gross Revenues for beans and vegetables production

District	Province	Season B 2014/15					Season A 2015/16					
		Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Mean output (kg)	Farm-gate Price RWF/kg	Area planted (ha)	Yield (kg/ha)	Gross Revenue/ha	Annual Total GR/ha
Bugesera	Eastern	224.7143	230	0.227	992.12	228,186.71	215.4545	230	0.2225	968.33	222,717	450,904
Karongi	Western	300.8667	250	0.425	707.92	176,980.41	127.5	250	0.425	300.00	75,000	251,980
Muhanga	Southern	22.5	300	0.208	108.43	32,530.12	142.0	300	0.065	2184.62	655,385	687,915
Musanze	Northern	6485	270	0.930	6973.12	1,882,741.94	114.0	270	0.05	2280.00	615,600	2,498,342*
Nyagatare	Eastern	1950	230	1.250	1560.00	358,800.00	1075.0	230	0.2225	4831.46	1,111,236	1,470,036*
Nyanza	Southern	136.5625	250	0.616	221.69	55,423.09	88.2	250	0.772	114.25	28,562	83,986*

* Outlier values from the average

4.2.3 Subsidised Inorganic fertiliser costs at farm household level

The highest fertiliser application costs were in Nyagatare and Musanze followed by Muhanga District. The fertiliser use in Nyagatare District was nearly two-times as much as Musanze District ,whose cost of fertiliser and manure use was also two-fold that for Muhanga District. The cost of fertilisers per hectare per year ranged from Rwf 5.49 million in Nyagatare District to Rwf 480,216 in Nyanza District (*Table 26*). The highest expenditure for fertilisers was on UREA suggesting a direct investment in increasing nitrogen based nutrients in the soil. In Musanze District the investment in organic manure was also considerable. The case in Musanze was further supported by the higher performance in beans and vegetables suggesting that a component of production may only be associated with organic manure use.

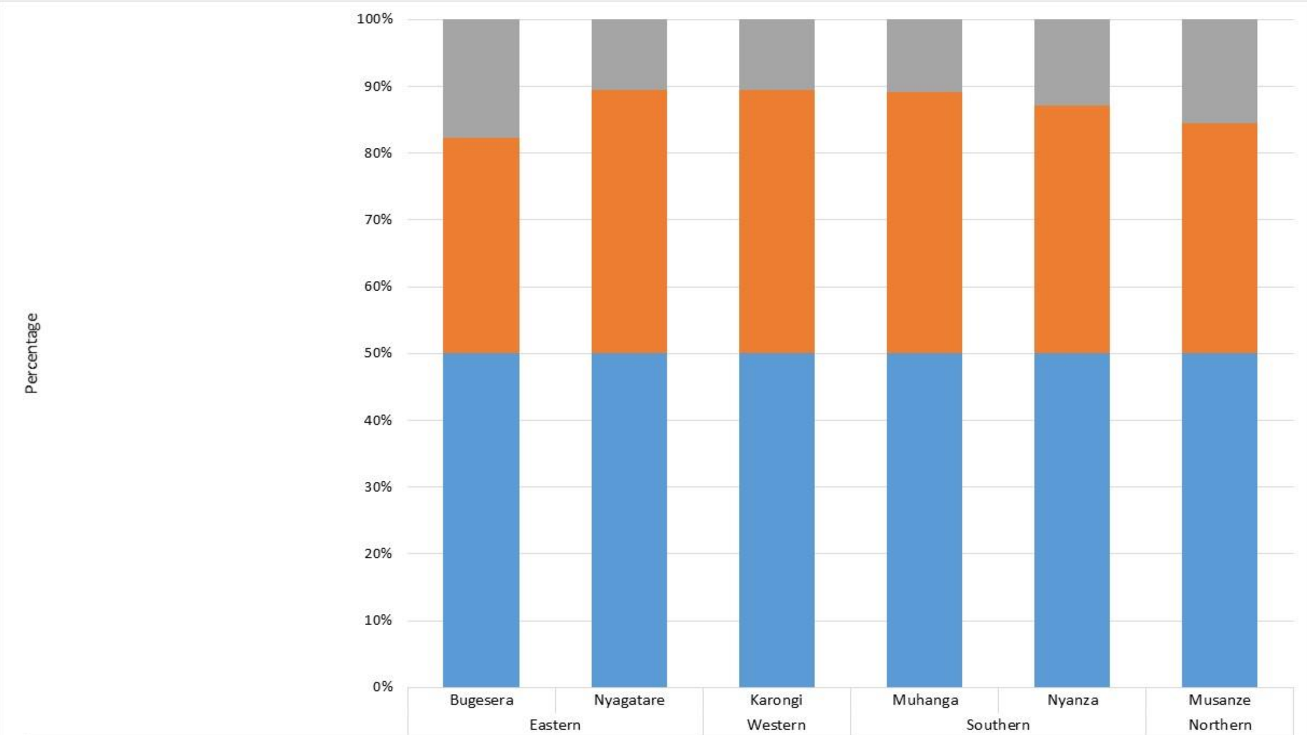
The high urea usage in Nyagatare and Muhanga was also associated with rice production in marshlands. Traditionally, rice production requires considerable nutrients and the need to boost nitrogen based nutrients may be an indication of absence of alternative sources of nitrogen such as organic manure, severally degraded lands and/or an indication of a relatively high intensity of production where nitrogen demand outstrips the supply from alternative sources. The higher demand for inorganic fertilisers was also associated with maize production in Nyagatare where crop intensification was a major undertaking so much so that many of the farm households employed additional hired labour to supplement the labour supplied by the family.

Table26: Subsidized cost of inorganic fertiliser and organic manure costs at farm household level

Province	District	Type of Fertiliser	Season B 2014 (RWF per ha) Maize	Rice 1	Potato	Wheat	Beans & vegetables	Season A 2015 (RWF per ha) Maize	Rice 2	Potato	Wheat	Beans & vegetables	Total expenditure (RWF/ha/year)
.Eastern	Bugesera	DAP	174,375				18,140	57,302				5,650	619,433
		NPK	35,938					12,500					
		UREA	78,667				1,035	12,160				10,000	
		Organic Manure	59,333				28,833	28,833				96,667	
Eastern	Nyagatare	DAP						480,000					5,489,250*
		NPK		540,000				500,000	556,250				
		UREA		1,012,500			500,000	288,000	1,562,500				
		organic manure					500,000						
Western	Karongi	DAP	186,000				128,061	34,500	45,000				799,123
		NPK			19,800	18,600	33,036						
		UREA					73,763		18,620				
		Organic Manure	90,150		18,000	18,000	31,593		84,000				
Southern	Muhanga	DAP	7,280	9,180				178,919					1,002,537
		NPK	19,080	8,640				84,658					
		UREA	40,500	29,800				359,174					
		Organic Manure		19,080			151,050	95,176					
Southern	Nyanza	DAP	74,917				124,750	69,563					480,216
		UREA	12,530				56,000						
		NPK	700				21,250	6,590					
		Organic Manure	48,750				41,500	12,000				11,667	
Northern	Musanze	DAP	20,580		186,000			232,734					2,840,024*
		NPK			4,590					550,000			
		UREA	4,410		580,000			426,710		120,000			
		Organic Manure	8,000		50,000		7,000	250,000		400,000			

d) Gross margins on fertilisers at farmer household level

Figure 12 shows the level of gross margins made on fertilizer relative to total annual expenditure and gross revenue at farmer level per year per hectare of farmed land. The figure suggests that the productivity aspects of the farmers and the gross margins they make when they use fertilisers may have considerable influence on whether or not they use fertilisers, and the actual viability for fertiliser use. The gross margins obtained net of fertilisers are only in the range of 25 to 40% of the gross revenues. This level of gain (gross margins) has to be able to meet the farmers' social and environment needs as well as allow for re-investment in fertilizer use for farmers to be attracted to purchase and use of fertilizer to enhance productivity. Therefore, the social and environmental benefits would also need to be considerable to make the enterprise viable; moreover, there is an indication that the productivity of the farmers has to be higher to make the fertilisers increasingly viable given the risks and costs associated with agricultural production in a subsistence setting. *Figure 12* also shows the trade-offs that farmers make to invest in fertilisers and earn incomes. A close observation shows that the farmers in Nyagatare invest a larger percentage of their gross revenue in fertiliser input and they are rewarded with a larger magnitude of gross margins even though by percentage they have smaller gross revenues. On the other hand the farmers in Nyanza and Bugesera Districts who invest relatively less of their gross revenue have smaller reward in gross margins. The gross margin for farmers in Nyanza and Bugesera Districts was as such found to be higher than that for Nyagatare, Karongi and Muhanga. The farmers in Musanze invest about two-thirds of their gross revenue in the fertilisers, and maintain about one-third as gross margins.



	Bugesera	Nyagatare	Karongi	Muhanga	Nyanza	Musanze
	Eastern		Western	Southern		Northern
Gross margins on fertilisers Rwf/year/ha	340,704	1,457,545	213,964	278,035	166,883	1,282,347
Total annual expenditure on fertilisers Rwf/year/ha	619,433	5,489,250	799,123	1,002,537	480,216	2,840,024
Gross revenue Rwf/year/ha	960,137	6,946,795	1,013,087	1,280,572	647,098	4,122,371

Figure 12: Gross margins (gross revenue net of cost of fertilisers) per hectare RWF/year/ha

4.2.4 Environmental impacts on surface water resources

Rwanda is a water scarce country. The per capita water availability declined from 977m^3/person in 2010 to 670m^3/person below a national threshold standard of 1000m^3/person effective performance, and way below the African average of 4000m^3/person (MINIRENA 2011; 2016). The major concerns with water resources are from the high run off levels especially into surface water systems. Whereas the leaching of nutrient fertilisers into ground water systems is envisaged to occur there is little scientific assessment of this case. The focus for soil fertilisers is generally towards soil mining and the negative nutrient balanced. However, nutrient run off with soil erosion is an important concern especially given the increase scarcity of water resources. Estimates based on spatial analysis showed that 47% and 37% of the country's arable land experiences soil erosion rates ranging between 50 and 100 tonnes/ha/year with much of the run off ending up as deposition in rivers (UNEP 2011).

The estimated value of nutrient run-off from farm lands was Rwf 444,951/ha (*Table 27*). The run-off was substantial given that the estimated gross revenue from crop production with fertilisers was estimated at about Rwf 1.5 million/ha. Therefore, not only does the soil nutrient erosion increase environmental externalities with soils enriched with fertilisers being swept into the surface water systems, but it also reduces the crop production performance possibilities on the farms.

Table 27: Estimates of cost of nutrient run-off from farm

Type of fertilisers	Fertiliser application (Kg/ha)	Shadow prices associated with the fertilisers	Estimated value cost from nutrient run-off
NPK	20.41	41,710	851,301.10
DAP	35.7	27,306	974,824.20
Urea	20.32	14,404	292,689.28
Total			2,118,814.50
21% estimated Risk of run-off into river system			444,951.05

4.2.5 Current state of the Benefit-Cost Ratio

The benefit-cost ratio calculated using static data based on primary data collections as well as secondary data analysis, indicated a current BCR of 1.23 (*Table 28*). This BCR ratio for the farmer level perspective exceeded the viability threshold of 1.0. Therefore, fertiliser use was viable at the farm level. The gross margins earned as discussed in the sections above point to a robust farm production system with diversification of enterprises, intercropped systems, and use of organic manure, the gross margins from crop production. These activities provided sufficient compliment leading to the viability observed. However, because these activities were not uniformly spread across the country based on the performance recorded in the SAS, the same viability could not be replicated at the national level (NISR 2013, 2014; Morris et al. 2007).

Table 28: Benefit-Cost Ratio for fertiliser use for the farming household perspective

	Benefits (Rwf/ha)	Costs (Rwf/ha)
ECONOMIC		
Gross revenue for CIP crops (maize, beans potato, rice, wheat) due to fertiliser use	1,423,144	
Variable cost for CIP crops (maize, beans potato, rice, wheat) due to fertiliser use		725,327
ENVIRONMENTAL		
Impacts of nutrient run-off per season/ha		444,951
SOCIAL		
Farm-level subsidy benefit	21,924	
Total	1,445,068	1,170,278
BCR	**1.23**	

The limiting factors to the viability at farm level are gross margins from crop production, variable production costs, and the environmental externalities from farmer's practice that could cause soil erosion run-off and environmental pollution. When all other variables are held constant, a 20% reduction in gross margins would make the use of inorganic fertilisers at farm level unviable. Given the low VCR ratios generally associated with fertiliser use (Dittoh et al. 2012 and Chianu and Mairura 2012) farmers in Sub-Saharan farmers are generally unwilling to sustain fertiliser programmes beyond external intervention from public programme and non-governmental interventions. A 30% increase in variable costs or a 48% increase in environmental pollution costs would also make the use of fertilisers unviable. The farm level sensitivity suggests a resilient farm system. Nonetheless, the strongest risk associated with gross margin is often influence by price of crop produce. When the prices decline 20% farmers are likely to struggle with low profitability and that increases the likelihood that they could choose not to use fertilisers. The indications were that the farmers are likely to be more resilient to price of agricultural inputs since they use a lot of local inputs; however, they are likely to be less resilient to price instability especially declines.

5 DISTRIBUTIONAL IMPACT OF FERTILIZERS

5.1 Current Fertilizer acquisition and practices up to farm level

The Ministry of Agriculture and Animal resources in collaboration with RAB organise importation of fertilizers to be implemented by private companies selected by the MINAGRI. Private companies involved may include the following but the companies may change from year to year. Those include: MEA Fertilizers (Kenya and Tanzania), YARA CHAPA MELI (Kenya and Tanzania), and PREMIUM AGRO CHEM. An important component of the entire fertilizer business management is the availability of funds. The BNR avail more than half of needed cash to distributors/agro-dealers as loans. The remainder is usually covered by the Development Bank of Rwanda (BRD) or People's Bank of Rwanda (BPR). At District and farm level, this exercise is facilitated by Micro Finance Institutions. The total amount around which the fertilizer business is running is extremely high. For instance, in 2007 A and B seasons, that amount was estimated to more than RWF 15 Billion. Other key players in advising farmers in agricultural production in general but also in respect specifically to CIP are the Rwanda Agricultural Board (RAB) of MINAGRI, the Local Governments; TUBURA (one acre fund); and through financial and technical support under the SPAT2 project. The overall linkage of the key players is as indicated in the sketch in *Figure 13*.

Research and extension have close links which could be strengthened further. The Rwanda Agriculture Board has deployed agronomists to work closely with sector agronomists. This system allows sector agronomists to get information from research results conducted by RAB. RAB can follow the impacts of its research results on yield and from this, RAB can design new research orientations for a better yield. In the same line, some organisations including: IFDC are disseminating research results to farmers' cooperatives. IFDC has undertaken its actions through different strategies including: training of farmers' cooperatives, training of agro-dealers with regards to fertilizer business and fertilizer application. In 2014, RAB and IFDC started collaborating in terms of technology transfer, research results dissemination and this collaboration has reached cell levels.

Programmes like SPAT 2 and TUBURA have shown positive impacts on training farmers with regards to fertilizer use through Farmer Field School training system. RAB has deployed 3 professionals in each zone with a clear mission to transfer research findings to local farmers' organisations through CIP activities. The Ministry of agriculture through RAB has established some policies to help agricultural technology transfer and research findings extension.

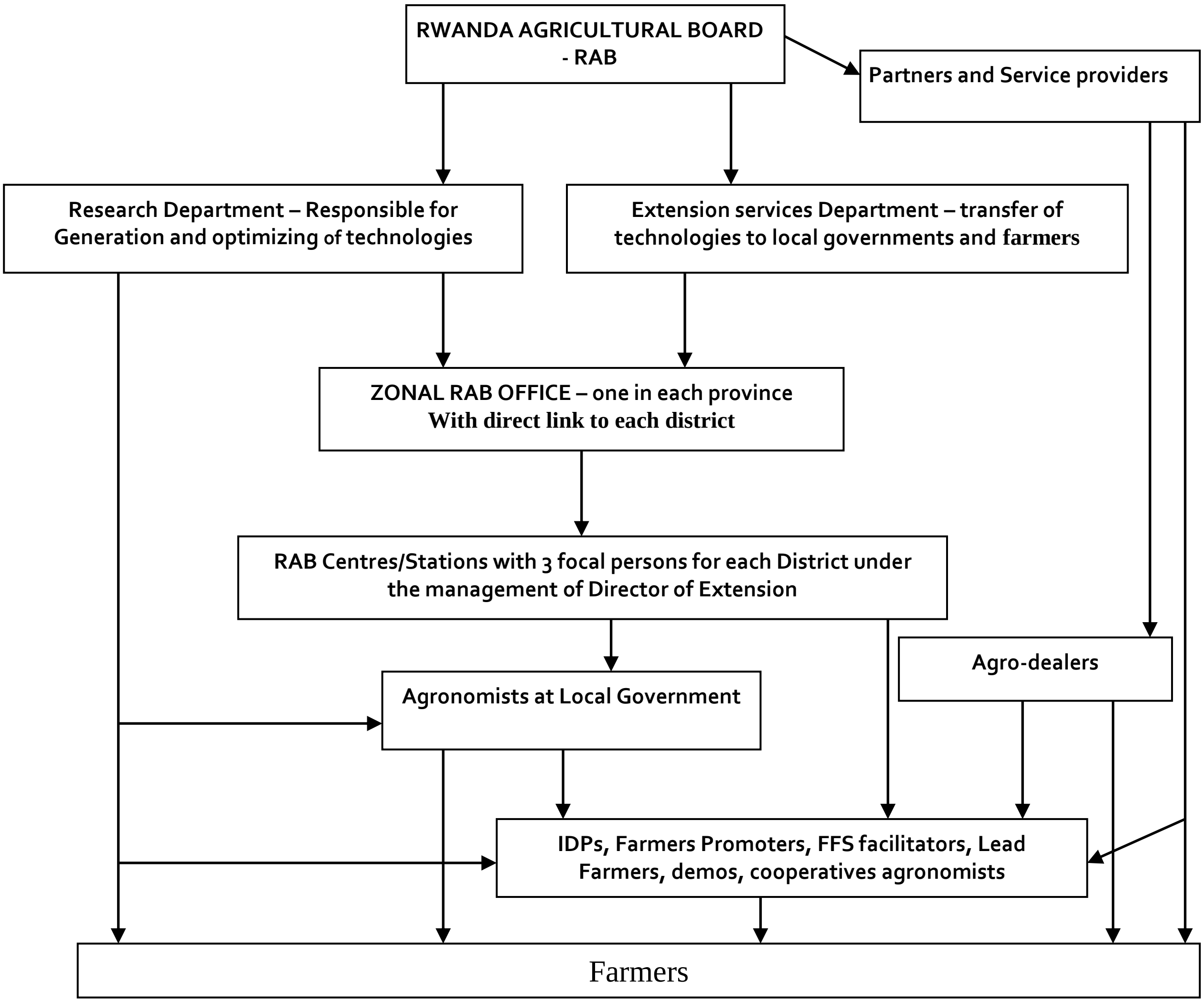


Figure 13: Schematic representation of the extension services under CIP

Role of Rwanda Agricultural Board in fertilizer use programme

The responsibility for the implementation and day to day management of the programme lies with RAB. This includes establishing how much fertilizer is needed by farmers, working with approved private companies on the importation of the fertilizers, conducting of the requisite research on the soil nutrient gaps and to guide on the fertilizer application rates, monitoring of supply and distribution of fertilizers throughout the country while working with agro-dealers, technical backup and support to Local Governments on fertilizer use and other agronomic issues, and working with farmers' cooperatives and farmers directly in promoting of good agronomic practices for enhanced productivity and production. Farmers are involved and informed of the results through use of on-farm trials as opposed to on-station research away from farmers. RAB is said to have adopted the on-farm trials as deliberate move to involve farmers, cut down costs of doing research, and allowing farmers to learn and uptake the good results easily. RAB also works in partnerships with key players and service providers such as IFDC and TUBURA in assisting farmers under the crop intensification programme. As indicated above RAB works through service centres linked to zonal offices that are under the headquarters based in Kigali. Zonal Offices are headed by Directors of extension while centres are under Centre Managers. At each centre there are three technical staff responsible for each of the 30 districts.

Role of Local Government

Local Government is responsible for providing of technical and socioeconomic information to farmers to assist them in their production and or other livelihood activities. In case of agriculture the mandate lies with the District Agronomist, which is held by one graduate level staff with agriculture related academic qualification for each District; the Sector Agronomist – with one person for each Sector who is also a graduate in agriculture related courses; and, an IDP for each village, who is a government employee responsible for dissemination of social and production information to farmers – one for each village with high secondary level education.

Role of the International Fertilizer Development Centre (IFDC)

IFDC as indicated above has played a significant role in rolling of crop intensification programme in regard to support to farmers and agro-dealers in the supply, access, handling and application of fertilizers. MINAGRI reported that over the last year IFDC has partnered with and supported RAB in undertaking critical research needed to guide the farmers on making choice of what type, form and quantity of fertilizer they need for their crops including setting of the fertilizer application rates for the different crops and zones (see demo site reports by AGRA). This is a positive development and move away from the blanket recommendations across the country.

IFDC also works directly with cooperatives and agro-dealers by providing training and other forms of support in managing the fertilizer use programme at that level as well as in imparting needed knowledge on technical issues for fertilizer use at farmer level. In a way they train cooperative leaders, agronomists and agro-dealers to provide extension services to farmers in handling and application of fertilizers.

Initially IFDC supported and worked directly with farmers to promote fertilizer use through hands-on training and setting up of demonstration plots for crop husbandry using fertilizers at village level. But in the last few years IFDC has chosen to work with RAB and Local Governments in delivering its services reportedly as a way of ensuring sustainability of the services offered – an innovation that is highly appreciated by MINAGRI. One such engagement is with partnering with RAB on training and guiding farmers on fertilizer use through setting up and operating of demo sites for fertilizer use. The demonstrations are now managed and operated jointly by IFDC, RAB and lead farmers.

Role of the SPAT2 programme

Another innovation considered very instrumental in aiding farmers under the fertilizer use programme by MINAGRI has been the establishing and operating of the farmer field school (FFS) concept at village level, led and supported by SPAT2 project. FFS facilitators, who are practicing farmers, have been given hands-on training by SPAT2 in fertilizer handling and application including establishing of demo sites allowing farmers to teach fellow farmers readily. FFSs have been set up across the country and according to MINAGRI, they have been a resounding success in disseminating fertilizer use among farmers. Among key innovations from SPAT2 that are thought to have aided the smooth implementation of the fertilizer use programme are:

- Empowering farmers through practical training on handling and application of fertilizers along with the general crop husbandry practices
- Setting and providing forums at which farmers meet and discuss challenges and solutions to the challenges faced.

Role of TUBURA (One Acre Fund)

TUBURA is considered as a service provider and key partner with RAB in the implementation of the CIP programme. It is a private organization involved with the importation, distribution and support to agro-dealers and farmers in the fertilizer use business. TUBURA is involved across the whole value chain of fertilizer use; from importation and distribution, to supporting of agro-dealerships and farmers in application of the fertilizer. TUBURA provides fertilizer, knowledge and skills and financing to agro-dealers and farmers to help with increased uptake of mineral fertilizers.

TUBURA has set up what are known as 'farmer promoters', one for each village to promote the use of fertilizers for increased crop production. The farmer promoters are trained in basic farming skills and given hands-on experience in fertilizer use and application skills, and incentivized to share this knowledge and skills with their fellow farmers. TUBURA has partnered with Government at both local and central government levels to foster delivery of extension services linked to increasing fertilizer uptake as a solution to the challenge of falling productivity. Among key innovations from TUBURA that are thought to have aided the smooth implementation of the fertilizers are:

- Giving agro-dealerships financial and technical support for management of fertilizers and other inputs.
- Training of agro-dealers as primary service providers for the fertilizer use programme.
- Support to farmers through 'farmer promoters' and extension of credit for purchase of inputs.

5.2 Challenges and opportunities of crop production under the CIP programme

5.2.1 Socioeconomic impacts, opportunities and challenges

Production systems: Agricultural production activities remain the dominant source of employment and livelihood sector, with 88% of the adult population engaged in agriculture production related activities. Although predominantly smallholder scale, the efforts over the last 10 years since the inception of the crop intensification program have seen an increasing number of farmlands consolidated and a number of farmers producing for both subsistence and marketing as opposed to past predominantly subsistence focus. Farmers are more organized and belong to functional cooperatives and producer groups which are linked to markets. The subsidized low prices of inputs and the facilitation of supplying inputs through the program have eased the access to inputs by farmers in the country. The challenge is whether rural poor farmers will continue to have ready access as the subsidy levels for key crops is reduced when other factors of production such as water for production (irrigation), climate change impact (rising temperatures), lack of ready access to extension services, and environmental challenges have not been adequately addressed to allow the poor farmers to reliably depend on their own production to support purchase of required inputs.

Food security and nutrition: There have been great improvements in food availability over the last 10 years since crop intensification programme. There were significant improvements in cereals and roots and tubers production output. The production of beans, a key protein for household nutrition, was also reported to have increased by over 200% in year 2010 when compared to after the war in 1994. Banana, sweet potato and sorghum are highly important crops for Rwandans historically. However, they show less sharp increases from 2007 as the CIP focused mainly on cereals, pulses and cassava until recently when bananas has been brought in the programme. Nevertheless, these crops remain at the core of the food basket for rural Rwanda. Review of the MINAGRI crop assessment reports indicates positive transition from food insecurity to increasing self-reliant country in food availability.

Household Nutrition: The combination of improved production in crop and animal related products has improved the availability of energy and had a positive impact on food security, measured in terms of availability. Most importantly, Rwanda has experienced an increase in kcal/person per day since 2008; this continued to improve with significant increase in availability of dietary protein, although there remains significant challenge with nutrition as a sizeable segment of the children and lactating mothers are faced with malnutrition. The DHS (2010) reported that 44% were stunted at the time of the survey, 3% of were found to be wasted and about 1 in 10 children (11%) were underweight. The figure of stuntedness is reported to have reduced to less than 40% by 2014 but this still represents a significant number of children that are malnourished.

Agricultural growth, poverty and hunger: Poverty in Rwanda is largely a rural phenomenon where still over 80% population resides. The EICV 4 survey (2013/14) shows that poverty is at 39.1% as of 2013/14, down from 44.9% as of 2010/11. During the same period, extreme poverty dropped from 24.1% to 16.3%. Household incomes are largely a function of landholdings, with 74% of households who own less than 0.3 ha falling below the poverty line compared to 54% of those households who own more than 1 ha. Only 26.6% of the households in Rwanda own more than 1.0 ha of land and the average size among this group is 1.94 ha. Generally the progress in poverty reduction is excellent but many challenges remain including having a significant portion of the population that is living in poverty, in poor living conditions, cannot readily access quality education and have no formal employment.

The high population growth rate of 3% per annum also poses a serious challenge in adequately addressing some Sustainable Development Goals; with poverty affecting the already struggling rural areas more than it does affect urban areas.

Another challenge is that although Rwanda has made tremendous effort in women emancipation, rural women-and child-headed households are generally still faced with risk of being poor especially so in the rural areas.

5.3 Financing of fertilizer use programme

An important component of the entire fertilizer business management is the financing. GoR is responsible for financing the implementation and operations of the CIP programme in as much as the management of CIP, cost of managing and providing public extension services, and for the subsidy to the farmers for purchase of fertilizer. Prior to 2013, MINAGRI imported fertilisers for the CIP program on its own account, and then auctioned the fertilisers to local distributors who had regional distributional monopolies through agro-dealerships covering several Districts. The default design in the arrangement was that distributors who won bids were only expected to pay 30% of the value of the bid upfront with the balance paid after receiving payments from farmers. Therefore in addition to providing a subsidy GoR also financed the fertiliser distributors. The arrangement was meant to ensure that the distributors also offer credit to agro-dealers and, by extension the farmers who would receive fertilizer on credit and only pay for the fertiliser after selling their crop. However, by 2012, a backlog of credit to the tune of $20 million was unpaid (IFDC 2014). Moreover, the chain of extended credit also led to loss of information over who had and had not paid, and to date MINAGRI is still making recoveries on this debt.

Government also used an unilateral price determine to ensure fairness of the price at which farmers purchases the fertiliser. The benchmarking of the price was done in a manner that allowed distributors and agro-dealers to have sufficient mark-up to recoup their investments and pay back their credit. However, this too inadvertently created an incentive for postponement of payments in case the price set reduced the competitiveness of distributors and agro-dealers. Since 2013, a more liberalised approach is pursued and MINAGRI only pays a subsidy on the imported fertiliser with clear and discrete roles for private sector and government.

Whereas there are initiatives to provide financing through the Development Bank of Rwanda, National Bank of Rwanda, Rwanda People's Bank and a number of micro-finance banking institutions (Credit and Saving Scheme: CSS, Agaseke Micro Finance, etc.), the arrangements are now negotiated between the different supply chain actors and the financial institutions. Some of the actors such as TUBURA are able to also access aid funding through United States Agency for International Development (USAID) to provide credit for their importation and distributional costs which can be recovered after farmers have sold their produce (*Figure 14*). The other supply chain involves private importers linking directly with agro-dealers and/or through wholesalers who have a network of agro-dealers.

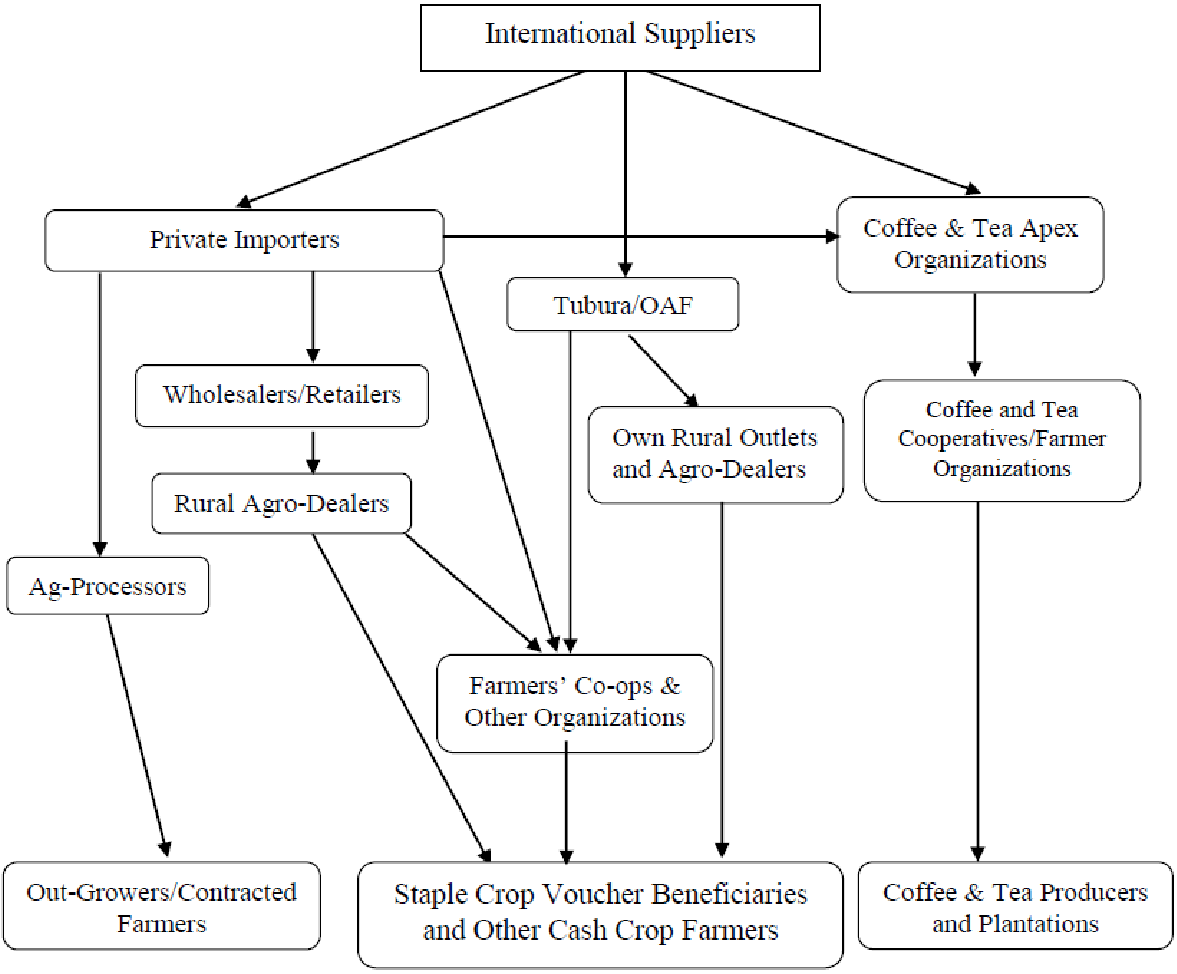


Figure 14: Flow of Fertilizer Distribution in Rwanda (2013)

Source: IFDC (2014)

In 2015 the direct public cost of the CIP was RWF 6.0 Billion for the subsidy; RWF 0.35 Billion for Research and Extension; and RWF 0.5 Billion for management of the fertilizer use programme (MINAGRI/RAB, 2016). The BNR has been operating a funding system where it makes available to the prequalified fertilizer importing and distributing firms and agro-dealers, more than 50% of the needed funds through affordable loans. The traders can then approach BRD or BPR funds for the remainder of the needed funds. Agro-dealers and farmers usually depend on microfinance institutions at district and sector levels. Financing is key to enhancing fertilizer use as the required amount around which the fertilizer business is running is extremely high, and farmers normally do not run cash based production systems requiring credit to purchase fertilizer for their crops. For instance, in 2007 A and B seasons, that amount was estimated to more than RWF 15 Billions.

The following financial institutions are involved with the financing of the CIP programme: Development Bank of Rwanda, National Bank of Rwanda, Rwanda People's Bank and a number of micro-finance banking institutions (Credit and Saving Scheme: CSS, Agaseke Micro Finance, etc).

These public financial institutions are also required to operate in rural areas, and can be found operating in the remote rural areas, close to smallholder farmers. It is important to note that the follow-up and the recovery of agricultural related loans remain problematic as the cost of borrowing or capital remains high and the crop failure rate remains high due to erratic weather (Naramabuye et al., 2008). Different institutions have different rates – but in terms of interest the farmers reported that the interest rates are about 20% and mostly much above that rate. To enhance access to agricultural production funding and improve on the recovery, the Development Bank of Rwanda is reported to have embarked on training of distributors, Microfinance Institution staff and farmers cooperatives managers, and on a farmer awareness campaign. These interventions focussed on basic skills such as: bank operations, loans acquisition and provision and loans recovery.

5.4 Environmental impacts, opportunities and challenges

a) **Environmental opportunities for fertilizer use**

Increased fertilizer use agricultural production related environmental problems in Rwanda. When soils are highly mined of plant nutrients as is this case in Rwanda owing to the high population and limited arable land. Current agricultural practices mine soil nutrients, with average removal of more than 30 kg/ha/year of nitrogen (N), phosphorus (P), and potassium (K). Organic sources are not sufficient to replace these nutrients. Increasing inorganic fertilizer use, consistent with agronomic recommendations and integrated soil management practices, will have few if any adverse environmental impacts, and many positive impacts, if used wisely. Increased inorganic fertilizer use would benefit the environment by reducing the pressure to convert forested hillsides and the ecologically fragile marshlands to agricultural uses and, by increasing biomass production, help increase the organic matter content of the soils. The organic material supplies and helps retain soil nutrients if recycled and worked in the soil.

Inorganic fertilizer and sustainable agriculture intensification can reduce pressure on forested hillsides and the ecologically fragile marshlands. Sustainable agricultural intensification does not only provide opportunities for increased employment and income enhancement, but also provides critical opportunities to protecting the environment, especially by reducing the pressure on farmers to push onto more fragile lands or to rely on labor-intensive gathering activities off-farm.

Increased biomass resulting from fertilizer use can increase soil organic matter. The increased inorganic fertilizer use is expected to result in increased crop residues, of which a significant proportion is left on/in the soil, raising its organic matter content. This serves to protect the soils from erosion, and allows for improvement in soil structure as well as replenishment of some nutrients, especially micro-nutrients, on decomposition. However, the low yields coupled with Government's programme for giving poor households with cows and the rising demand for fuel, has put more pressure on the crop residues owing to its use for fuel, fodder, and building material. These demands will certainly continue, but with higher yields from inorganic fertilizer use, some residues can remain on the soil.

Improved soil management. One of the key objectives and major activities that have been implemented under the CIP has been the control of soil erosion using terraces. This is critical given the rugged terrain of Rwanda, and the fact that with pressure of land farmers have increasingly taken on the hillsides for production. This will abate soil erosion and hence the leaching of plant nutrients and thereby increase fertilizer use effectiveness.

b) **Environmental challenges and impacts of fertilizer use**

Extensive literature review and examination of technical reports on Rwanda agriculture crop intensification programme impact, including review of the fertilizer use programme and activities, revealed limited information on environment impact of such activities. However review of Africa wide studies on environmental and management measures of agricultural intensification and production systems reveals a fair amount of information where a good deal of it also reflects on the obtaining situation of potential risks imposed by crop intensification in Rwanda.

It is an established fact that a significant proportion of applied nutrients will be lost without being taken up by the target crops, especially if the soils don't have the capacity to hold and keep the nutrients added to a depth and in time and in a form that crops can continuously and efficiently assess the nutrients. The potential risk here is that a significant proportion of the added nutrients will be lost, which is not only an economic loss, but will also negatively impact the environment especially in polluting of both the underground and surface water sources. This in the long run undermines the capacity of the soils to sustainably support the production of food and fibre and also impacts other ecosystem services. In the tropical environments, such as that of Rwanda, it is also a known factor that significant quantity of nitrogen fertilizer will be volatilised on application even before the crop assesses it, and adds to the Green House Gases (GHGs).

Inappropriate fertilizer use resulting from farmers not raising the level of other management practices (variety, tillage, crop establishment, pest control) in balance with fertilizer use, or not following recommended agronomic practices, also poses significant risk to the environment. Application of fertilizer based on inappropriate rate, manner, quality/form, and time, poses environmental risks. As long as complementary integrated soil management practices are followed (including incorporation of organic matter, timely and appropriate placement, and water harvesting and management). Given the relatively low understanding of farmers with regards to environmental negative impact of fertilizers when inappropriately used, there is a need of focusing on bringing farmers to a level of comprehend the risks around non environmentally friendly use of fertilizers. Strategies may include: introducing a policy in this regards, creating ownership of the idea for all stakeholders, establishing policy implementation measures at all the hierarchy level up to the farmers using MINAGRI and RAB resources.

The application of fertilizers in excess of crop uptake results in potential pollution. Until up to recently when RAB and IFDC produced soil nutrient maps (*Figures* 3 to *7*) farmers were using a uniform rate for different farmlands under CIP across the country, leading to potential application above the required amount with excess fertilizer lost to the environment, more so where particular elements are naturally at sufficient levels as indicated for some areas in the *figures* 3 to *7*. On the other hand underuse would lead to excessive soil nutrient mining where the nutrient gap for nitrogen, phosphorus and potassium, among other nutrients exists. The excessive nutrients are linked to the increasing pollution status of both underground and surface waters as significant contributing factor. High levels of nitrate is also likely to be experienced, especially in light-textured soils with high fertilization and/or manuring rates, particularly in areas subject to high rainfall or intensive irrigation, and on organic soils drained for agricultural use.

Key environment impacts can be considered at three stages of the production cycle including impacts during the pre-production activity; production activity and post production activity.

a) Pre-production activity

Land degradation and erosion: Land clearing exposes land to physical and chemical degradation, as well as contributing to air pollution. Key environmental concerns are over-cultivation and tillage of degraded and marginal lands. These activities damage the soil structure, expose the farmlands to soil loss through erosion processes and reduce water retention capacity. In Rwanda clearing of vegetation on the hillsides will certainly exacerbate the wind and water erosion on sloping uplands with loss of nutrients.

Loss of wild biodiversity, both off-farm and on-farm: Cropland expansion, cropping intensification and repeated plantings negatively affect wild biodiversity, directly through removal of vegetation, trees; habitat loss, and or pesticides killing non-target organisms, as well as indirectly by disrupting the trophic ecology, breeding cycles and destroying habitats of sensitive species.

Loss of food crop genetic diversity: With the emphasis on crop intensification the CIP programme was focused initially to only four crop species, and more recently only up to 10 crop species that will benefit from proposed interventions including fertilizer use. With the 10 crops based on 'high quality' planting materials that may not have been ably adopted to local ecological conditions. The crop intensification has also reduced agro-ecosystems by removing trees or intercrops from farmlands, and switching from production of multiple locally-adapted and genetically diverse crop landraces or varieties with a smaller number of modern varieties reduces local agro-biodiversity. During the course of this assignment there were already reports of cases of increasing vulnerability to drought - like the case of maize, pest infestations - like in the case of cassava currently, as well as other abiotic or biotic threats.

Climate change and air pollution: GHG emissions (such as CO_2, CH_4 and N_2O) from crop fields tend to increase with increased crop intensification, especially when the potential sinks for such gases are converted to food producing lands as is the case with Rwanda. CO_2 emissions arise primarily from land conversion (releasing C), soil tillage (releasing soil C) and burning of fields and crop residues which releases both GHGs and particulate air pollution. Other major GHG sources are more crop- or system-specific: CH_4 emissions are primarily associated with flooded rice fields and livestock, and N_2O emissions arise from N fertilizer application.

c) Production activity based impacts

Soil nutrient depletion ("nutrient mining"): Rwanda soils, like most of places faced with high population pressure, are faced with enormous farming pressure leading to repeated use of land with no or only limited rest/fallow periods leading to excessive nutrient mining. This has led to negative nutrient balances, with extraction losses occurring faster than the replacement of nutrients. This is worsened when food crops are integrated into intensive repeated sequences and rotations with inadequate nutrient management associated with socio-economic circumstances that afflict farmers and the limited technical options (such as access to new locally adapted crop varieties) - preventing adequate replenishment of nutrients on depleted soils.

Soil and water contamination: Excessive applications of synthetic nutrients can accumulate in and acidify soils, and / or as runoff of the excess nutrients accumulate in rivers and lakes and leach into groundwater. As shown in *figure 6* above, there is already a growing concern with the increasing acidity levels across over 25% of the country requiring amelioration with lime. This problem is expected to grow as use of mineral fertilizers intensifies. Overuse of synthetic N is also a major source of GHG emissions associated mainly with tropical conditions and rising temperature linked to climate change. Also overuse or improper use of agrochemicals in crop intensification systems poses risks to human safety and health (via poisoning) and can further contaminate soil and water, in addition to being an inefficient use of scarce farm resources.

Water depletion: Drought and water shortages represent significant constraints to yields in Rwanda, especially with increasingly erratic and unreliable rains – which droughts and unreliability of the weather predicted to increase both in severity and the areas that are drought-prone. The solution is for Rwanda to increase the proportion of farmlands under irrigation.

Rice production related environmental impacts: Most of Rwanda's rice production takes place is largely extensive low-productivity system in flooded ecologically important lowland/wetland and fragile ecosystems. The relatively recent introduction of formal irrigation into rice production in Rwanda has been linked to dramatic increases in rice productivity as indicated in *Table 13* above. Although intensification also entails impacts such as chemical runoff and GHG emissions, such impacts have received little empirical attention in the published studies to date.

Maize production related environmental impacts: The environmental impacts of maize cropping in Rwanda largely relate to land consolidation programme and fertilizer use with a good level of land clearing and intense tillage, which makes them prone to soil erosion, nutrient depletion and biodiversity loss. Because maize has become increasing popular food security as well as cash crop in Rwanda, these effects will be widely experienced where appropriate environment management measures are not put in place.

d) Post-production activity

The environmental and productivity-related impacts of land-use decisions are not only direct, but also systemic and cyclical in nature. For example, in addition to the intrinsic lost value of wild biodiversity, impacts stemming from land-use decisions may also inhibit provision of valuable ecosystem services such as pollination and pest control, with implications for future crop production.

The only major study on the environmental impact of fertilizer use in Rwanda is that conducted by Green World Consult Limited (GWCL) in 2014 for REMA on the 'Impact of fertilizer use on the Rweru-Mugesera lakes-wetlands complex'. In addition, there are a few reports on the routine assessment of the pollution status of major rivers and wetlands system in Rwanda, that lend credence to the reflection of the impact of lost agricultural origin nutrients impact on the environment. The Rweru-Mugesera study found that as a result of nutrient losses from the fields, surface waters had levels of chemical species related to the three macronutrients commonly used in fertilizers (N, P &K) significantly beyond the natural water standards used. The routine assessment of pollution status of major rivers in Rwanda by the Rwanda Natural Resources Authority (RNRA) has also indicated increasing pollution levels of a number of water bodies, a phenomenon associated with agricultural nutrients leaching and runoff.

5.4 Capacity and capacity gaps for improving fertilizer use in Rwanda at both farmer and national levels.

5.4.1 Assessment of the existing management structure for fertilizer use

The key policy agency for the CIP and in particular the fertilizer use programme is the Directorate of Agriculture in MINAGRI managed by the Director General for Agriculture together with technical and policy oversight of other national agriculture plans, programmes and projects. CIP implementation is by the Rwanda Agricultural Board, one of the three directorates of MINAGRI under the guidance and management of the Director General of RAB. Review of the management structure including offices and attached responsibilities showed that implementation of CIP key activities are spread through the various departments of RAB with some specialized offices such as that one responsible for coordinating the importation and distribution of fertilizer; or irrigation development; and that for soil conservation and management. The aspects of research fall within the Department responsible for research in RAB. The analysis also showed that there was no specific office responsible for environment management of CIP neither in MINAGRI nor in REMA. Implying that planning, coordinating and monitoring of implementation of environment management plans linked to implementation of CIP is not provided for either in MINAGRI as the proponent or within REMA, the body charged with management of the Environment Sector.

5.4.2 Assessment of the technical capacity for management of fertilizer use programme

With restructuring of the government agencies in Rwanda to make Government more responsive and in lieu of the decentralized services, a number of units and MINAGRI were significantly reduced – in many cases to one or a few technical persons at the central level yet not all the services could be provided for at the local government level to fully take control of the responsibilities expected of programmes such as the fertilizer use programme. *Table 29* shows a review of the key staff positions and staffing levels, as well as the critical staffing gaps for fertilizer use programme management together with the associated support programmes and offices under the CIP responsible for ensuring fertilizer use efficiency and sustainability. Key areas that the Consultant considers to require extra focus in terms of staffing are water use efficiency and research. Although there is an existing department in RAB for Land husbandry, Irrigation and Mechanization (LIME), it is the considered opinion of the Consultant that LIME has focused largely on soil conservation and irrigation expansion and not much on improving soil fertility, water use efficiency and conservation. Given the limited resources to expand irrigation (which is projected to be only 75,000 ha out of existing farmed 2 million ha by 2020), there is need to focus on improving water use efficiency through water conservation methods – approaches that can be adopted by a lot more farmers and cover a much wide area than the pace at which irrigation is expanding. This will require two more critical positions in LIME including water use engineer and water conservation specialist. Another key area considered vital for efficient and sustainable implementation of the fertilizer use programme is the generation of research technologies and information. The mandate for agricultural research lies with RAB. Key areas found crucial for ensuring efficiency and sustainability of the fertilizer use programme under the research ambit are soil nutrient assessment, monitoring and mapping; environment management and monitoring of fertilizer use (can be implemented in close partnership with REMA or District Environment Office); and although already being undertaken there is need for more crop performance assessment and monitoring.

Table 29: Technical capacity analysis for the fertilizer use and other related programmes under CIP

Key functions related to fertilizer use programme	Key Player	Organization Department or unit	Current Staffing level	Areas found lacking
Agrochemicals use managemen	RAB	Fertilizer Use Programme	• 1 Fertilizer Use Programme Manager and Coordinator	▪ Agro-chemical specialist (1) ▪ Agronomist (1) ▪ Agribusiness specialist (1)
Seed availability and quality management	RAB	Seed Programme	• Crop Protection Specialist	▪ Seed quality specialist (4), one for each of the major food security crops ▪ Consideration of setup of National Seed Certification Board or Committee
Land husbandry & improved water use services	RAB	Land Husbandry, Irrigation and Mechanisation (LIME)	• Head of Department • Irrigation specialist • Land husbandry specialist • Agricultural mechanization specialist • Administrative Assistant	▪ Water use engineer ▪ Water use efficiency specialist (1)
Extension Service provision	RAB	Extension	▪ 3 Senior Management at RAB headquarters ▪ 4 Directors of Extension at zonal level ▪ 90 Technical Managers /Extension Service Providers operating at zonal level with 3 for each district	▪ Considered adequate
	District	Agronomy	▪ 30 District Agronomists – one for each District ▪ 416 Sector Agronomists – one for each Sector ▪ 2,148 IDPs with one for each cell	▪ Assistant Agronomist responsible for CIP (2)
	Farmer level	FFS Facilitators	-80,000 facilitators	▪ FFS teams should be crop focused
		Farmer promoters	14,000 promoters	▪ Considered quite innovative but need to

Key functions related to fertilizer use programme	Key Player	Organization Department or unit	Current Staffing level	Areas found lacking
				be one for each major crop in each village
Generation of Research Technologies & Information	RAB	Crops production and food security	6 Research Fellows with those relevant for fertilizer programme as: ▪ Crops production Research Fellow ▪ Natural Resources Management Research Fellow ▪ Socioeconomics Research Fellow	▪ Soil nutrient monitoring and mapping Specialist (1) ▪ Environment management including monitoring ▪ Crop performance assessment & monitoring

5.4.3 Farmer knowledge of fertilizers for effective and efficient utilization

According to the current GoR arrangement, the mandate and responsibility for extension services and guiding of farmers lies with the local governments with the central line agencies, specifically RAB, responsible for technical backup of the responsible local government offices. To this effect RAB under the 'Crop Production and Food Security Department' has a Directorate of Agriculture Extension that is responsible for working with local governments to ensure increased efficiency and effectiveness of agriculture extension services in the areas of crop production, crop protection and postharvest activities. According to the structure of RAB there is one senior manager referred to as Crop production and extension specialist that oversees four zonal offices (northern, southern, eastern and western), that have technical staff supporting the respective districts in four zones. Directorate of Extension is also charged with implementing government strategies for preventing and controlling plant diseases, insects and pests; as well as monitoring and controlling agricultural production and trade activities. This implies that Directorate of Extension is also charged with implementation and controlling the CIP activities.

The Central Government Structure for delivery of extension services was reviewed and found to be adequate. However, as indicated in *Table 26* above the analysis showed that the capacity at local government was too limited to sufficiently support the farmers. Government's decision to involve other players in extension beyond Government Technical Managers was found to be very innovative, including use of farmer promoters and farmer field school approach with facilitators in nearly each of 14,000 villages. The Consultant however is of the view that this should be expanded so that the focus goes beyond the village and is set at having an FFS facilitator and a Farmer Promoter for at least each of the 10 key food security crops for each village depending on existing of production activities for respective crops. The goal of extension services should be raising the level of knowledge and exposure of farmers, one which may not be always ensured through the classic government extension service, but under a mixture of methods involving both government and non-government approaches with regular monitoring and evaluation to adjust to the ever changing needs of the farmers.

Table 30 below gives the number of extension workers associated with the CIP programme and by extension the fertilizer use programme. Glaringly missing is the ambit for environment management at all levels. For fertilizer use programme to be sustainable, it needs to adequate provide for environment management so as to get farmers to adopt environmentally agricultural production practices. Mitigating nutrient loss and adopting measures that increase the retention of nutrients while allowing for more uptake by crops is not only good for the environment but it saves farmers money, increases productivity and allows soil fertility improvement. It is therefore the strong recommendation of the Consultant that fertilizer use programme works closely with agencies responsible for environment sector to sensitize and train farmers on use of environmental friendly agricultural practices involving use of synthetic fertilizers. This is especially critical as fertilizer use is expected to grow from the current 30 kg/ha to nearly double within the near future.

Table 30: Number of persons involved with extension under CIP/fertilizer use programme

Agency/Organization	Category	Number
MINAGRI/RAB	CIP Programme Management	15
	Technical Extension workers	90
Local Government	District Agronomists	30
	Sector Agronomists	416
	IDPs	2148
Private Sector /NGOs	Agro dealers	916
	Farmer Field Facilitators	1,883
	Farmers promoters	14,098

5.4.4 A review and description of policies for importation of fertilizers into Rwanda, and recommendations for ensuring policy consistency

From analysis of the data from MINAGRI on fertilizer use, Rwanda's fertilizer consumption reached nearly 60,000 tonnes of fertilizer in 2015 from just above 4,000 tonnes in 1998. This increase in fertilizer use is majorly linked to GoR's policy for crop production intensification that commenced in 2007 to improve agricultural productivity and production in effort to address the challenge of food insecurity.

This impressive rise in fertilizer consumption and resultant impact is attributed to the crop production intensification policy (CIP). The CIP was aimed at increasing consumption of the productive inputs, principally the use of quality seeds and synthetic (inorganic) fertilizers; increase water use by investing in and improving irrigation; and consolidation of the land under production by bringing the fragmented farmlands under sizeable production lots for specific target crops as well as developing marshland and hillside land use for agricultural production, all as a means of increasing production to ensure food security. The main objective of the CIP policy therefore was to boost agricultural productivity through an improvement of productive inputs use, irrigation coverage and soil quality management. *Table 31* provides an outline of the investment areas (principles) of the CIP policy, the associated target actions and outputs, and forecast investment costs of the CIP as proposed by MINAGRI.

Table 31: Rwanda Crop Intensification Program in the agricultural crops sector

Target Action Cost	Target Actions	Cost (RWF) '000
Sustainable management of natural resources, water and soil husbandry	• 852000 ha of additional land protected against soil erosion, using radical and progressive terracing • 70 new valley dams and reservoirs constructed	158,571,429
Marshland development	• Additional 9000 ha of marshlands developed	41,188,900
Irrigation development	• 13000 ha of hillside area irrigated (increased from 130 ha) • Legal provision for water user associations and tenure for irrigation systems created.	131,190,000
Supply and use of agricultural inputs	• 56000 MT national fertilizer usage (increased from 4,000 MT) • 15000 MT production of founded seeds (increased from 3000 MT) • Crop Intensification Program expanded	215,690,211
Food and nutrition security and vulnerability management	• Average availability per day increased from 1,734 kcal to 2150 kcal, 49 g to 55g of protein 8.8 to 23g of lipids • Food and nutrition security monitoring system expanded • 1000 hermetic storage cocoons operational	17,700,000

Source: Cantore (2013)

From the production status it is evident that CIP policy has been successful in boosting Rwanda's food production and increasing the country's self-reliance in terms of food security. The purpose of this review was to examine this policy as the basis for importation and use of fertilizer in Rwanda. To this effect the analysis finds that the CIP policy has been quite effective in boosting importation and consumption of fertilizer overall.

The questions in reviewing the CIP policy were whether the CIP is socioeconomically and environmentally effective, profitable and sustainable in a short term and in a long term perspective? We sought to establish if there or any consequences socio-economically or environmental under the current fertilizer use and importation arrangement based on CIP policy. *Table 32* shows that although there has been an increase in volume of fertilizer imported and an increase in use of fertilizer and quality/improved seed by farmers, there are still challenges with the majority of farmers not able to access these inputs. Whereas the GoR has moved from public sector based importation of agro-inputs to privatized supply and distribution of inputs, which has significantly increased the availability, there are questions whether the majority of farmers even with the subsidy arrangement can readily access and use these agro-inputs.

For CIP to be sustainable it is important that the CIP includes in its target actions specific elements for enhancing the environmental quality and contributing to revamping of the natural resource base for agricultural production by integrating agricultural production with natural biological processes. The CIP will need to expand measures and actions for increasing agricultural production to include integrated soil fertility management. Use of synthetic fertilizer should include measures to limit the leaching and loss linked to excessive hydrous soil erosion. To the credit of the CIP policy, there have been increased measures to curb soil erosion, especially the use of terraces. However, there is need for policy to be reviewed to actively promote the use of other sustainability measures such as Agroforestry, reduced tillage, improved fallow, use of grass bands and others, beyond the current level – as the level of importation and fertilizer use increases.

There is always fear that push for crop intensification by using one or two measures (inorganic fertilizer use, quality seeds and land consolidation), whereas it may bolster the agricultural productivity in short to medium term, such efforts may result in soil degradation in the long term. Efforts under CIP to develop water for production through expanding irrigation is also moving towards the right direction, but given the limited resources emphasis though should be on improving water use efficiency through promotion of farm level water conservation measures. It is therefore the recommendation that further enhancement of agricultural productivity and self-reliance in food production and security in Rwanda must be based on incorporating environmental sustainability interventions discussed above into the planning process and target actions for crop intensification to ensure investments are adequately allocated such that agricultural practices are sustainable and that yields do not decline in order to minimize negative environmental impacts, such as water pollution. This will not only allow for environmental sustainability but is also seen as crucial in improving the efficiency and effectiveness of the fertilizer use and other measures under the CIP.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Rwanda's fertiliser incentive programme was founded on the low crop productivity experienced in the 1990s and the early 2000s. Targeting of food crops under the CIP was intended to improve both food security and also create prospects for trade, given that food crops contributed 86.2% of the agricultural GDP at the outset of the programme.

The use of inorganic fertilisers was justified by the high soil nutrient mining levels on farms. Rwanda was ranked highest in soil mining for phosphorus and potassium in a study of 13 African studies and the mining of nitrogen was also among the highest (Chianu and Mariura 2012). Estimated rates of net nutrient depletion are high, exceeding 30 kg of nitrogen (N) and 20 kg of potassium (K) per hectare of arable land per year in Ethiopia, Kenya, Malawi, Nigeria, Rwanda, and Zimbabwe (Stoorvogel et al. 1993). Several studies conducted in the early 2000s (Meyers et al. 2004) also pointed to strong prospects from increased inorganic fertiliser use. By the end of 1990s, Rwanda was one of a few countries in Sub-Saharan Africa, alongside Tanzania, Mozambique, and Niger, where nutrient depletion accounts for 12% or more of the agricultural share in GDP, indicating nutrient mining as a significant limitation to economic growth (Drechsel and Gyiele 1999).

In the early 2000s, Rwanda had a mixed system of fertiliser import and use dominated by small dealers and some government fertiliser imports mainly targeting the cash crops like tea and coffee and some also for food crops. The CIP was out-rightly conceived for crops with the initial target crops including maize, wheat, rice, bush beans and Irish potato. The programme has subsequently increased to cover eight crops, including cassava, fruits, vegetables, and bananas alongside the five primary crops of maize, rice, beans, wheat and Irish potato. Combined Nitrogen, Phosphorus and Potassium (NPK) fertilisers were the main fertilisers imported in the early 2000s, therefore, the CIP programme enhanced NPK imports and also boosted Urea (Nitrogen) and DAP (Phosphate) imports. The supply chain was initially dominated by direct government imports but since 2013 the government is increasingly working through private (NGOs and private sector) service providers.

A comparison of fertiliser use and recommended fertiliser application rates suggested that the nitrogen and potassium levels were still below the recommended rates, although the levels of phosphorus were closer to the recommended levels. Indeed, the phosphorous applications in 2010, 2011 and 2013 did exceed the recommended levels for the farmers who were beneficiaries of the fertiliser incentive. The increase in use of phosphorous may have been simply reactive to poor crop characteristics; such as stunting or poor leaf colour in the previous season. Whereas the annual soil nutrient depletion was 60, 9 and 11kg/ha of nitrogen (N), phosphorous (P) and potassium (K), the annual average application rate by 2013 was 27, 35 and 7 for N, P and K.

Given the ragged hilly nature of the farming landscapes in Rwanda, and other factors such as population growth and reducing agricultural land, there is increased farming on steeply sloping soils that are acidic, deficient in organic matter and phosphorous (Killebrew and Wolff

2010; World Bank 2014). Moreover, the steep slopes have low water retention capacity (Kelly et al. 2004) are likely to have contributed to higher application of phosphorous. Plants need phosphorus for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division. Phosphorus is a very stable element and moves only 1–5 mm from where it is spread. It binds quickly with soil minerals, so is unlikely to leach through soil except under high rainfall in very sandy soils. It is mainly lost from the soil by erosion when soil particles holding the phosphorus are blown or washed away (FAO 2003). For this reason and given the steep slopes, high binding capacity of the mineral and high risk of erosion, phosphorous fertiliser is likely to be lost through run suggesting a key role for actions to reduce nutrient runoff..

The general outlook of crop output and fertilisers suggested a positive and proportional relationship between increased inorganic fertiliser use and crop output. However, an examination of crop responsiveness to fertilisers as part of the nutrient use efficiency showed that though the relationship was generally positive both for aggregated crop output and for individual crops, the responsiveness was not as high as envisaged. The coefficients showing the percentage increase in output for every one-percentage increase in fertiliser use 0.35%, 0.84%, 0.14% and 0.18% for aggregate crop total, maize, rice and beans respectively, with weak significance for beans and rice. The response for Irish potato was negligible while that for wheat was not significant.

The gross margin analysis at farm level shows that farm level actions are built to create a more resilient system through intercropping, organic manure, and crop rotation among others. Aggregation at the national level includes the performance of farmers with little or no production enhancing inputs such as inorganic fertilisers, organic manure and improved seed, among others and this could have smoothened the results observed.

The value cost ratio (VCR) results showed that at subsidised prices the fertiliser use can be recommended for use with maize and rice, whereas the weak significance and lack of significance for beans and wheat means that more primary data and indeed research is needed to establish where these two crops (wheat and beans) seem to have high crop output response to fertilizer which though is analytically insignificant. Likewise the negligible but significant crop output response to fertilizers for Irish potatoes requires further research with consideration of more information such as existing nutrient levels for potato producing areas and information beyond farm level to capture the marketing/price dynamics of such a crop. There are certainly other aspects that influence profitability and viability such as efficiency in other economic, social and environmental factors and scale of production (CIMMYT 1988). Therefore, the results VCR here are best used rather as a reference.

The results of the BCR show that the farm-level production with inorganic fertilisers was viable with a BCR of 1.23. The BCR was estimates as the ratio of discounted benefits to discounted costs of fertiliser use, and the decision criteria indicates that an intervention is considered viable one the ratio of discounted benefits to discounted costs is greater than one., Therefore, production with fertilisers was not viable with a BCR of 0.32. The potential BCR holding other factors constant from increasing fertiliser use until the annual fertiliser input is exceeded would be 0.82. The 0.82 result indicated the long-term viability that would be attained by the fertiliser component of the CIP. The analysis of BCR at the national and farm level demonstrates the importance of complementary needed for the inorganic fertiliser programme to attain higher success. At farm level, the discretion of the farmers in the sampled Districts lead to viability. In a national programme, such complementary needs to be implemented by government.

6.2 Recommendations

6.2.1 Improving the effectiveness and efficiency of fertilizer use in Rwanda

- **Complementary practices.** Complementary agronomic practices (organic matter, nitrogen fixing legumes used in crop rotations, water harvesting, and erosion control) are needed in addition to inorganic fertilizers. The organic content of soils needs to be increased through residue management and other available sources to compensate for the lack of active clays in the soils.
- **Site-specific nutrient deficiencies.** Soil and water conditions vary greatly, but many nutrients are severely and widely deficient for good crop growth; fertilizer recommendations must be based on site-specific research results.
- **Low fertilizer use efficiency.** Low Nutrient use efficiency (NUE) should be considered as a constraint to the use of inorganic fertilizer, and improving the NUE should be a priority for research and extension system.
- **Fertilizer policies.** Policies on fertilizer use (subsidies, distribution) are key to soil fertility management, and need to be cross-linked with other relevant policies such as water development, environment management, and rural financing.
- **Development and dissemination of improved technologies & strategies** including improved varieties, environmentally friendly pest management (IPM); enhancement of environment attributes of smallholder cropping systems, which reduce environmental degradation and enhance the natural resource base; methods for improving nutrient status with natural and synthetic fertilizers; and research on new cropping systems which provide multiple environmental and economic benefits.
- **Enhancing the national research systems and capacity** to be able to continuously monitor the fertilizer use at all levels and guide on the soil nutrient gaps as well as related environmental concerns. It is also important to consider Rwanda collaborating with other regional players especially in East Africa to allow for resource sharing in a bid to generate appropriate technologies (Best Agricultural Practices) to non-fertilizer issues of agricultural production.
- **Benchmark long term fertilizer use efficiency studies** so as to use actual data from the Rwanda farmlands rather than proxies.
- **The Rwanda Agricultural Board (RAB) needs to urgently conduct research to update soil maps** that indicate the soil types and textures, in addition to the soil nutrient maps so as to guide on the appropriate holding and retention capacity of the soil nutrients.
- **Build on already existing fertilizer supply chain system,** MINAGRI and RAB, and create mechanisms allowing the smooth running of the fertilizer supply chain by the production and the market forces. Government is still heavily involved in management of the supply chain, situation which introduces management costs and limits free competition to effectively bring the prices of fertilizers down despite the subsidy. There is clearly

need for Government to complete transfer its roles in the supply chain for fertilizers to the producers and private sector, and only remain with quality assurance and regulation with the Government keeping an eye on the needed balance for the different forces involved to ensure especially the protection of the farmer and their key assets of production - land and environment.

- **Enhance the capacity for environment management at farmer level** including equipping farmers with environmental management knowledge and skills; ensuring farmers have farm level safe-guards such as personal protective gear, appropriate storage systems and preventive health measures against fertilizers; making farmers aware of direct impact of loss of nutrients to surface water systems and marshlands; and putting in place long-term chemical management and compliance monitoring system by MINAGRI and REMA.
- **Continuously assess the social and economic contributions** of fertilizer use to livelihoods and food security from production and productivity performance so as to follow the perceived benefits of farmers engaged in fertilizer use. This will require regular surveys of farming households under CIP, and requiring and training of farmers to capture the farm level production data.
- **Increase the numbers and capacity of agricultural extension officers** so that farmers received more support to improve fertiliser use and to increase the uptake of agriculture sustainability practices in general.
- **Put in place risk management and/or social protection measures** for crop failures, especially when input investments are made.

6.3.2 Future research priorities on fertilizer use in the context of Rwanda national development priorities and agricultural strategies

1. **Understanding the magnitude of nitrogen fixation** inputs and role of shrub legumes in upland hillside systems
2. **Updating the soil data** of the most important agricultural soils, especially: marshlands, terraced lands and eroded and deforested lands
3. Continuously **monitor the change in soil properties** in order to adjust fertilizer use and types
4. **Run adaptive research** to facilitate adoption of research results already available in RAB and the University of Rwanda.
5. **Conduct a critical assessment of the indigenous crop varieties** in order to promote them because they are better adapted to the Rwandan environment while integrating desired traits through establishment of a crop breeding programme.
6. **Investigate and quantify the impacts of fertilizers on ecosystems** and establish environmental friendly and integrated nutrient management recommendations for different crops.

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ANNEXES

Annex 1: About Assignment

Green World Consults Limited was contracted to undertake a study to assist the government of Rwanda (GoR) to improve the cost-effectiveness and ecological sustainability of inorganic fertilizer use from both the farm and national perspective. The consultancy is executed by the Rwanda Environment Management Authority (REMA) and the Ministry of Agriculture and Animal Resources (MINAGRI) while the contract was signed between Green World Consult Ltd. and the United Nations Development Programme (UNDP).

Proposed outputs

Proposed outputs to achieve the purpose and objectives of the assignment are:

1. Gathering available data from MINAGRI, REMA, MINECOFIN, National institute of Statistics and Compile an update of inorganic fertilizer use in Rwanda since 2004, including any trends at farm level use
2. Describe and analyse the state of knowledge in Rwanda on production use efficiency of fertilizers for main crops (Maize, Rice, Irish potatoes, Coffee), identify and document data gaps (including environmental variables). Recommend a detailed research programme for enabling such analysis to be undertaken in future for addressing the above gaps.
3. Determine the benefit-cost ratio (BCR) for main crops using existing data or establishing proxies, including fertilizer uptake and loss.
4. Describe and analyse the fertilizer distribution mechanisms positive and negative impacts at farm level. In particular describe and analyse the implications for household incomes and poverty reduction. Poverty should be interpreted in multi-dimensional sense. E.g. increased household income may improve health status and school attendance.
5. Identify current and future opportunities and constraints on improving fertilizer effectiveness on national and farm decision-marking levels. This includes improvements to general agricultural practices (e.g. and conservation agricultural practices used widely, the combination of organic and inorganic fertilizer used, adoption of Agroforestry, private sector engagement, and agricultural policy and extension strategies.
    a. National level decision-making includes institutional factors (institutions, policies, laws, strategies, programmes, capacity, decision making processes including coordination mechanisms and methodologies, extension services, marketing, cooperatives, financial resourcing etc.)
    b. Farm level decision-making includes choice of crops, livestock, agricultural practices, types and mixes of fertilizers etc.
6. Describe and analyse policies and policy coordination mechanisms relevant to the use and importation of inorganic fertilizer, and if necessary recommend enhancements to improve policy consistency with cost effective and ecologically sustainable fertilizer use, within the broader aim of achieving pro-poor sustainable agriculture outcomes.
7. Assess capacity in agriculture sector relevant to improving fertilizer use and broader agricultural physical and economic efficiencies. Include a substantial focus on agricultural extension services.
8. Provide recommendations for strengthening the effectiveness of inorganic fertilizes in Rwanda, in the context of broader agricultural practices, policies, and national agricultural and EDPRS II priorities. The recommendations should seek to:
    a. Maximize the crop nutrient uptake and economic efficiency of inorganic fertilizer use.
    b. Better technical knowledge of soil properties to guide specific fertilizer use and application practices recommendations
    c. Maintain or enhance soil nutrient levels using organic and inorganic fertilizers in the contact of integrated small-holder agriculture methods to enhance agricultural productivity.
    d. Adoption of evidence based environmental friendly use of inorganic fertilizer to minimize water, soil and atmosphere pollution
    e. Optimization of fertilizer use (application time, specific type, amount required,...)use fertilizer when, where needed
    f. Minimize potential negative human health impacts.
    g. Improve institutional capacity for the implementation of the study recommendations through policy reforms on the light of research results.
9. Prepare a policy brief of no more than six pages designed to persuade relevant decision-makers in agriculture sector, environmental sector, financial sector, parliament, cabinet and donor community that the study recommendations should be implemented.

Expected out puts

1) Update of inorganic fertilizer use in Rwanda since 2004, including any trends in farm level use.
2) State of knowledge in Rwanda on production use efficiency of fertilizers for main crops, identify and document data gaps (including environmental variables), described and analysed.
3) Benefit-Cost Ratio (BCR) for main crops using existing data or proxies, including fertilizer uptake & loss determined.
4) Distributional impacts (positive or negative) of current fertilizer and practices at farm level, particularly implications for household incomes and poverty reduction describe and analysed.
5) Current and future opportunities and constraints on improving fertilizer effectiveness on national and farm decision-marking levels, identified, described and analysed.
6) Policies, policy coordination mechanisms relevant to use and importation of inorganic fertilizer, recommendations for enhancements to improve policy consistency with cost effective and ecologically sustainable fertilizer use.
7) Agriculture sector capacity relevance to improving fertilizer use and broader agricultural physical and economic efficiencies, assessed (include a substantial focus on agricultural extension services).
8) Provide recommendations for strengthening the effectiveness of inorganic fertilizes in Rwanda, in the context of broader agricultural practices, policies, and national agricultural and EDPRS II priorities.
9) Policy brief of six or less pages for relevant decision-makers in the agriculture sector, environmental sector, financial sector, parliament, cabinet and donor community that the study recommendations should be implemented.

Deliverables

1. Present in synthesis form a Consultancy Report with key conclusions and recommendations of the consultancy on fertilizer use effectiveness and efficiency in Rwanda
2. Produce a policy brief to guide the necessary actions for review and strengthening of the fertilizer use programme

Annex 2: National Description of Characters and Features of Rwanda

LOCATION AND PHYSICAL CHARACTERISTICS OF RWANDA

Rwanda is located at 1°04' and 2°51' south latitudes, 28°45' and 31°15' east and shares its borders with the Democratic Republic of Congo in the West, Uganda in the North, Tanzania in the East and Burundi in the South. It is found in the southern west of the Lake Victoria basin as one of the Upper Nile River States. Rwanda has total surface area of 26,338 sq km; and is divided into two mains basins; the Congo basin representing 17% of the territory and the Nile Basin with 83%. Its relief comprises of a succession of several high and low hills and valleys – hence the reference to being a rugged terrain. More than 40% of the country is located on an altitude of between 1500 m and 1 800 m; and 90% of the national water resources are drained through the Eastern part by the main rivers Nyabarongo and Akagera. The surface occupied by lakes, rivers and marsh is 212,450 ha, approximately 8% of the national territory with lakes accounting for 128 190 ha whereby Lake Kivu alone accounts for 102 800 ha. The permanent Rivers have 7,260 ha whereas the seasonal rivers, marshlands and valleys make up nearly 170,000 ha. Rwanda is one of the highest populated countries in Africa with currently over 400 persons per sq. km, where nearly 90% of the populations earn their livelihoods from smallholder agriculture on an average landing holding of less than 0.3 ha per household.

CLIMATE

Rwanda has a temperate tropical highland **climate**, with lower temperatures than are typical for equatorial countries due to its high elevation. Annual rainfall ranges from 800 mm to above 1 600 mm, divided between two rainy seasons (March to May and September to December). The amounts of rainfall, falling in two wet seasons, are fairly high, in most parts of the country, but there is a persistent risk of drought especially the eastern region. The temperature is moderate highland equatorial averaging 16° to 23°C. Based on elevation, available rainfall and soils conditions, the country has been divided by Delepierre, 1982 into 8 different agriculture regions. Those regions include the Volcanoes Highlands, Buberuka North ridges, Buberuka foot ridges, Gikongoro, Lakes Kivu shores, Central plateau, Eastern lowlands and Kibungo. Further studies with fine resolution confirmed the similar farming patterns. And the country has been divided into 8 clearly distinct regions depending on crop production in term of calories, farming systems, staple crops and animals grown.

SOILS

The Rwandan pedology is characterized by six types of soils including those derived from physico-chemical alteration of schistose, sandstones and quartize formations (50%); from gneissic and granite formations making up 20%; soils from basic intrusion rocks, making up 10%; from recent volcanic activity materials, making up 10%; from old volcanic rocks, making up 4%; and from alluvial and colluvial soils that make up 6%. The underground earth contains deposits of minerals such as tin, wolfram, colombo-tantalite and gold. There are also big numbers of quarries (clay, sand, building stones, limestone, peat, etc). The Rwandan soils are naturally fragile, and the situation is heightened by the high cultivation pressure arising from the population pressure for which nearly 90% is dependent on primary agricultural production activities. Tilling of the soils exposes especially the hilly terrains and flood prone areas to hydrous erosion that affects a big portion of cultivated lands. Hydrous erosion causes yearly losses of over 15,000,000 tonnes of soil, an estimated 945,200 tonnes of organic materials, 41,210 tonnes of nitrogen, 280 tons of phosphorus, and 3055 tons of potassium across Rwanda due to inadequate soil conservation measures, impacting the country's ability to feed up to 40,000 people yearly (Twagiramungu, 2006). Other generic impacts of erosion are numerous:

- Loss of soil fertility due to leaching of arable land with its consequences on agricultural production;
- Increase of sedimentation downhill cultivated lands from eroded plots.
- Risk of crops destruction and silting-up in marshes and plains (areas that are more favourable to agriculture);
- Risk of local landslides and mudslides;
- Risk of irreversible leaching of soils. The hilly nature of Rwandan topography is one of the main factors of soil vulnerability.

Under CIP and other programmes in MINAGRI, a significant investment has been made over the last 10 years to put in place soil conservation and land management measures to curb among others the agricultural induced hydrous erosion – with resounding success.

AGROECOLOGICAL ZONES

Although Rwanda is relatively a small country it is characterized by a high degree of agroecological diversity caused by a number of factors of which the major one is its rugged topography. The Congo-Nile divide runs along Rwanda's western regioin at an average altitude of 2000m along its crest. The northern part of this mountainous range is even higher with the region known for its rich volcanic soils. The country becomes less mountainous but remains mostly hilly and rugged as it slopes down into the eastern plateau. The altitude drops to 1,200m in the eastern region forming savannah like system close to the Tanzania border. Closely associated with variation in altitudes is rainfall. Although their reports of increasing erratic weather the western region has more rainfall, and because of relatively higher altitude is cooler than the eastern region with rainfall ranging from 1,500 mm in the west to 900 mm in the east. The variation in environmental conditions across the rugged terrain has created different agroecological conditions across the country creating micro-climatic divisions that necessitate specific planning for efficient and sustainable agricultural production. MINAGRI identifies up to 10 key agroecological based largely on altitude, rainfall, soil type, and dominant production system

Although small, Rwanda is characterised by a relatively high degree of agroecological diversity, and has been divided in 10 regions differentiated by geographical, ecological and socioeconomic attributes. One of the principal causes of diversity is topography of the country. The Zaire-Nile divide runs north-south along the western border with an altitude of 2000 m at its crest. The north of this range is recognized for its high mountain ranges and rich volcanic soils. Going east word the country becomes less mountainous but remains hilly with high slopes – up to the eastern plateau. The altitude drops to 1,200m along the eastern border that can be characterised as savannah like. Change in altitude is also associated with change in rainfall pattern with rain much abundant in the western region than the eastern side. Rainfall varies from 1,500m in the western region to 900 in the eastern region. This variation has led to the policy makers agreeing to classification of the country into 10 agro-bioclimatic zones (Figure 22).

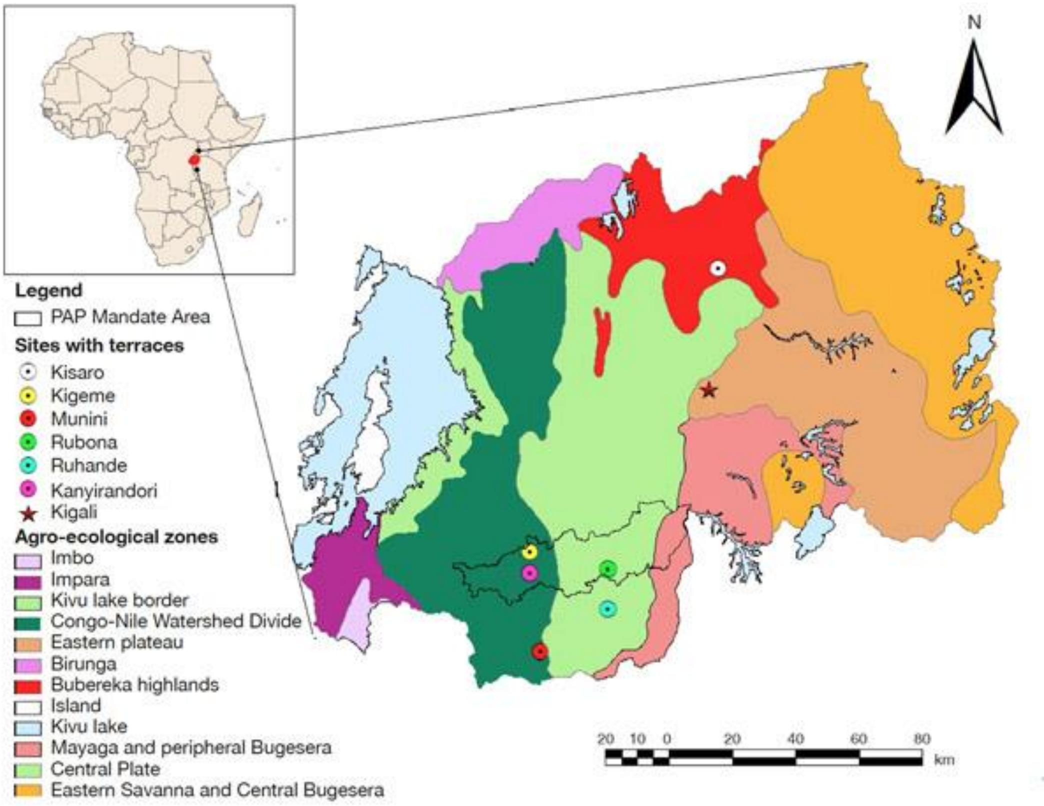


Figure 1. Location of Rwanda within Africa, Rwanda Agro-Ecological Zones and sites cited in the text (adapted from Verdoodt, 2003a and Schörry, 1991) — *Localisation du Rwanda par rapport à l'Afrique, Zones Agro-Écologiques du Rwanda et sites cités dans le texte (d'après Verdoodt, 2003a et Schörry, 1991).*

Source: google maps

Figure 2: Map showing the agroecological zones of Rwanda.

Table: Household structure Family structure and

Farmer household family structure description	Eastern	Western	Southern	Northern	Eastern	Southern
	Bugesera	**Karongi**	**Muhanga**	**Musanze**	**Nyagatare**	**Nyanza**
	Mean	**Mean**	**Mean**	**Mean**	**Mean**	**Mean**
Males less than 5 years own family	1.00	1.09	1.00	1.00	1.11	1.29
males less than 5 years relatives	-					
Females less than 5 years own family	1.00	1.20	1.00	1.00	1.14	1.00
females less than 5 years relatives						
Males aged between 5 and 13 years	1.72	1.73	1.58	1.31	2.00	1.13
Male relatives aged between 5 and 13 years						
Females aged between 5 and 13 years	1.42	1.45	1.13	1.67	1.59	1.43
female relatives aged between 5 and 13 years						
Males aged between 13 and 34 years	1.24	1.29	1.48	1.11	2.05	1.43
Male relatives aged between 13 and 34 years						
females aged between 13 and 34 years	1.17	1.55	1.20	1.47	1.73	1.30
female relatives aged between 13 and 34 years						1.00
Males aged between 35 and 64 years	1.00	1.00	1.05	1.00	1.00	1.00
Male relatives aged between 35 and 64 years						
females aged between 35 and 64 years	1.04	1.05	1.05	1.00	1.00	1.00
Males aged between 64 years plus	1.00	1.00				
Male relatives aged between 64 years plus						
females aged between 64 years plus			1.00	1.00	1.00	1.00
female relatives aged between 64 years plus						
Number of male children in school	1.86	1.53	1.47	1.53	2.36	1.39
Number of female children in school		1.69	1.39	2.44	2.09	1.40

Land type

Consolidated land use type

District	Province		Percent			
			Consolidated	Not consolidated	Own private plot	Don't own private plot
Bugesera	Eastern	Yes	43.3	56.7	40.0	60.0
Karongi	Western	Yes	76.7	23.3	16.7	83.3
Muhanga	Southern	Yes	60.0	40.0	26.7	73.3
Musanze	Northern	Yes	58.6	41.4	20.7	79.3
Nyagatare	Eastern	Yes	66.7	33.3	23.3	76.7
Nyanza	Southern	Yes	83.3	16.7	30.0	60.0

Annex 3: Current status of fertilizer use in Rwanda

Rwanda currently consumes 30 kg/ha of fertilizer compared to the global rate of 115 kg/ha. However, Rwanda has made significant strides being three times higher than the average for sub-Saharan Africa which stands at 10.0 kg/ha. Global assessments conducted by the United Nations Food and Agriculture Organisation (FAO 2014) showed that a total of 179 million tons of fertilizer were used in 2012, in magnitudes of; 109 Mt of nitrogen (N), 41 Mt of phosphate (P2O5) and 29 Mt of potash (K2O); at an average application rate of 115 kg nutrients/ha. Asia is by far the main consuming region, with East Asia and South Asia accounting for 38 and 18%, respectively, of the world total.

Table 6: Trends in fertilizer use indices for Rwanda compared to that of Africa and globally

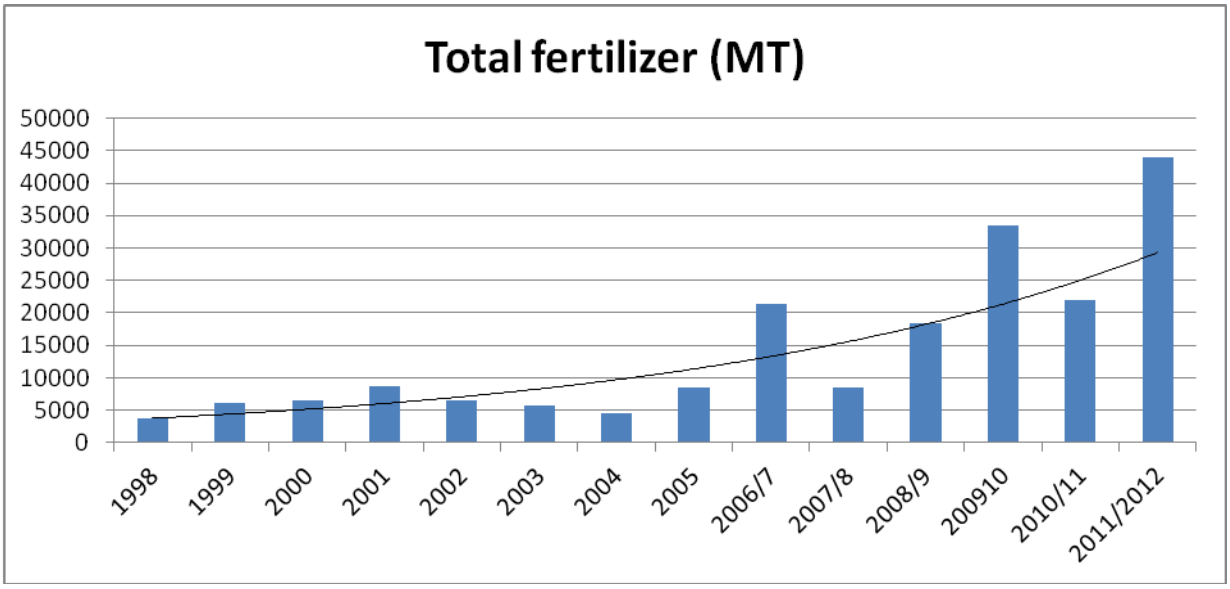
2006	**Rwanda**	**sub-Sahara Africa**	**Global**
Fertilizer use (million tons)	0.006	4.42	165.88
Nitrogen (million tons)	0.006	2.81	97.75
Phosphate P_2O_5 (million tons)	0.015	1.03	40.71
Potash (K_2O (million tons)	0.018	0.58	27.42
Average application rate (kg nutrients/ha)	4.10	7.93	101.00
2013	**Rwanda**	**Sub-Sahara Africa**	**Global**
Fertilizer use (million tons)	0.042	3.30.	189.8
Nitrogen (million tons)	0.021	1.80	119.7
Phosphate P2O5 (million tons)	0.025	1.39	41.5
Potash (K2O (million tons)	0.0000002	0.53	28.6
Average application rate (kg nutrients/ha)	30	10.00	115
2020 – projected	**Rwanda**	**Sub-Sahara Africa**	**Global**
Fertilizer use (million tons)	0.1	20.00	208.0
Nitrogen (million tons)			115.3
Phosphate P2O5 (million tons)			56.0
Potash (K2O (million tons)			36.7
Av**erage** application rate (kg nutrients/ha)	50	50.00	130

Sources: MINAGRI(2014); FAO (2012; 2014)

By contrast, Africa consumed less than 3% of the world demand (Drechsel et al. 2015). The global fertilizer use is projected to reach 200 million tons by 2020 (Economic Development and Poverty Reduction Strategies (EDPRS, 2014). Even though there is some significant growing trend in the use of fertilizers in Africa, the region remains one of the lowest users of mineral fertilizer, with sub-Saharan Africa registering an average application rate of 9 to 11kg per ha in 2013 (FAO, 2014), which is less than 10% of the global average. This means that crop production in the sub-Sahara region is taking out more nutrients than actually what is replenished in terms of synthetic fertilizer. This has created a problem of excessive nutrient mining with consequent environmental impacts in terms of reduced soil fertility and unsustainable productivity. Such situation is exacerbated in areas like Rwanda where the high population density and high dependence on agriculture means no room for allow the land to fallow to naturally regain some nutrients.

Rwanda has made impressive gains moving from under 4kg/ha of fertilizer use in 2000 to 30kg/ha in 2013 (MINAGRI, 2014). This rate is projected to increase to above 45kg/ha by 2018. Rwanda has moved from about 4,000 tons (2kg/ha) in total amount of fertilizer used in

1998 to nearly 45,000 tons (~22.5kg/ha) in 2012 (Figure 1) to 59,244 tons (~30 kg/ha) in 2015. This is trend is in line with the targets set in PSTA (2006). This level of fertilizer use has seen tremendous improvement in production and is equally matched by impressive record in self-reliance in meeting the national food requirements. However given the nutrients needs for most of the farmed crops in Rwanda being over 150 kg of nutrients per hectare, the net result even with the use of synthetic fertilizers at the above rates is loss of soil fertility through crop production. The situation is compounded by nutrient loss through soil erosion and leaching. It is therefore critical to reduce nutrient loss and replenish them, but do it in such a way that involves measures against loss of nutrients through runoff and leaching.



Fertilizer importation for the period of 1998 to 2012

Source: Naramabuye et al (2014)

The quantities of total fertilizers imported have increased 15 fold since 1998; and 3 fold since the CIP inception. The types of fertilizers proposed at the inception of the CIP for key 'strategic' crops in terms of food security and income generation were general for all areas and major the macronutrients as shown in Table 7, with each benefitting crop, until recently, using uniform recommended application rates across the country despite the variation in nutrient content.

Types of fertilizers used for Maize, Wheat, Rice and Irish Potatoes 2007 - 2014

Crops	Most popular type of fertilizer	2nd most popular type of fertilizer
Maize	NPK (17-17-17)	DAP + urea
Rice	NPK (17-17-17) + Urea (46%)	DAP + urea
Irish Potato	NPK (17-17-17)	DAP + urea
Wheat	NPK (17-17-17)	DAP + urea

Source: RAB 2016

The type of fertilizers used have also increased with time, from the basic four shown in Table 7, to over twenty types including use of micronutrients (not indicated in the table) such as boron, zinc, copper etc. as of present. Until recently all areas under CIP across the country were taken to require a uniform treatment, as there was no information on the soil nutrient levels for the different areas. Recently, with collaboration and support from IFDC, MINAGRI carried a soil nutrient assessment across the country and has developed soil nutrient maps (Figure 2 to Figure 7) that are assisting in identifying the types and levels of nutrients required. Table 8 shows the yearly amounts of fertilizer imported and used in Rwanda since 2007.

Quantity of fertilizer used in Rwanda yearly from 2007 to 2016 by type

Year/ Fertilizer(MT)	2007	2008	2009	2010	2011	2012	2013	2014	2015
1. Ammonium hydroxide								0	
2. Organic fertilizer								21	
3. Urea	2,602	3,200	4,499.93	4,000	9,000	7,911	11408	8,562	10,420
4. Ammonium sulphate								1	
5. Ammonium nitrate								239	
6. CAN								12	
7. Sodium nitrate								0	
8. UAN								0	
9. SSP								4	
10.MOP								103	
11.SOP								28	
12.NPK 17-17-17	2,501	8,226.9	16,893.27	5,877.98	16,,000	16,835	11,459	5,104	26,880
13.NPK 25-55 +3S								9,069	6,715
14.NPK 22-6-12								4,219	3,026
15.NPK 25-5-5	3,000	3,000						991	2,202
16.NPK 20-10-10	1,010	3,000							
17.DAP	4,530	2,992.14	8,942.38	12,000	20,000	10,966	20,032	11,856	5,518
18.NP.								5	
19.Agriculture Lime								263	
20.Aluminium phosphate								2	
21.Others								0	4,484
TOTAL	13,643	23,411.18	30,335.58	21,877.98	45,000	35,712	42,899	42,132	59,244

Source: MINAGRI (2016) and IFDC (2016).

Currently the number of crops benefitting from the subsidy has been increased to 10 from four when the CIP started in 2007. The 10 crops include the original four (rice, potatoes, wheat and maize); and the additional six that include bananas, cassava, soya beans, beans, vegetables and fruits (Table 9). The general trend has been decreasing subsidy from 50% of the cost to 35%, and in case of rice and potatoes from 50% to the current 15%.

Recommend rates for fertilizer application rates under CIP

Table 9 shows the application rates for the fertilizers for the different crops which have been in use until recently. The rates were similar across the country in the different agro-ecosystems.

Fertilizer application rates as obtained from the technical managers

No.	Crop	Fertilizer Application Rates
1.	Maize	• DAP 100kg/ha • UREA 50kg/ha
2.	Rice	• DAP100kg/ha • UREA 50kg/ha • NPK 100kg/ha
3.	Cabbages	• DAP 80kg/ha • UREA 40kg/ha
4.	Tomatoes	• DAP100kg/ha • UREA 50kg/ha

	• NPK 100kg/ha

Source: MINAGRI Technical Managers

Table 10 shows the unsubsidised prices for crops and the subsidy attached to the different crops under the crop intensification programme (CIP). The subsidy broadly covers bananas, cassava, soy bean and rice, irish potato, maize, wheat, bush beans. A lot of the emphasis of the programme has been on the latter five crops (Egide Gatari pers.comm. 2016); however, the programme is expanding to cover more crops.

Total price of fertilizers to spend per Ha by crop, as per recommended application rates

Crop/Year/ha	2007	2008	2009	2010	2011	2012	2013	2014
Bananas (RWF)	35,625	36,250	60,000	39,375	41,250	53,125	58,750	80,000
Subsidy(RWF)	0	0	0	0	20,625	14,375	15,625	0
Subsidy %	0	0	0	0	50	27.1	26.6	0
Rice(RWF)	113,000	133,200	151,350	135,000	143,900	123,000	138,000	193,000
Subsidy (RWF)	0	0	75,675	0	71,950	23,000	25,000	52,500
Subsidy %	0	0	50	0	50	18.7	18.1	27.2
Potatoes(RWF)	84,000	87,000	144,000	111,000	96,000	114,000	132,000	195,000
Subsidy(RWF)	0	0	0	0	0	0	0	0
Subsidy %	0	0	0	0	0	0	0	0
Maize(RWF)	61,000	71,000	75,000	43,000	66,000	83,500	85,000	106,500
Subsidy(RWF)	0		37,750	0	33,000	415,00	42,500	53,250
Subsidy%	0	0	50.3	0	50	49.7	50	50
Wheat(RWF)	46,750	55,000	75,000	43,000	66,000	83,500	85,000	106,500
Subsidy(RWF)	0	0	37,750	0	33,000	41,500	42,500	53,250
Subsidy%	0	0	50.3	0	50.0	49.7	50.0	50.0
Cassava(RWF)	84,000	87,000	144,000	111,000	96,000	114,000	132,000	195,000
Subsidy(RWF)	0	0	0	0	0	0	0	0
Subsidy%	0	0	0	0	0	0	0	0
S. beans(RWF)	32,500	39,000	55,000	30,000	49,000	60,000	60,000	75,000
Subsidy(RWF)	0	0	27,500	0	24,500	30,000	30,000	37,500
Subsidy%	0	0	50.0	0	50.0	50.0	50.0	50.0
Beans(RWF)	36,000	39,000	55,000	30,000	49,000	60,000	60,000	75,000
Subsidy(RWF)	0	0	27,500	0	2,4500	30,000	30,000	37,500
Subsidy%	0	0	50.0	0	50.0	50.0	50.0	50.0

*** unsubsidised prices of fertilisers for crop**
Source: RAB (2016)

Farm production systems, existing farmer programmes and inputs

Support for farmers in fertilizer management and integrated soil fertility management

A number of media are used to transfer knowledge to farmers including farmer field schools, radio and television broadcast, posters, leaflets, on-farm visits, farmer-to-farmer visits and on-farm demonstration plots. The International Fertilizer Development Centre (IFDC) in collaboration with MINAGRI and RAB set up a total of 505 demonstration plots by year 2008, with this number increased by multiple folds and spread throughout the country currently (Table 11). Demonstration plots are intended to promote fertilizer use by showing the positive impacts of applying fertilizers to crops. They are also used as training facilities to teach farmers on appropriate ways of applying fertilizer.

Season A 2008 demonstration plots across the country

Districts	Corps	No. demo plots	Number of farmers exposed to the technologies
Nyagatare	Maize	64	-
Gicumbi	Irish potatoes	29	600 farmers visited the demonstration

	Wheat	39	
Nyabihu	Irish potato	24	77 farmers visited the demonstration
	Maize	24	
	Wheat	14	67 farmers visited the demonstration
Nyamagabe	Irish potato	59	
Bugesera	Maize	64	70 both farmers and technicians visited the demonstration
Rusizi	Maize / Irish potato	62	528 farmers, agro-dealers and technicians 172 New farmers had joined of farm group.
Nyanza	Maize	64	-
Musanze	Irish potato	24	518 farmers visited the demonstration where 146 had adopted the technologies in the following season (28%).
	Maize	24	365 farmers visited the demonstration where 43 had adopted the technologies (12%).
	Wheat	14	371 farmers visited the plots, and at least 87 adopted the technology (23%).

ANNEX 4: Estimates of crop prices, fertiliser use for section 4.1.3

Variable	**Means**	**Std. Dev.**
Crop prices	**Price (Rwf).**	
Wheat	301	49.42
Rice	625	90.21
Maize	215	35.30
Beans	302	22.88
Irish potato	145	34.47
Output	**Mean ('000tons)**	
Wheat	68,352	20,833.92
Rice	78,646	10,740.54
Maize	393,487	213,842.20
Beans	35,6408	54.599.38
Irish potato	1,708,313	566,225.5
Fertiliser	**Subsidised prices (Rwf)**	
NPK	450	81.50
DAP	293	45.08
UREA	232	53.94
FERTILISER USED		
Variable	**Mean fertilisers use (tons)**	**Std. Dev.**
MZNPK1	44936.71	21035.49
MZUrea1	4085.155	1912.317
MZDAP1	7149.022	3346.555
BnNPK1	762.0675	351.2444
BnsUrea1	84.67417	39.02715
BnsDAP1	127.0113	58.54073
WhTDAP1	608.496	334.7598
WhTUrea11	405.664	223.1732
WhTUrea11	405.664	223.1732
RCNPK1	2856.311	1190.773
RCUrea1	1785.195	744.2334
RCDAP1	1249.636	520.9634
IRPNPK1	39194.7	16548.06
IRPUrea1	10451.92	4412.816
IRPDAP1	13064.9	5516.02

Annex 3: Checklist for representative farms at Provincial level in assessing the fertilizer use performance, benefits and costs

Background

This checklist is designed to get the farm level perspective of the contribution and impact of fertilizer use as part of the Consultancy Work for assessing the efficiency and cost effectiveness of fertilizer use in Rwanda by REMA and MINAGRI. Given that the study cannot get information from all farmlands and households, the approach will be to conduct the assessment using representative sample farms in the different provinces and or agroecological zones both under the fertilizer use and those not use mineral fertilizer. The aim will be to assess whether the representative farms land conditions (i.e. land qualities and land characteristics) relate to the land use requirements and limitations?; whether the inputs (seed, fertilizer, labour, etc.) or land improvements (e.g. land levelling, weeding, soil conservation, irrigation) are considered by the farmer as part of variable costs?; and what are the output:input relationships, first in physical terms (e.g. yield vs. water deficiency) and secondly, in economic terms?

1. **Particulars of the farmer**
    a. Name of farmer: ______________________________

    b. Name of farmer group/cooperative: ______________________________

2. Define the Land Utilization type ______________________________
    a. A single LUT specifies only one kind of use undertaken on an area of land (e.g. irrigated rice, or irrigated sugarcane, or irrigated tree crops).
    b. A multiple LUT specifies more than one kind of use simultaneously undertaken on the same area of land, each use having its own inputs, requirements and produce. An example is irrigated rice grown alongside fruit trees, vegetables, and bananas at the same time.
    c. A compound LUT specifies more than one kind of use sequentially undertaken on the same area of land. Examples cropping of maize in season A and cropping of beans on the same plot in season B.
3. **Location:**
    a. Omudugudu:
    b. Cell:
    c. Sector:
    d. District:
    e. Province ______________________________

4. **Education/Literacy level**
    a. No formal education:
    b. Primary education
    c. Secondary education:
    d. Tertiary education: ______________________________

5. Biophysical and agroecological environmental setting
    a. Type/name of Agroecological zone: ______________________________

    b. Terrain/landscape of the farm: Marshland Hillside Flat ______________________________

    c. Type of soils:
        1. sandy
        2. alluvial
        3. Sandy-clay ______________________________

4. loamy
5. volcanic

6. Climate characterization
   a. Wet and rainy most of the year
   b. Alternating equal wet and dry seasons each year
   c. Mostly dry with limited rain

7. Farm practices and choice of crops
   a. Engaged in production of the following crops under the fertilizer use :
      1. Maize Acreage Fertilizer Qty (Kg)
         Fertilizer Qty (kg)
         Fertilizer Qty (Kg)
      2. Rice Acreage Fertilizer Qty(kg)
         Fertilizer Qty (kg)
         Fertilizer Qty (Kg)
      3. Potatoes (Irish) Acreage Fertilizer Qty (kg)
         Fertilizer Qty (kg)
         Fertilizer Qty (Kg)
      4. Wheat Acreage
         Fertilizer Qty (kg)
         Fertilizer Qty (Kg)

8. Yield

9. Estimated yield for the last two seasons/cycles:
   a. Current cycle Sept 2015 – March 2016:
      1. Maize:
      2. Rice:
      3. Potatoes:
      4. Wheat:
   b. Past cycle September 2014 – March 2015
      1. Maize:

2. Rice:
3. Potatoes
4. Wheat:

10. How did the farmer get to be selected to benefit from the fertilizer use programme?
    a. Own initiative___________________
    b. Local leaders____________________
    c. Extension worker and or agronomist ______________________
    d. Farmers' group and or cooperative___________________________

11. Detailed characterization of the farming unit at household level

	HEADINGS	DESCRIPTIONS	RESPONSES
i.	Cropping system	Single, multiple or compound Land Utilization Type (LUT). Crops grown, cultivars, cropping calendar, cropping intensity. Perennial cropping systems, cultivation factor, cropping index.	• Single ____ Multiple ____Compound____ • Cropping calendar: o Season A:____________________ o Season B:____________________ • Cropping index: how many times is a particular crop planted in a year?_______ • What are the perennial crops on same farmland under fertilizer use? ________________________________ • Cultivation factors: o Soil type __________________ o Soil nutrients _______________ o Use of organic fertilizers ________ o Chemical fertilizers used (Macro): N___ P___ K____ Ca___ (Micro): Fe___ Zn___ Bo____ Mg ___Cu ____ o Temperature regime _____________ o Altitude _____________________ o Humidity __________________ o Common pests ______________ o Control measures against pests: ▪ Inorganic pesticides ___ ▪ Organic Pesticides ____ ▪ No pesticides ____ ▪ Integrated pests management _____
ii.	Markets	Subsistence, commercial or both, domestic or export, or both.	• How much is produced _______ kg (%) • How much is consumed ------ kg (%) o ---– over 50% is consumed (Subsistence) o ___over 50% is put up for marketing (Commercial) • How much is reserved for seed ------- kg (%)
iii.	Water supply	Seasonal supply and quality.	• Rainfed (seasonal) __ Good quality __ Poor quality__ • Irrigation (seasonal) __ Good quality __ Poor quality__ • Irrigation (all season) __ Good quality __Poor quality__
iv.	Irrigation method 1/	Gravity or lift, run-of-river or storage releases, surface, overhead, drip, etc.	• Type of irrigation: o Marshland _____ Hillside _____ o Gravity ____ lift _____ o Run-of-river/canal____ Storage releases ______ o Overhead ___ Sprinkle __ Sprinkle__ Hose __
v.	Capital intensity	Value of capital investment and recurring costs per ha.	• Cost in RWF for main season o Cost of plowing/preparation of fields ________ o Cost of fertilizers: Mineral _____ Organic______ o Cost of planting material (seeds) ________ o Cost of applying fertilizers _______ o Cost of weeding_____ o Cost of harvesting ________ o Cost of processing and or marketing _____ o Cost of storage ________

vi.	Labour intensity	Family and hired labour, man-months per ha, seasonal peak periods, festivities and holidays	• Main source of labour: ○ Family ___ & ___% ○ Paid labour ____ & ____% ○ Most labour demanding activity ________ ○ Most labour demanding season _________ • Estimated cost of labour ○ For the whole farmed plot (RWF) _________ ○ Man-months ________ ○ per hectare (RWF) _______
vii.	Technical skills and attitudes	Experience, response to innovation and change, literacy	• Knowledge and skills in fertilizer use: ○ Does the farmer have any training in fertilizer use __ ○ How long was the training? ____ days/months and how long ago? __________ months/years ○ Where was the training conducted? ___________ ○ Who facilitated the training? ___________ and who paid for the training? _______________ • Does the farmer understand how fertilizers work and why they are applied? ○ Yes ________ No ________
viii.	Power	Extent of human, animal and tractor power impact on land preparation, harvesting, etc.	• Type and cost of power on the farm ○ Human ______ Animal ______ Tractor/Machine ___ • Estimated cost of power (Tractor/Machine use) per season (RWF)____________
ix.	Mechanization and farm operations	Which operations are mechanized or partly mechanized.	○ Purpose of the power (mechanization) employed on the farm ▪ Land clearing and preparation _______ ▪ Fertilizer application _______ ▪ Sowing /planting __________ ▪ Harvesting ___________
x.	Size and shape of farms	Farm size, size by LUTs, fragmentation of holdings.	• Size of farming plot by crop (for single LUT) ○ Maize ______acres ○ Rice _______ acres ○ Potatoes ____ acres ○ Wheat ______acres • Fragmentation of the holdings ○ How many households own & farm on plot? ____ • Is the farmer under land consolidation programme? ___ ○ If yes, what is the size of the consolidated land ____ acres ○ If yes, how many farmers own and or use the land? ___________ ○ What is the average farm holding? _____ acres
	Land tenure	Freehold: family farm, corporately owned estate.	• Type of land tenure ○ Family farm ______ ○ Customary land _____ ○ Leased farm _______ ○ Corporately owned farm/estate ______
		Tenancy: cash rent tenancy,, labour tenancy, share cropping.	• Type of tenancy ○ Cash tenancy _____ amount per season ________ RWF ○ Labour tenancy _____ State the arrangement ____ ____ ○ Share cropping _____ % owner _____ % for user____
		Communal ownership: cooperative (collective) farming, village land with rights to cultivate, etc.	• Communally owned land: ○ Is it for collective farming _______________ ○ Village land with rights to cultivate__________ ○ Communal food production system __________ ○ Group commercial farming ________________ ○ Cooperatively owned commercial farming __________
		State ownership: state farm, national park.	• Stated owned farm land ______ size ______ acres ○ Crops produced: Maize__ Rice __ Potatoes __ Wheat __ ○ Management of the farm: Government agency __________
xii.	Water	Right of access to and	• Water rights and access

<table>
<tr><td></td><td>rights</td><td>adequacy of supply of water for production, especially under irrigated agriculture.</td><td>○ Is the farm under irrigation? ________
○ If yes, is the water supply adequate for the crops? ____
○ Does the farmer have fully rights for accessing the water? ________
○ Does the farmer have the requisite infrastructure in place to access the irrigation water? _____
○ If not, what proportion of water does he/she get? ___%</td></tr>
<tr><td>xiii.</td><td>Infrastructure</td><td>Assumptions about processing facilities, storage depots, markets, access to farm inputs. Roads, housing, schools, medical facilities, electricity, domestic water supplies. Research and extension services and facilities.</td><td>• Does the farm have adequate storage for the produce? ___
• Does the farmer readily access the market? _______,
• Is the farm and farm storage readily accessible by vehicle? ______
• Does the farmer benefit from public extension services? ___
○ If yes, how many times in a season? __________
○ Who provides the extension services? _______________
• Does the farm need and access public utilities (including electricity and potable water)? ____________________
• Does farm benefit from research services? ______; and how often is the farm visited by scientists? ______________</td></tr>
<tr><td>xiv.</td><td>Fertilizer use infrastructure</td><td>Assumptions about easy of access, supply, affordability, and knowledge of handling and application</td><td>• Fertilizer accessibility
○ Are fertilizers readily accessible whenever needed? _______
○ Relative to other inputs are fertilizers affordable? ________
○ Is the farmer trained and knowledgeable in handling and applying fertilizers? _____________________________</td></tr>
<tr><td>xv.</td><td>Material inputs</td><td>Prior assumptions about quantities and quality of inputs especially for seed, planting material, fertilizers, pesticides, herbicides, etc.</td><td>• Quantities and quality of inputs
○ How does the farmer ascertain the quantity of the inputs (seed and fertilizers)?
▪ Measured at the stockist/agro-dealer _______
▪ Measured at the farm ________
▪ Informed by the extension worker ________
○ How does the farm ascertain the quality of the inputs (fertilizers, seeds, herbicides, pesticides and others)
▪ Guidance from the District Agronomist _______
▪ Information from the Stockists _______
▪ From the Rwanda Bureau of Standards _______
○ Who guides the farmer on application of the inputs?
▪ Guidance from the District Agronomist _______
▪ Information from the Stockists _______
▪ Guidance by fellow farmers ____________
▪ Guidance from the Agronomist for the Cooperative ___</td></tr>
<tr><td rowspan="2">xvi.</td><td rowspan="2">Cultivation practices</td><td>Preparation of land including clearing.</td><td>• Does preparation of land include levelling of the fields? ___
• Does preparation of land include making of terraces of other provisions for control of soil erosion? _________</td></tr>
<tr><td>Tillage operations (including duration for plowing, leveling etc.)</td><td>• What tillage practice is used?
○ Minimum (conservation) tillage _____
○ Conventional tillage _____</td></tr>
<tr><td>xvii.</td><td>Livestock and crop husbandry interactions</td><td>For traction, milk or meat, manure, forage requirements, including crop by-products, field grazing, zero grazing, stall-fed, etc.</td><td>• What is the level of interaction between livestock and crop husbandry on the farmland under fertilizer use?
○ Used to grow fodder on the fringes for livestock ____
○ Livestock manure is applied together with mineral fertilizer on the farmland _____
○ Acts as grazing land during the fallow period (off growing season) ________</td></tr>
<tr><td>xviii.</td><td>Associated rainfed</td><td>Influence of LUT of competing rainfed agriculture, forestry agriculture, shifting cultivation or agro-forestry, from land consolidated for fertilizer use.</td><td>• How much of land under fertilizer is or was part of other none CIP produce? ____________ Acres (%)
○ What was the main commodity/crop cultivated on the land before the consolidation?
▪ Forestry ___
▪ None CIP food crops _____
▪ Agroforestry ____
▪ Cash crops (coffee, tea, sugar cane etc) _____</td></tr>
<tr><td>xix.</td><td>Yields and production</td><td>Yields per unit area on S1 land (ceiling values for</td><td>• Total yield (kg)
○ Maize: Year 1 __________ Year 2 ________ Year 3 _____</td></tr>
</table>

		relative yield).	○ Rice: Year 1 __________ Year2 ________ Year 3 ______ ○ Potatoes: Year 1_______ Year 2 _______ Year 3 ______ ○ Wheat: Year 1_______ Year 2 _______ Year 3 ______
		(Specify mean yields with confidence limits, or ranges suitable for economic and financial sensitivity analyses.)	• Mean yields (kgs/hectare) ○ Maize ____________ ○ Rice ______________ ○ Potatoes ____________ ○ Wheat _______________
		Land equivalent ratio, income equivalent ratio.	• Land Equivalent Ratio ○ How much land is under single cropping? ____% ○ How much land is under intercropping? _____ %
xx.	Environmental impact of fertilizer use	Fertilizer related public health problems (impact on eye sight, skin, body physiology etc).	• Impact on humans: ○ Knowledge of any health problem related to exposure to fertilizers ____ ____
		Alteration in soil texture e.g. crusting; loss of fertility; change in coloration; reduction or increase in water holding capacity etc	• Impact on soils: ○ Crusting _______ ○ Loss of fertility or less productive ________ ○ Change in texture _______ ○ Reduced or increased permeability _______ ○ Increased porosity _________
		Impact on surrounding vegetation including scorching, loss of colour and change in composition/type of vegetation	• Impact on vegetation ○ Loss of vegetation cover in the immediate surrounding __ ○ Scorching of vegetation _____ ○ Loss/change in coloration of the vegetation _____ ○ Change in composition of vegetation ____ ○ Change in dominant type of vegetations ______
		Pollution of surface and ground water sources	• Increase in pollution status of adjoining waters ______ • Change in coloration of waters ______ • Increased stench of water sources _______ • Mortality of aquatic organisms ________
		Impact on wildlife (birds/animals/rodents/reptiles/insects)	• Reduced occurrence of Wildlife ○ Birds ___ Animals ___ Rodents ___ Reptiles __ Insects__ • Visible mortality of wildlife ○ Birds ___ Animals ___ Rodents ___ Reptiles __ Insects__
xxi.	Economic information	Market prices, input costs and availabilities, subsidies, credit.	• Cost of inputs (RWF/Kg or Unit) ○ NPK fertilizers ____________ % of subsidy _______ ○ Microfertilizers ___________ % of subsidy ________ ○ Quality seeds _____________ % of subsidy _______ ○ Herbicides _______________ % of subsidy _______ ○ Pesticides _________________ % of subsidy _______ • Farm-gate prices ○ Maize (RWF/kg) __________ ○ Rice (RWF/Kg) ___________ ○ Potatoes (RWF/Kg) _________ ○ Wheat (RWF/Kg) ____________ • Credit for inputs ○ Source of credit _________ ○ Amount of credit (RWF) _________ ○ Funding/financing level for investment ___________

12. Agronomic characterization and information of representative farms

Land use requirements or limitations - land qualities (where applicable)	**REPRESENTATIVE LAND CHARACTERISTICS, INPUTS, LAND IMPROVEMENTS AND OTHER RELEVANT CONSIDERATIONS (see**	**Farmer Responses**

		Part Two for full explanations)	
A.	**<u>AGRONOMIC:</u>** **<u>- crop requirements or limitations</u>** **<u>- the crop environment</u>**		
1.	GROWING PERIODS: - growing period requirement - growing periods	Growing cycle of crops. Dates and duration (days).	• What is season for the following crops? o Maize: Planting month __________ Harvesting month __________ o Rice: Planting month ___________ Harvesting month ___________ o Potatoes: Planting month ________ Harvesting month ____________ o Wheat: Planting month _________ Harvesting month __________
2.	TEMPERATURE: - temperature requirement - temperature regime	Uniform temperature throughout the growing cycle or discernable change in temperature during growing cycle?	• Temperature regime in the area o Uniform throughout the growing season _____________ o There is significant variation throughout the growing season __________
4.	ROOTING: - rooting requirement - rooting conditions	Effective soil depth for roots. Root room. Volume percent of stones. Penetration resistance or soil strength.	• Does the farmland have sufficient soil depth for crop rooting? _______ o Is there significant stone percentage on the farmland that interferes with crop rooting? ___
5.	AERATION: - oxygen & aeration requirement - oxygen supply and soil aeration	Periods with or without adequate aeration during the growing period. (Depth and fluctuation of groundwater)	• How much is water table a problem during the rainy season in terms of application of fertilizers? Significant _____ Non-significant _____ • How much is the farmland flooded during rainy season or irrigation? No flooding ____ flooding is always menace _______ • Does flooding and or rise of the water table cause aeration problems to crops? Significant _________ Insignificant _________
6.	WATER QUANTITY: - water requirement - water supply	Water balance, water storage. Yield vs. evapotranspiration relationships; deficient periods. Run-off, run-on, seepage and percolation, groundwater contribution, effective precipitation. Stream flows, diversions, storage releases, aquifer safe yields.	• Does the farm receive sufficient water for good crop performance throughout the growing season? _______ • How serious are the following problems: o Water run-off? ______________ o Water run-on? _____________ o Soil erosion? _______________ o Water seepage/percolation? __________ o Flooding from adjust rivers/water bodies? ______________
7.	NUTRIENTS (NPK) - nutritional requirement - fertilizer requirement, etc. - nutrient supply - fertilizer supply	NPK uptake by crops and responses to NPK. Losses of NPK (leaching, volatilization, fixation, etc.). Nitrogen fixation. Soil nutrients and their retention, cation exchange capacity, etc. Fertilizer requirements and availability including manures, etc.	• What is the farmer's assessment of the performance of crops under fertilizers? o Significant improvement _______ o No difference ___________ o Significant reduction in performance/yield ________ • How does the farmer tell that the farm requires fertilizers? o According to information from experts and extension workers __ o Following the performance of crops _____

			○ According to performance and signs of the vegetation ______ ○ Following national guidance by responsible ministry (MINAGRI/RAB) _________
8.	WATER QUALITY: - crop tolerance to water quality - water quality	Total salt concentration. Ionic composition. Electrical conductivity dS/m at 25 °C. Sodium adsorption ratio (SAR). pH, carbonates and bicarbonates. Suspended solids, BOD, COD, etc.	• How does the farmer discern the quality of the water in case of irrigation water supply? ○ According to information from experts and extension workers __ ○ Following the performance of crops ______ ○ According to performance and signs of the vegetation ______ ○ Following national guidance by responsible ministry (MINAGRI/RAB) _________
9.	SALINITY: - crop tolerance to salinity - salinity regime (salt balance)	Plant salt tolerances, present and future soil salinity, inputs of salt through water supply, losses of salt by leaching, salt balance. Seasonal salt movement in profile, salt from groundwater.	• Does the farmer experience any impact of salinity on the crops or soil in the farmland under fertilizer use? ○ Yes __________ ○ No ___________
10.	SODICITY: - crop tolerance to sodicity - sodicity regime	Predicted pH, ESP and or SAR of soil solution, predicted effects on soil structure, infiltration and permeabilities. Sodium toxicity.	• Is there any evidence of sodium toxicity on the farm? ○ Poor crop root performance ____ ○ Poor soil structure _____ ○ Poor water retention ______ ○ Formation of soil crusts _____
11.	pH, MICRONUTRIENTS AND TOXICITIES: - crop tolerances, susceptibilities - toxicity or micronutrient regimes	On non-rice cropland, pH effects and crop tolerances and susceptibilities to excesses or deficiencies of Ca, Mg, Zn, Fe, S, B, Cu, Mn, Mo, Al. On submerged soil effects of pH, salts, Fe, Si, Mo, Zn, Cu, H_2S. Soil and plant composition, relevant inputs.	• Are there are noticeable deficiencies or excesses that prevent good crop performance? ○ Lack of micronutrients ________ ○ High or low pH levels ______ ○ Soil toxicity _________
12.	PEST, DISEASE, WEEDS: - crop tolerances, susceptibilities - pest, disease, weed hazard.	Crop tolerances and susceptibilities. Wild animals, birds, arthropods etc. Fungal, bacterial, viral pathogens. Weeds. Pesticides, fencing, inputs.	• What is the prevalence of the following factors during growing season? ○ Pests: High _______ Low _______ ○ Diseases: High ______ Low ______ ○ Weeds; High _______ Low ______
B.	**<u>MANAGEMENT:</u>** **<u>- management requirements and limitations</u>** **<u>- conditions affecting management</u>**		
14.	LOCATION: - location requirements - location	Closeness to markets, processing units. Access to inputs and services. Access to water (gravity, pumped). Travel & transport problems & cost. Day-to-day management problems. Accessibility of machinery.	• What is the distance of the farm to the following points (km)? ○ Water reservoir _________ ○ Agro-dealership _________ ○ Extension Office _________ ○ Farm storage __________ ○ Produce processing unit _______ ○ Farm machinery for hire _______

15.	WATER APPLICATION MANAGEMENT: - limitations of irrigation method - conditions affecting water application management	Size, shape of management units. Labour requirement availability. Conditions affecting uniformity of water application, rate, frequency and duration of application.	• What is the effect of water management on fertilizer application on the field? ○ Critical __________ ○ Significant_________ ○ Insignificant __________
16.	PRE-HARVEST FARM MANAGEMENT: - pre-harvest farm management requirements and limitations - conditions affecting pre-harvest farm management	Effects on timing of pre-harvest operations (e.g. of soil workability) including land preparation, nurseries, seeding, transplanting, fertilizer application, irrigation, weeding, spraying, etc.	• What is the effect of timing of pre-harvest activities on fertilizer use and crop performance? ○ Critical __________ ○ Significant_________ ○ Insignificant __________
17.	HARVEST AND POST HARVEST MANAGEMENT: - requirements or limitations - conditions affecting	Atmospheric wetness, dryness, wind. Soil wetness, dryness. Effects of soil or humidity on the quality of the crop produce.	
18.	MECHANIZATION: - requirements for mechanization - conditions affecting potential for mechanization and on-farm transportation	Slope angle, rock hindrances, stoniness, soil depth, soil texture, shape and size of fields. Effects of soil compaction. On-farm transportation.	• What is the level of mechanization on the farm? ○ Highly mechanized ________ ○ Moderately mechanized _______ ○ Lowly mechanized ______ ○ Wholly manually operated ______
C.	**LAND DEVELOPMENT AND IMPROVEMENTS** **- land development requirements** **- factors affecting cost of land development and improvement**		
19.	LAND CLEARING: - land clearing requirements - conditions affecting cost of land clearing	Forest: underbrushing, felling, burning, stacking; costs, value of timber, charcoal; time period to development. Persistent weeds: mechanical cultivation, flooding, chemical control; costs, time period to development. Rocks and stones: removal costs.	• How much of forest cover or trees were failed over the last two seasons to make way for crops? _____________________ (Acres or number of large trees) • How much of forest cover or number of trees would the farmer have cut if he/she was using fertilizers over the last two years? _________________ (Acres or number of large trees)
20.	FLOOD PROTECTION: - flood protection requirements - conditions affecting cost of flood protection	Earthmoving costs for embankments, costs of structures.	• How much does the farmer spend on soil erosion and flood protection? (RWF) __________
23.	PHYSICAL, CHEMICAL AND ORGANIC AIDS AND AMENDMENTS: - requirements - conditions affecting costs	Need for deep ploughing, subsoiling, profile inversion, sanding, marling; gypsum, lime, organic matter, costs.	• Does the farmer apply any amendments to the farmland? ○ Physical – deep ploughing ___ ○ Mechanical soil inversion _____ ○ Use of chemicals such as lime, gypsum etec _____ ○ Use of organic maure/matter ___ • How much is spent on the amendments

			(RWF)? ___________
E.	**<u>SOCIO-ECONOMIC</u>:** **- <u>socio-economic requirements and limitations</u>** **- <u>socio-economic conditions</u>**		
31.	FARMERS' ATTITUDES TO FERTILIZER USE		• Does the farmer willingly plan and utilize the mineral fertilizers? _____ ○ Does the farmer accept to use mineral fertilizer from MINAGRI because of other associated benefits such as access to quality seed? __________
32.	OTHER SOCIO-ECONOMIC LIMITATIONS THAT MAY BE CLASS-DETERMINING	Other limitations/complications to fertilizer use access to water for production, tenurial and land-ownership complications, disincentives of taxation, fragmentation, etc.	• What complications does the farmer face is accessing and applying fertilizers? ○ Land ownership _______ ○ High taxation _________ ○ Affordability __________ ○ Limited land size _______

Annex 4 - PART I for Public Technical Managers: Institutional Capability Assessment Questionnaire

This capability assessment is the means of examining the ability vested in the government to pursue measures to improve efficiency of fertilizer use and mitigate the impact of hazards resulting from fertilizer distribution, handling and application to environment.

In completing this questionnaire, you must look for the Window of Opportunity i.e. the beginning or the potential for development of measures for improving the efficiency and sustainability of fertilizer use in Rwanda, and mitigation activities for your respective Ministry/Department/Agency.

1.0 MINISTRY/DEPARTMENT/AGENCY PROFILE:

1.1 Name:

1.2 Mandate:

1.3 List the major/main functions which are performed by the department/agency.

1.4 Provide a list of all the specific services you provide to the public with regard to the fertilizer use programme.

1.5 Identify your major stakeholders in relation to the fertilizer use programme?

2.0 INSTITUTIONAL CAPABILITY:

2.1 Which stage of the fertilizer use process are you involved in or responsible for? Select all that may apply:

- Promotion of fertilizer use
- Importation and distribution of fertilizers
- Delivery and access of fertilizers
- Storage, handling and application of fertilizers
- Training and extension services for fertilizer use
- Health, safety and environmental impact of fertilizers
- Mitigation (e.g. enforcement of regulations, farm and fertilizer use planning, etc)

2.2 List the specific responsibilities under the area(s) identified in 2.1.

2.3 What activities are required in fulfilling the responsibilities in 2.2?

2.4 Does this Ministry/department/agency carry out the activities required in 2.3?

2.5 What are the specific responsibilities of the Minister under which this Ministry/department/agency functions? List

2.6 What are the responsibilities of the Head of this Ministry Department/Agency?

2.7 Is interagency coordination required in performing the activities noted in 2.3? If yes, is it formal coordination or informal coordination? Explain.

2.8 Are there any existing impediments in performing the actions in 2.7? If yes list

3.0 INSTITUTIONAL INTERACTIONS

3.1 Provide a description of measures this Ministry/department/agency has taken to improve fertilizer use efficiency and sustainability

3.2 Please also provide a description of measures this Ministry/department/agency has undertaken to reduce or prevent the environmental impacts associated with fertilizer use

3.3 What are the social and economic impacts associated with fertiliser use that your Ministry/ department contributes or benefits from as associated with fertiliser use?

4.0 LEGAL CAPABILITY:

4.1 Does your legislative mandate make provisions for carrying out the fertilizer use programme activities identified above in 2.3? If yes, go to question 2.3. If no, go to question 2.2.

4.1 What are the legislative powers that give you the authority to undertake any fertilizer use programme related activity, which you now carry out?

4.2 Please identify the legislation and note the section that makes these provisions or gives such authority.

4.3 Does your legislative mandate apply to one or more of these groups? Select the ones that may apply.

- Regulations – answer questions 3.5 to 3.17
- Acquisition – answer questions 3.18 to 3.21
- Fees/permits/taxes – answer question 3.22 to 3.23
- Spending – answer question 3.24

Regulations:

4.4 Does your existing legislation or legislative mandate enable you to regulate or prohibit conditions or actions that may endanger the public's health or safety? If yes, identify the specific regulations.

4.5 Which of the regulations identified in 3.5 are enforced?
4.6 How effective has the enforcement of these regulations been as it relates to 3.5 above?
4.7 Which of the regulations identified in 3.5 are not enforced?
4.8 Why aren't these regulations enforced?
4.9 What is required to enforce these regulations?
4.10 Is there an administrative system in place to carry out the enforcement of the regulations identified in 4.5, If yes, what is the structure of this system? If no, answer question 4.13.
4.11 What are the perceptions about the effectiveness of this administrative structure effective?
4.12 Has the absence of an administrative system resulted in the lack of enforcement at 4.8 above? If not, explain.
4.13 In order to legally perform the activities under 4.3 above, which one of the following actions would be required

- New legislation
- Amendments to the existing legislation

4.14 If any amendments are required, give a brief description of what would be required.
4.15 When was the legislation under which your Ministry, Department, Agency operates last revised?
4.16 Is there a proposal for a revision? If yes, state the reason. For revision.

Sanctions/Permits/Taxation:

4.17 Does your legislative mandate enable you to levy charges and other penalties for non-compliance in general? If yes, give a brief description of this provision.
4.18 Are there any provisions in your existing legislative mandate, which can be used to facilitate mitigation activity using fees or charges?

Spending:

4.19 Does your Ministry/department /agency have a budgetary provision for mitigation activity? If yes state type of activity budgeted for?

5 INSTITUTIONAL MANDATE AND STRATEGIC INTEREST

5.1 Does the mandate and/or strategic interest of your Ministry, Department, agency also include fertilizer use management in your?
5.2 What areas of fertilizer use programme management are of most importance? Select those that may apply.

- Importation
- Fertilizer distribution and delivery
- Fertilizer accessibility and application
- Environmental aspects and impacts of fertilizer use
- Fertilizer use health and safety issues

5.3 Are there any specific environmental impact, health and safety related issues that are of interest in your Ministry, Department, Agency?
5.4 Why are these issues important?

6. FINANCIAL/FISCAL CAPABILITY:

6.1 Does your Ministry/department/agency allocate revenue within its annual budget for the activities identified in 2.3 above? If yes, list the activities that receive funding.

6.2 List some potential sources for fiscal aid (Grants).
6.3 Are any fiscal provisions made for environmental impact and health and safety fertilizer use related risks?
6.4 Does your Ministry /Agency/Department/require funding for environmental impact and health and safety impact mitigation activity? If yes state the specific activities which require funding.

7. TECHNICAL CAPABILITY:

7.1 Does this Ministry/Department/Agency have adequate and the necessary technical expertise to administer or manage the activities in 2.3 above? If no, answer question 6.2 and 6.3.
7.2 Which function or group of activities lack the required technical expertise?
7.3 What levels of training are needed to administer or manage these activities?
7.4 Given existing technical expertise in your Ministry/Department/Agency, is this expertise used for informing policy planning and decision-making activities with respect to mitigation? If yes, indicate the areas where this is done.
7.5 From your experience, state any institutional, expertise, legal, organisational gap you think may handicap the fertilizer use programme

Remarks:

Please remember to look for the Window of Opportunity i.e. the beginning or the potential for development of mitigation activities for your Ministry/Department /Agency.

Annex 5 - PART II for Public Technical Managers: Questionnaire: Institutional And Distributional Mechanisms and Processes for Fertilizers In Rwanda' -

Purpose: To identify institutional opportunities and constraints to improving the efficiency and effectiveness of fertilizer use at both national and farmer level. This will include analysis of economic, social (distributional), and environmental factors.

Questions

A. Legal and administrative framework for the collection of agricultural inputs

1. Does there exist a legal basis for import, distribution and delivery of agricultural inputs?
   YES: NO:
   a. If "Yes" to 1, how adequate is the legal framework for agricultural inputs importation and distribution to farmers? Please answer with a code.
      i. (1) Fully
      ii. (2) Workable
      iii. (3) Somewhat adequate (
      iv. 4) Somewhat inadequate (5)Totally inadequate
2. Is there a legal or statutory basis for Fertilizer use programme activities in the country in general? YES: NO:
   a. If "Yes" to 1, name the executive agency for agricultural inputs distribution activities in general specified under the law:
3. Explain how the mission of the organization supports the achievements of objectives of the fertilizer use programme
4. Give a brief overview of the organization
   i. Type of organization
   ii. Number of staff
   iii. Organizational structure
   iv. Capacity to manage fertilizer use programme
5. Give a brief overview of experience in coordinating and management agro-inputs distribution and use
6. Provide some explanation and list of other important institutions, in case the responsibility for agricultural inputs importation and distribution is shared or spread.

B. Structure of the National Agricultural inputs distribution System

7. Which of the following most appropriately describes the structure of the agricultural inputs distribution system in Rwanda?
   a. A agricultural inputs distribution system with only one national office responsible for all types of agricultural inputs
   b. A agricultural inputs distribution system with a main operating office for general agricultural inputs but partially decentralized with a coordinating mechanism to manage the agricultural inputs distribution.
   c. A agricultural inputs distribution system decentralized, with a coordinating authority
   d. A agricultural inputs distribution system decentralized, with no formal co-ordination.
8. Does there exist a formal allocation of responsibility among different agencies producing agricultural inputs? YES: NO:
   a. If "Yes" to 8., is there a mechanism to establish coordination among different agencies producing agricultural inputs ?
   b. If "Yes" to 8.a, is the mechanism for coordination functioning, i.e. is there adequate communication among different agencies producing agricultural inputs?

c. How effective is the existing mechanism for coordination? Tick one of the following:
    i. Highly effective;
    ii. Effective;
    iii. Fairly effective;
    iv. Weakly effective;
    v. Ineffective
d. What modalities of coordination and collaboration practiced? (Tick as applicable)
    i. Periodic conference of the data producing agencies
    ii. Common work plan with assigned responsibility for specific activities outputs
    iii. Working group and task team on technical issues

9. Is there a general agricultural inputs distribution system at the sub-national level?

C. Strategic framework

10. Does the country have a National Strategy, Plan or Programme for the development of agricultural inputs (e.g. National Strategy for Development of Agricultural inputs (NSDS) or National Action/Master Plan)?
    YES; NO;
    a. If "Yes" to 10., is this Strategy/Plan/Programme operational?
    b. If "Yes" to 10.a, State the period covered by the present Strategy, Plan or Programme:
       Starting year: Ending year:
    c. If "No " to 10.a, is its design in process or intended? Tick one of the following:
        i. Under development ;
        ii. Planned;
        iii. Not planned
    d. If "Yes" to 10., does the strategy include programme of work for the sub-sector relating to: (Tick the relevant one)
        i. Planting materials
        ii. Herbicides
        iii. Pesticides
        iv. General agrochemicals
        v. Fertilizers
        vi. Farm implements

11. Does there exist any national Strategy/Plan/Programme specific to mineral fertilizers?
    a. If " Yes" to 11., is fertilizer use strategy integrated into the Strategy for Agriculture Sector Development (ASD)?
    b. If "No" to 11., is its design in process or intended? Tick one of the following:
        i. Under development;
        ii. Planned;
        iii. Not planned

D. Dialogue with farmers or other agricultural inputs users

12. Does there exist an official forum for dialogue between suppliers and users of agricultural inputs in the country?
    a. If "Yes" to 12., are regular meetings of such a forum held?
    b. If "No" to 12., is there at least an informal forum for dialogue between producers and users of agricultural inputs?
    c. Are there well established channels for receiving feedback from users of agricultural inputs (web contact, emails, etc.)?
    d. If "Yes "to a, b or c, what is you r assessment of the level of dialogue between users and producers Tick any of the following:

i. Extensive;
ii. Adequate;
iii. Moderate;
iv. Somewhat;
v. Inadequate

13. If "Yes" to 12.a or 12.c, please indicate which of the following are represented in the forum (formal or informal)?
    a. MINECOFIN
    b. Line ministries and departments (like water resources, environment, forestry fisheries)
    c. Central Bank
    d. Representatives of academic and research community
    e. Chamber of commerce
    f. Media
    g. Representatives of socio-professional bodies
    h. Private sector representatives
    i. Development partners (Donors, NGO's, etc.)
    j. Other, specify

E. Availability and coverage of agricultural inputs

14. It is only in project areas? YES NO
15. It is on regional basis? YES NO
16. It is nationwide? YES NO

F. Financial resources (for the current year in local currency)

17. Total national budget for fertilizer use programme (RWF) ______________________
18. National regular budget for fertilizer use programme staff activities (RWF) ___________
19. National regular budget for fertilizer use programme staff trainings (RWF) ____________
20. National regular budget for fertilizer use programme non-staff activities (travel, consultancies, IT purchases etc.) (RWF) ___________________.
21. Total project budget for the CIP (RWF)

G. Human resources and training for fertilizer use programme activities (present)

		Total Number	No. fertilizer use program
22.	Number of regular professional staff in the MINAGRI head office		
23.	Number of regular professional staff in the regional/local offices		
24.	Number of regular support staff in the MINAGRI headquarters		
25.	Number of regular support staff in the regional/local offices		
26.	Number of project professional staff in regional/local offices		
27.	Number of project support staff in MINAGRI		
28.	No. staff trained at local training institutions during the last year		
a.	Professional staff		
b.	Support staff		
29.	No. fertilizer use programme staff trained abroad last year?		

30.	Is there a regular training programme for fertilizer use programme staff?	YES	NO

H. International cooperation in agricultural fertilizer use programme (during last three years)

31. Did your office benefit from a significant Technical Assistance Programme during the last three years? YES: NO:
    a. 'If Yes", did it cover fertilizer use programme also?
32. Main development partners/donors agencies which have provided funds or technical assistance in the country during the last 5 years? (List below in decreasing order of contribution)
    a. ________________________________
    b. ________________________________
    c. ________________________________
    d. ________________________________
    e. ________________________________
    f. ________________________________

I. Critical constraints

33. Please use the codes indicated below for grading. Response code:

i. (1) Not at all;
ii. (2): Somewhat;
iii. (3) Relevant
iv. (4) Significant
v. (5) Dominant constraint.

A "Dominant constraint" mean that that any improvement in the situation will dramatically improve fertilizer use programme. On the other hand "Not at All" means that any improvement in situation in this regard will in no way affect the status of fertilizer use programme.

	Constraint	**Extent**
1.	Number of professional staff at headquarters for fertilizer use programme activities	
2.	Number of support staff at headquarters for statistic al activities	
3.	Up-to-date information technology hardware	
4.	Number of field workers for fertilizer use programme activities	
5.	Technical skills of the available fertilizer use programme staff	
6.	Appreciation at the policy-making level for importance of fertilizer use programme activities	
7.	Support at political level in the Government for fertilizer use programme activities	
8.	Up-to-date information technology software	
9.	Funds for field-oriented fertilizer use programme activities vis-à-vis plans.	
10.	Transport equipment for field activities	
11.	Building space for office	
12.	Sound methodology implemented for extension services and support in fertilizer use	
13.	Level of demand for fertilizer use programme	
14.	Turnover of professional staff.	
15.	Others (please specify)	

16. Any other comments (Please provide your views on improvement of fertilizer use in the country)

Annex 6 - Checklist for Key Informant Service Providers and MINAGRI Partners: Roles and functions of key fertiliser use programme institutions and the fertilizer supply chain

1. Indicate where in the supply chain for fertilisers the institution or organisation is placed. Indicate the value added or service performed specifically by the institution/agency. If more than one value added activity or service please indicate. What other institutions and/or agencies you relate with in performing your role in the supply chain, and what has your experience of interaction with institutions, policy and/or legislation and rules contributed to or affected your operations, and the lessons thereof?

2. Please state what innovations and/or regular activities the institution does to ensure that it is able to perform the function is required to perform; for instance, capacity building, extension, additional services provided, outreach activities, micro-credit and others

3. Whether the institution has made efforts to assess the level of efficiency of service provided against a benchmark. For instance, what percentage of targeted stakeholders have been serviced? Benchmarks relate to farmer productivity may also be useful

4. What efforts have been undertaken by your agency/institution to improve the roles, responsibilities and services provided within the fertiliser supply and use chain; e.g. changes in way key stakeholders in fertilizer use value chain functions, capacity building, etc.

5. What are the barriers to farmers enhancing and/r maximising the benefit from fertiliser use (both from the institutional perspective as well as the farmer perspective). Which groups of the community (women, poorer etc.) are the major beneficiaries of the fertiliser use programme, who would be losers what can be done to reduce the impact on losers?

6. Any technical studies on the efficiency and sustainability of the fertilizer use programme under CIP or any other programme in Government or outside Government?

7. Any data sources relevant to analysis of Benefit Cost Ratio of the fertilizer use programme that your agency may possess or know of that can assist in the analysis of the CIP fertilizer use programme?

Annex 7 – Checklist for Agro-dealers: on effectiveness and efficiency of fertilizer use programme in Rwanda

Purpose: To identify institutional opportunities and constraints to improving the efficiency and effectiveness of fertilizer use at both national and farmer level. This will include analysis of economic, social (distributional), and environmental factors.

Key Questions

- Who are the actors, the status of linkage and how knowledge flow works within the system?
- What are the influential factors for the smooth functioning of input demand-supply system?
- What is the influence of policy in providing an enabling environment to the system?

Characteristics of agro-input dealers questionnaire

A: General information

1.1. Date of interview: ____________

1.2. Name of the enumerator: ________________

1.3. Name of agro-dealer: ______________________

1.4. Gender of agro-dealer: ______

1.5. Age of agro-dealer (years): _________

1.6. No. of years in school: _________

1.7 What is the highest level of education you have attained?

1) No education---------
2) Primary education------
3) Secondary education------
4) Tertiary education-----

1.8. Main occupation (major proportion of income): __________________________

1.9. Secondary occupation (secondary source of income): ______________________

1.10. Year started agro-dealer business: ________

1. 11. Name of market or point where interviewed:

i. Town or Village: __________________________
ii. Cell___________________
iii. Sector____________________
iv. District ________________________
v. Province________________________

1. 12. Apart from you, how many other agro-input dealers are in this county? _________

1.13. What proportion (%) of the shop is occupied by:

a. Agro-input items? _____%
b. Non-agro-input items. ______%__

1. 14. Name the three key non-agro-input items you sell:

(a) ______________________________
(b) ______________________________
(c) ______________________________

1. 15. Have you ever been visited or advised by extension staff? YES_______
NO__________

1.16. A. If YES, how many times were you visited by extension staff in 2015 (Jan –December)?

1.17. B. If YES, how many times were you visited by extension staff in 2015 (Jan –December)?
-

1.18. Have you ever been visited or advised by researcher? YES_______ NO__________

1.19. A. If YES, how many times were you visited by researcher in 2010 (Jan –December)? ---
--

1.19. B. If YES, how many times were you visited by researcher in 2015 (Jan – November)? ---
-
1.20. Do you attend field days/agricultural shows/fairs? YES_______ NO__________
1.21. A. If YES, how many did you attend in 2010 (Jan–Dec)? ....
1.21. B. If YES, how many did you attend in 2010 (Jan –Dec)? ....
1. 22. Have you ever been involved in any form of farmer education or agricultural extension work? YES______ NO________
1. 23. If yes, indicate for how long .... (yrs) and year last involved ________
1. 24. As a dealer on farm inputs, have you ever been encouraged to sell fertilizer to smallholder farmers? YES_______ NO__________
1. 25. If yes:

a. Who gave you the encouragement? ___________; (
b. Which year? ___________;
c. What was the result? ___________________________

1. 26. What proportion of your client farmers can classify as:

a. Small-scale farmers? _______%;
b. Medium-scale farmers? _______%;
c. Large-scale farmers? _______%

1. 27. About how many customers do you have? (a) Regular _____; (b) Irregular _____?
1. 28. Approximately how many (average) customers visit your shop in a day? _________

B. ASSESSMENT OF ISFM AWARENESS

2.1. Do you usually advise farmers on methods of fertilizer application? YES____ NO____
2.2 If yes, kindly indicate the different methods you often advise them to use:

i. Branding _______;
ii. Side dressing ____________;
iii. Top dressing _______________;
iv. Broadcasting ___________;
v. Foliage spraying_________;
vi. Injecting gaseous Fertilizer __________;
vii. Others _________________;

2.3. Do you know what is meant by 'Soil Fertility Management practices' (ISFM)? YES_ NO_
2.4. If YES, indicate aspects of ISFM your know in the table below

ISFM	**Are you aware of the following technologies**	**Have you been trained (Yes=1/ No=0)**	**Who trained you (list)**
Inorganic Fertilizers			
Precise fertilization(Micro dosing)			
Nitrogen Fixations by Legumes			
Improved Seeds(Germplasm)			
Biomass Transfer			
Agro-Forestry			
Improved Fallow			
Composting			
Crop Rotation			
Animal Manure			
Farm Machinery			
Seed Treatment Chemicals			
Pesticides			
Storage Chemicals			
Other(specify)...........			

2.5. Have you EVER used any of the following agricultural information resource tools in guiding farmers on their needs?

Tools:	Response (Yes = 1/ No = 0)	If yes, have you been providing such services to smallholder farmers in your catchment? (Yes = 1/ No =0)
Maize Crop Doctor (Be your own maize doctor)		
Soil maps		
Soil testing kit		
Nutrient Expert		
Any other (specify)		

2.6. Do you know how to test the soil for any of the following characteristic? [Use table below]

Soil Test	Response [Yes = 1, No = 0]	If yes, have you been providing such services to smallholder farmers in your area? [Yes = 1, No =0]
pH (acidity)		
Carbon: Nitrogen ratio		
Other (please specify.....)		

2.7. Apart from selling inputs, which of these other services do you provide to farmers? [NB this question will be used before and after the crop doctor has been administered to agro-dealers]

Other services provided to Farmers	**Do you provide this service? (Yes =1/No=0)**	**How many male farmers benefit per year?**	**How many female farmers benefit per year?**	**How do you rate your current ability to extend this service to farmers (none =0; little=1; medium=2; high=3)**
Spray their crops for free				
Spray their crops at cost				
Allow them to buy on credit				
Provide them with farm credit				
Information on agronomic practices				
Information on agronomic practices for pesticides/ herbicides/etc.				
Information on agronomic practices for fertilizers				
Information on soil suitability				
Information on soil fertility				

C: ASSESSMENT OF CHANNELS USED BY AGRO-INPUT DEALERS TO RECEIVE ISFM INFORMATION

3.1. Which of the following channels of communication do you use to receive ISFM information?

ISFM Information Channels	Rank the different information sources on the basis of the following context [1-low; 2=medium; 3=high]					What needs influence the preference for this information source [Use codes below]
	Accessibility	Reliability	Informative-ness	Comprehension	Preference	
Workshops/Seminars						
Other agro-input dealers						
Billboards/Posters						
Internet						
Brochures						
Newspapers/Magazines						
DVD/CD players						
Radio						
Books						
Television						
Songs/Poems/Skits						
Public gatherings/ barazas						
Farmer Field Days						
On-farm demonstrations						
Mobile phones						
Other specify (___)						

NEEDS:1= Information/Knowledge needs ; 2= Social integrative needs;3= entertainment needs ;4= Personal integrative (credibility, status) needs; 5= other (please specify)

Annex 8: **Key stakeholders and informants of the fertilizer use study**

No	Stakeholder	Focal person & contact
01.	MINAGRI	Dr. Charles MUREKEZI 0783 008 453
02.	RAB	Dr. Vicky Ruga Mr. John Kayumba Mr. Egide Gatari: 0788 215 435 / 0736 707 333 Mr. Mitchell Kirima Mr. Jules Ruteguka
03.	MINECOFIN	Ariane Zingiro: 0788 861 397 ariane.zingiro@minecofin.gov.rw Jonathan NZAYIKORERA: 0788 631 072 Jonathan.nzayikorera@minecofin.gov.rw
04.	MINERENA	Grace
05.	REMA	Mr. Fred Sabiti : 0788 681 314 Ms. Janet Umugwaneza Mr. Jan Rijpma
06.	FAO	Mr. Joseph BIZIMA: 0788 383 040
07.	Private Sector Chambers for Agriculture & Livestock	Ms. Christine MUREBWAYIRE 0788536121
08.	IFDC	
09.	UNDP	Mr. Janvier NTALINDWA
10.	USAID	Ms. Aimee MPAMBARA: 0788 855 075 / 0788 319 816 ampambara@usaid.gov
11.	Farmers Association	Christine MUREBWAYIRE 0788 536 121
12.	Fertilizer importer	
13.	One Acre Fund (TUBURA)	TUBURA – Mr. Alex : 0784 445 323 Ms. Sarah Billson: sarah.bilson@oneacrefund.org
14.	179 Farmers	Districts of Nyagatare, Muhanga, Karongi, Musanze, Bugesera, Nyanza