The Crop Intensification Program in Rwanda: a sustainability analysis

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Abstract

The recent Crop Intensification Program represents a great opportunity for Rwanda to guarantee food security and strengthen the country`s agricultural productivity. However overwhelming evidence is arising that a sustained growth path will be preserved over time only if the production process incorporates sustainability issues. Through qualitative interviews, a quantitative analysis and findings from the literature we will assess the sustainability of the current Rwanda Crop Intensification Program formulation and will analyze the interventions that are needed to reconcile immediate food security needs and long run environment proof methods of crops production.

Keywords: Crop Intensification Program, Rwanda, sustainability

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1. Introduction

Whereas Rwanda agriculture has seen growth in the recent past, the 2010 Government of Rwanda (GoR) leadership retreat asserted that "Agriculture is not fulfilling its potential for increasing GDP and reducing the trade deficit". Thus it is imperative to understand the need for enhancing sustainability of agricultural practices if agriculture is going to fulfill its potential for increasing GDP. Enhancing agricultural productivity and preventing food insecurity in Rwanda will rely on incorporating environmental sustainability interventions into the planning process to ensure investments are adequately allocated to address environmental priorities within the relevant sectors.

For these reasons it is very important to evaluate agricultural policies in developing countries from a sustainability perspective. The recent Crop Intensification Program (CIP) policy in Rwanda is aimed at boosting agricultural productivity through an improvement of productive inputs use, irrigation coverage and soil quality. The main research questions that we will try to answer by this paper will be the following:

- Is the CIP economically profitable and sustainable in a short term and in a long term perspective?

- What is the environmental impact of the CIP and what could be the consequences for the national budget?

The section 2 will introduce the concept of sustainable agriculture, in the section 3 we will present our sustainability analysis, finally we will draw our conclusions.

2. Concepts of sustainable agriculture

2.1 Definition of sustainable agriculture

As defined by the U.S. Department of Agriculture in the 1990 Farm Bill sustainable agriculture must: ". . . over the long term, satisfy human needs, enhance environmental quality and natural resource base, make the most efficient use of non-renewable resources and integrate natural biological processes, sustain economic viability, and enhance quality of life." (FAO, 2005). Sustainable agriculture does not refer to a prescribed set of practices and it differs from organic agriculture because, in sustainable agriculture, agrochemicals (synthetic fertilizers and pesticides) still play a role (Gomiero et al. 2008). Integrated soil fertility management ISFM is one of the most

used means to promote sustainable agriculture. As outlined by Breman (2001) ISFM concerns technologies, which combine the use of soil amendments (organic matter, phosphate, lime) and inorganic fertilisers. As pointed out by Breman:" Integrated soil fertility management technologies should be validated, improved and implemented in regions where fertiliser use will become attractive through soil improvement. In regions where economic feasible fertiliser use cannot be expected from the agronomic point of view, even in case of soil improvement, the socioeconomics of the technology should be compared with those of other approaches for desertification control".

Due to the soil amendments, the soil organic matter status and/or the availability of P and/or the pH improve and the use of fertilisers (and of other production factors like water and labour) becomes more efficient. Agroforestry together with other relevant soil conservation measures (reduced tillage, crop rotation, improved fallow) represent useful options to promote sustainable agriculture.

2.2 Soil management practices that promote sustainable agriculture

Table 1 is very useful to emphasize that a decrease of the soil organic matter (SOM) can be induced by a lower content of organic material in the soil or a high speed of the organic material decomposition that leads to humus and to mineralisation of nutrients which is necessary to feed crops. Decomposition is essential for agriculture, but if the speed of decomposition is too much high, the loss of soil organic matter can lead to unsustained production in the long run.

Table 1. The impact of soil management practices on soil organic matter and long run productivity.

	Decrease of biomass production	**Decrease in organic matter supply**	**Increased decomposition rates**	**Increased biomass production**	**Increased organic matter supply**	**Increased organic matter supply**
Impact on SOM	- SOM	- SOM	- SOM	+ SOM	+ SOM	+ SOM
Practices	Replacement of perennial vegetation	Burning of natural vegetation and crop residues	Tillage practices	Increased water availability for plants	Protection from fire	Reduced or zero tillage
	Monoculture of crops and pastures	Overgrazing	Drainage	Balanced fertilization	Crop residue management	
	High harvest index	Removal of crop residues	Fertilizer and pesticide use	Cover crops	Forage by grazing rather than by	

					harvesting	
	Use of bare fallow			Improved vegetative stands	Integrated pest management	
				Agroforestry and alley cropping	Manure and compost	
				Reforestation and afforestation		

Source: FAO (2005)

Each land management practice would deserve a separate discussion to investigate economic and environmental impact in the short and in the long run for different countries. An IFDC study (2005) investigates the effects of manure treatments and no tillage practices on sorghum production in Burkina Faso and Sudan. Results are quite interesting as the application of manure generates an increase in the level of production (table 2). No tillage decreases the level of short term production, but in the long run increases carbon content and soil productivity (table 3). An economy based on intensive agriculture is likely to suffer a dangerous trade off between higher productivity in the short term and land degradation in the long term (Takeshita and Akaia 2006). On the other side unfortunately sustainable management practices in many cases provide visible benefits in terms of SOM and carbon content only after a few years (IFDC, 2005).

Table 2. Effects of long term addition of organic manure on soil carbon and crop grain performance in Burkina Faso. 1980 – 2000.

Treatment	Grain (Yield t ha^{-1})
Control plot	0.78
Urea	0.69
Straw	0.66
Straw + Urea	1.68
Kraal Manure	2.52
Kraal Manure + Urea	2.73

Source: IFDC (2005)

Table 3. Impact of tillage on mayze and soybean crops in Sudan. 1996 – 2000.

Tillage	Carbon level (t/ha)	Mayze yield (kg/ha)	Soybean yield
Manual	19.74	2,812	1,770
Bullock	19.19	2,983	1,793
Tractor	16.66	2,539	2,489
Zero	22.36	2,334	1,781

Source: IFDC (2005)

We will use the concepts of sustainable agriculture explained in this section to develop our analysis on the sustainability aspects of the Rwanda policies towards agriculture in the following paragraphs.

3. Is the Rwanda Crop Intensification Program economically sustainable?

The Gouvernment of Rwanda (GoR) has recently launched a Crop Intensification Program (CIP) to increase national agricultural productivity and improve food security. The CIP towards crops production mainly involves 5 targets that are summarized in the table 4.

Table 4. Rwanda Crop Intensification Program in the agricultural crops sector.

Target	Action	Cost
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 FRw
Marshland development	- additional 9000 ha of marshlands developed -	41,188,900 FRw
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 FRw
Supply and use of agricultural inputs	- 56000 MT national fertilizer usage (increased from 14 MT) -15000 MT production of founded seeds (increased from 3000 MT) - Crop Intensification Program expanded	215,690,211 FRw
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 FRw

Source: MINAGRI (2010). Investment Plan.

The idea behind the Rwanda CIP is very simple and effective from a conceptual point of view: the increase of productive inputs (fertilizers), water use (improvement of irrigation) and a higher level of land use (marshland development) should lead to an increase of production and food security.

According to WCED (1987) sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. According

to this definition the concept of sustainability involves an intergenerational process that guarantees well being of the present and future generations according to economic, environmental and social criteria.

3.1 CIP economic productivity in the short run: preliminary evidence

As first step we will evaluate if the Crop Intensification Program is sustainable from an economic point of view in the short run. Under CIP, the government procures improved seed and fertilizer, which distributes to farmers in selected zones chosen for their food crop production potential. During the first year of the program, roughly 9,000 MT of fertilizer were imported and distributed by the Rwanda Ministry of Agriculture (MINAGRI). Yields of CIP target crops showed encouraging results. Wheat yields more than doubled and maize yields increased by about 90 percent (Morris et al. 2007).

However the following table shows that at aggregated level since 2006 to 2009 the increase of chemical fertilizers import did not always lead to an increase of the Rwanda crop production, though this finding should be cautiously considered as not all the imported fertilizers are used for production purposes.

Table 5. Fertilizers import vs crop production in Rwanda.

	Fertilizers import (tons)	Crops Production (Mt)
2006	13942	7166567
2007	22443	7098512
2008	17533	8234188
2009	33500	9261945

Source: RADA (2010) and MINAGRI (2010)

3.2 Modelling Rwanda agricultural productivity in the short run through a linear regression technique

This finding from the table 5 is more evident if we consider our results deriving from an estimation of a production function for the Rwanda agricultural production. We assume a typical neoclassical production function as in the equation 1:

1) $$Y_i = \alpha + \beta_1 LAND + (\beta_2 + \beta_{2k}) IF_i + (\beta_3 + \beta_{3k}) OF_i + \beta_4 TS_i + (\beta_5 + \beta_{5k}) IS_i + \beta_6 EQ_i + \beta_7 PEST_i + \beta_8 LABOUR_i + \beta_9 IRR_i + \beta_{10} NPS_i + \beta_{11} NONED + \beta_{12} PROV_k + \varepsilon_i$$

Where i represents each of the 30 districts in Rwanda, k represents each of the 5 provinces[1], Y = agricultural production, LAND represents the level of arable land, IF is the households` expenditure for inorganic fertilizers per district, OF is households` expenditure for organic fertilizers, TS is the expenditure of households for traditional seeds, IS is the households` expenditure for improved seeds, EQ represents the households` expenditures for agricultural equipment, PEST is the households` expenditure for pesticides, LABOUR is the number of workers in the agricultural sector, IRR is the percentage of irrigated land, NPS is the percentage of soil that is not protected against erosion, NONED is the percentage of agricultural workers that are totally uneducated, PROV is an additive dummy variable representing the 5 Rwanda provinces (Kigali, West, East, Nort, South) and representing productivity differences across provinces deriving from local economic conditions (prices) cultural differences.

3.3 Interpretation of the coefficients in a linear regression model

Given a generic equation $y = \alpha + \beta x + \varepsilon$ the coefficient β represents the variation of the dependant variable y deriving from a unit variation of the independent variable x. If the sign of the coefficient β is positive we can deduce that a variation of 1 unit of the X variable generates an increase of the y variable. If the sign of the coefficient β is negative we deduce that a variation of 1 unit of the x variable generates a decrease of the y variable. Moreover we should look at the significance of a coefficient beyond the sign. When a coefficient is significant it means that the reader can rely on the magnitude and sign of the coefficient, otherwise the analyst should conclude that the statistical evidence supporting the sign and the magnitude of the coefficient is not robust.

This quick introduction allows us to anticipate how we should interpret coefficients in our model. The interpretation of the equation 1) is trivial: we expect that an increase of households` expenditures in the level of inputs (IF, OF, TS, IS, EQ, PEST) increases the level of output and for these variables we expect a positive sign. Similarly we expect that an increase of the level of arable land LAND, percentage of irrigated land IRR and number of workers LABOUR increase output. LAND and IRR are particularly interesting for our analysis as the increase of irrigated land and an increase of arable land through marshland development are specific CIP targets. Finally we expect that an increase of the percentage of unprotected land from soil erosion NPS, and the percentage of non educated people NONED should decrease with a negative sign.

A remark should be devoted to the variables IF, OF and IS. Whereas for all the other variables we assume that the coefficients β_i are uniform across districts, for IF, OF and IS we test the assumption

[1] In the appendix 1 a table with Rwanda provinces and districts is available.

that the impact of inorganic and organic fertilizers expenditures and expenditures for improved seeds can be different across provinces. For IF and IS our assumption is based on the fact that the GoR policy to subsidy improved seeds and inorganic fertilizers improves the impact of households` expenditures on crops production. 1 RwF spent by households for inorganic fertilizers is more effective in increasing crops production if the Gouvernment increases the quantity of available chemical fertilizers for production for a particular province through appropriate distributions subsidised by public funds. A non uniform coefficient across districts captures the fact that the distribution of subsidized fertilizers can be different across provinces. For OF, the assumption of non uniform coefficient across provinces is based on the fact that crops production is also based on inorganic fertilizers that are not purchased on the market by households expenditures. If we assume that the in -house production of organic fertilizers is different across provinces the variation of production from 1 Rwf of households` expenditures in organic fertilizers will be higher in those provinces where there is more availability of “free cost” non market organic fertilizers that increase the crop production generated by market organic fertilizers.

The reader should notice that:

1) According to the MINECOFIN (Ministry of Finance and Economic Planning) budget in 2008 expenditure for agriculture including investments for Agriculture represented about 5.3% of the national budget corresponding to about 25 billions of Rwf. According to the same document “In line with the crops intensification policy, a large amount of the funds was used for the importation of fertilizer as well as for the purchase of improved seeds for the farmers to improve productivity”. According to the Rwanda National Survey of farmers in 2008 the households` expenditures for improved seeds and chemical fertilizers was around 10 billions of Rwf. This means that public funds for the Crop Intensification Program hugely affected the availability of chemical fertilizers quantities and improved seeds in Rwanda provinces and further supports the use of non uniform coefficients in our model.
2) The choice of non uniform coefficients is further justified by the fact that from the qualitative interviews it emerged that fertilizers in Rwanda are more productive for some crops rather than others (tea and coffe, wheat, irish potatoes, rice) and the distribution of crops varies across districts.

We take data about regressors from the Rwanda National Institute of Statistics Survey of Farmers in 2008.[2] Data about production quantities across districts are taken from MINAGRI. Data about agricultural output in different districts are expressed in Rwf by multiplying crops production in different districts and Rwanda crops prices according to FAOSTAT production prices for crops in 2007 adjusted to 2008 levels through a Rwanda inflation rate taken from an International Monetary Fund database. We have 60 observations representing data for 30 districts in the Season A and Season B of 2008. To incorporate the seasonal effect we add in the equation 1) a dummy variable representing time effects. Time effects capture the fact that for some reasons (typology of land management practice, habits, climatic conditions etc...) agricultural production in the season A can be different from that of Season B with the same level of inputs.

3.4 Results of the regression model

Results are very interesting. According to our estimations the only variable that is significant is labour (with a positive sign) together with arable land (with a negative sign). This shows that in spite of the great progress induced by the CIP at national level, within the country it is not statistically supported the hypothesis that higher inputs expenditures (IF, OF, TS, IS, EQ, PEST variables), irrigation percentage (IRR), soil protection (NPS) affect agricultural output. Our results show that Rwanda is still a labour led agricultural economy. These results contrast those found Ekborn and Sterner (2008) that find for Kenya agriculture an economy were the labour coefficient is not significant and expenditures for chemical and organic fertilizers that are significant. Next table summarizes our results.

Table 6. Expected signs and results of estimations. Dependant variable: Agricultural output per district. R^2 = 0.84. Robust standard errors

Coefficient	Expected sign	Estimation. Significance (5%) and sign
Arable land	Positive	Significant and negative
Inorganic fertilizers	Positive	Non significant
Organic fertilizers	Positive	Non significant
Traditional seeds	Positive	Non significant
Improved seeds	Positive	Non significant
Equipment expenditures	Positive	Non significant
Pesticides	Positive	Non significant
Labour	Positive	Positive and significant

[2] In the Appendix II we include a more detailed explanation of variables.

% of irrigated land	Positive	Non significant
% of non protected soil	Negative	Non significant
% of non educated workers	Negative	Non significant

Source: Our elaboration

Results are quite in line with what emerged from the previous literature for Rwanda and for sub Saharan African countries. For *inorganic fertilizers* (IF variable in equation 1) a first evaluation draft of the CIP outlines that:" Besides, fake fertilizers were imported from neighbouring countries and used by farmers in certain parts of the countries with very disappointing results. It is reported by SOPAV (which had a small blending unit) that random tests carried out on some fertilizers supposedly NPK 25-25-5 had so low nutrients at the level of NPK 6-10-6. Currently, these complaints about the quality of the fertilizers imported from regional fertilizer firms are not expressed even if some distributors have noticed that sometimes the supposedly 50 kg bags have less than the labelled weight". These words together with our results show that the quality of fertilizers could be very heterogeneous across districts ***and the quality of public expenditure for the import of fertilizers should be improved. This is a first very relevant policy implication of our results about the consequences of the Crop Intensification Program on the national budget.***

The ***quantity of subsidies for fertilizers*** is another crucial component of agricultural development. As outlined by the Catalyst[3] project researchers, intensive agriculture founded on inorganic fertilizers, improved seeds and crop protection chemicals provide huge improvements of the cost – benefit ratio for Rwanda farmers.

Table 7. Average yields and production costs for four crops obtained for Rwandan extensive and intensive production systems.

	Intensive production		**Extensive production**	
	Yield (kg/ha)	**Production costs RwF/kg**	**Yield (kg/ha)**	**Production costs RwF/kg**
beans	3,500	75	675	250
cassava	12,000	51	5,000	64
maize	5,000	63 - 75	1,000	155
rice	6,800	118	1,800	173

Source: Catalyst project

[3] CATALIST is a 5-year project to mobilize local resources and help farming communities increase agricultural production in the Great Lakes Region—one of the world's poorest areas, with the highest population density in Africa," said Dr. Amit Roy, IFDC President and CEO. The region comprises Rwanda, Burundi, southern Uganda, western Tanzania, and eastern Democratic Republic of the Congo.

A problem is that according to the Rwanda National Institute of Statistics Survey for farmers in 2008 only 17.7% of households used chemical fertilizers and only 75.4% chemical and/or organic fertilizers. Moreover just 13.3% of households used improved seeds and 15.7% used pesticides. In other words the distribution of productive inputs is likely to be unequal in the country. These are number showing that the transition from a labour led to intensive agriculture still needs to be completed in the country and our econometric results confirm these numbers. *The non significance of the pesticides* (PEST variable in equation 1) *and improved seeds coefficients* (IS variable in equation 1) can be easily explained by the fact that the depletion of this input is still low to generate a virtuous process of crops production at aggregated level, whereas the counter intuitive negative sign of the *land coefficient* (variable LAND in the equation 1) may be explained by the different soils properties and productivity in the country. Ekbom and Sterner 2008 widely stress in their paper that data about soil properties are crucial to understand agricultural productivity. Unfortunately we have not data about soil properties in different provinces and we cannot capture these effects in the model. Through an improved model specification we could understand more in depth the reason why some provinces where the arable land is higher show lower levels of crops production.

For *organic fertilizers* (OF variable in the equation 1) an interesting recent paper from Nyamangara et al. (2009) shows the results of organic application (cattle manure, miombo and mango) in Zimbabwe fields. The authors conclude that "all the three organic resources were poor and inadequate sources of N for plant growth in the short term and should therefore be supplemented with mineral N to reduce N immobilization and consequent N deficiency in plants". *Our intuition is that as the coefficient associated to inorganic fertilizers is not significant* there could also be a problem in Rwanda about the low quality of organic fertilizers. ***Funds for the Crop Intensification Program could also be addressed to improve the quality of organic fertilizers, but there is currently no mention of organic fertilizers utilisation in the current GoR official CIP targets.*** Interestingly from a statistical point of view results deriving from our statistical analysis do not qualitatively vary if we consider a model with and without uniform coefficients for IF, OF and IS and this finding further confirms our previous discussion.

The non significance of *soil protection* (NPS coefficient in the equation 1) was already outlined by the previous peer reviewed published literature for Rwanda agricultural production. As pointed out by Roose and Ndayizigiye (1997), "Thanks to agroforestry it was possible to reduce erosion hazard but not to restore soil productivity...thanks to agroforestry and mineral fertilizer complementation erosion hazard was controlled and the productivity of soil and labour intensified more than 3 times".

In other words a combined menu of practices are needed to boost crops production. ***For this reason from a national budget perspective it will be crucial a timely and well coordinated planning of public investments for soil protection and inputs use increase.***

Soil protection is a vital problem for the Rwanda economy (see table 8) and is crucial to preserve soil organic matter over time. This is very important for the Rwandan economy as the future path of climate change could even worsen soil erosion and productivity problems. According to the Stokholm Environment Institute (2009) soil erosion in Rwanda results in a loss of 1.4 million tons of soil per year, equivalent to an economic loss due equivalent to US $ 34,320,000, or almost 2% of GDP. Farmers very often perceive the danger deriving from soil erosion (Nyongabo 2004 shows this finding for the Gikongoro prefecture), but an important issue is to verify if soil protection can lead to productivity increases (and not just stop productivity decreases). Moreover it is relevant that Rwanda's anti-erosion programs incorporate local physical conditions (rainfall, soil type, slope), household specific economic circumstances (crops, livestock) and indigenous practices (Verwimp 2002).

Our results (in particular the non significance of the NPS coefficient in the equation 1) show that soil protection may not drive short term crops productivity as complementary land management practices may be needed to ensure productivity. Moreover in Rwanda management practices based on the use chemical and organic fertilizers may not be characterized by high quality and all these elements may affect the effectiveness of the CIP national public expenditure for agriculture.

Table 8. Classification of Rwanda soils according to the risk to be eroded due to the slope

Risk class	Very high	High	Average	Low	Very low
Surface (ha)	357529	436563	763005	340376	136625
Per cent of soils	17.6	21.5	37.5	16.7	6.7

Rwanda state of environment and outlook (2008)

A paper by Breman et al (2005) supports in some ways our finding by claiming:"Active replenishment of depleted African soils is no requirement for agricultural development. However, public investments in soils can contribute largely to the success of Integrated Soil Fertility Management". According to the authors intensification and development can start in those village fields where fertility is maintained and improved.

Moreover soil protection may provide different productivity results in different soils. As pointed out by Berry et al. (2003):" The biological erosion control methods also produce fodder or green manure that increase soil organic matter and nitrogen. On-station research indicates, however, that controlling erosion and increasing organic matter using animal or green manure is insufficient to increase productivity on the acidic, ferrallitic soils of Rwanda due to P-deficiency. Applications of mineral fertilizers and dolomite, in addition to erosion control, produced a reasonable yield. Additional improved techniques, such as careful composting of animal manure to reduce the loss of N and K, economically viable opportunities to increase the number of animals raised, and increasing vegetative cover with perennial crops or by using mulch, would also improve soil productivity".

There is also a problem of cost effectiveness of investments that should be carefully evaluated. MINAGRI has recently acted as cofounder of the Land husbandry, Water harvesting, and hillside irrigation project including different interventions against soil erosion and to include sustainable management practices together with the World Bank. The project includes an investment of 263200000 Rwf for radical terraces covering an area of 16450 hectares. This choice was justified by a wide literature that finds bench terraces more profitable (Garcia et al. 1990). However a more recent literature stresses that bench terraces may not be cost effective as they often require maintenances costs especially in areas where the slope is very high or because they do not provide improvements in terms of productivity (Posthumus and Stroosnjder 2009). A recent study of Fleskens (2007) shows that investments required for terracing are much higher than those for agro – forestry measures in Rwanda. A careful attention should be paid to CIP investments towards soil protection measures to verify which areas are most profitable to increase soil fertility and profitability.

The outcome of the CIP program will also crucially depend on the effective full implementation of the actions that have been planned at policy level. The recent MINAGRI Agriculture Investment Plan (2010) emphasizes a funding gap of actions for agriculture ranging from 21% and 80 %. The current irrigation program currently shows a 40% funding gap and this could explain why the percentage of irrigated land varies in the range 0.1 – 1.6 in Rwanda districts and why *the coefficient associated to irrigated land in the equation 1) (IRR) is not statistically significant in our analysis.* ***In a national budget perspective it will be very important to ensure the full implementation of the CIP program by strengthening public/private partnership and by seeking the needed funds through internal and external institutions and donors.***

Table 9. Funding gap for interventions in agriculture.

Intervention	Investment gap (RwF)	Gap (%)
Sustainable management of natural resource and water and soil preservation	127,627,789	80.49
Integrated systems of crops and livestock	33,376,975	55.19
Marshland development	15,961,404	38.75
Irrigation development	52,467,431	39.99
Supply and use of agricultural inputs	46,072,560	21.36
Food security and vulnerability management	15,856,658	89.59

Source: MINAGRI 2010. Agriculture sector investment plan.

3.5 CIP sustainability in the long run

In the long run intensification driven by chemical fertilizers and pesticides could strongly reduce soil fertility and organic matter. CIP programs explicitly recognise soil protection as an important measure to preserve soil fertility, but the current GoR is much more ambiguous in recognizing the importance of sustainable agriculture for long run land productivity. A CIP target mentions the fertilizers use but not the use of organic fertilizers. MINAGRI is currently implementing programs to strengthen sustainable agriculture but there is not yet a clear national strategy for sustainable agriculture. MINAGRI estimations say that sustainable practices within the Land Husbandry, Water harvesting and hillside irrigation project would be very profitable.

Table 10. Benefits estimated to come from the comprehensive land husbandry component of the MINAGRI Land husbandry, Water harvesting, and hillside irrigation project.

Slope %	Major land use	Area in ha	% crop production increase	Value in US$ from the increased yield
6 - 16	Legume feed from intercropping and green manuring	11129	50	834675
16- 40	Tree crop from planting trees/shrubs along the lower side supporting radical terraces	7100	50	177500
16 - 40	Legume feed produced from intercropped green manuring legumes within the perennials	7100	50	532500
40 - 60	Legume feed produced green manuring legumes with perennials	1558	50	116850

Source: MINAGRI 2010

However it will be crucial to involve as much as possible Rwandan farmers in changing behaviours as sustainable agriculture will not have to be a “top down” process funded and decided by

authorities. An interesting study from Clay, Reardon and Kangasniemi (1998) shows that a series of favourable conditions such as low crops price risk, level of non farm income, land property (not rent) and the presence of infrastructure all represent factors that can stimulate internal conditions for an increase of Rwanda farmers investments in land conservation. The GoR can make a lot of efforts to promote these conditions. The National Land Policy (2004) elaborated by the Ministry of Lands, Environment, Forests, Water and Mines points out that:" As indicated earlier, most of the land in Rwanda is governed by customary law. Lack of an adequate legal framework is a real impediment to the rational use of land". An interesting working paper of Olson (1994) claims that in the past woman were rarely given caretakership of their formal husband`s cattle and had few resources to feed animals and the result was that woman headed households had only one third of the manure of men headed households. Legal and social norms are crucial to promote sustainable agriculture.

Moreover an appropriate plan for roads and transport development in the country could represent an interesting opportunity for farmers to strengthen market conditions, business opportunities and financial capability in order to overcome constraints generated by market failures such as credit constraints. Of course in terms of national budget plan, the improvement of conditions for investments of farmers could require additional funds especially for infrastructure reasons. Sustainability and growth issues are strongly interconnected and policy makers should consider both issues for a sustained development.

An opportune solution could be to address in the long run Rwanda agriculture towards integrated soil fertility management. As outlined by Bremen et al. (2005) "the integrated use of inorganic fertilizers and organic forms of manure triggers a positive spiral of improved nutrient use efficiency and improved soil organic matter status. The increasing value:cost of fertilizers use improves the access to this and other external inputs". The Crop Intensification Program should incorporate sustainable management practices to balance short term food security needs and long term soil fertility targets.

4. Environmental sustainability

Until now we have focussed our attention on the link between sustainable management practices and productivity. From our interviews to policy makers[4] emerged that food security is of course a policy priority, but it is worth to spend some words also on the other environmental impacts that can arise from agricultural intensification. We discuss this issue as environmental externalities represent costs for the society that are not captured by the market. An interesting distinction from

[4] Please see Appendix III for a list of the persons that have been interviewed to write this report.

the national budget point of view is between *national externalities* and *transboundary externalities*. Transboundary externalities are actions deriving from Rwanda intensive agriculture that affect other countries. National externalities arise when intensive agricultural production affects other Rwanda economic activities. Another important distinction is between *market externalities* and *non market externalities*. Market externalities arise when they affect activities/goods for which there is a market price (eg. Externalities on consumption or externalities on the production of other industrial sectors). Non market externalities affect non market goods (eg biodiversity).

From a national budget perspective the interviews reveal that it is more likely that decision makers could be more available to cover externalities that affect *national and market* activities as they are more related to food security that is one of the current priorities of the GoR. Just some non market externalities such as health effects may be pivotal for the policy makers. Table 11 summarizes externalities deriving from agricultural intensification.

Table 11. Matrix of the possible externalities from the Rwanda Crop Intensification Plan.

Externalities	Market	Non Market
National	- Chemical fertilizers use generates contamination of acquifers because of nitrogen leaking. - Nutrients of chemical fertilizers are transported to water bodies and causing eutrophication, which might lead to harmful algal blooms and oxygen depletion - Insects can become more resistant to pesticides and this causes impacts on the agro – ecological system and may lead to decrease of productivity - Change of the landscape in areas with potential touristic interest - Salinisation from irrigation plans generates a loss of land cultivation - Erosion for the water run off of irrigation decreases land productivity	- Health effects from pesticides use - Nutrients of chemical fertilizers are transported to water bodies causing biodiversity loss - Change of the landscape - Waste management - Relocation of people and economic activities from intensive agriculture - Biodiversity loss from marshland development
Transboundary	- Intensive agriculture generates more greenhouse gas emissions as it is more energy intensive and because it guarantees carbon sequestration. A	- Intensive agriculture generates more greenhouse gas emissions as it is more energy intensive and because it guarantees carbon sequestration. A

	higher level of emissions generates market damages to other countries such as damages on agricultural production	higher level of emissions generates non market damages to other countries such as biodiversity loss.

Source: Our elaboration

An analysis of these costs for Rwanda is outside the scope of this work and would deserve separate studies. Elaborated techniques are used to estimate market and non market externalities and a huge availability of data would be needed to tackle the problem with scientific basis (Pearce and Turner 1990).

About water pollution from agriculture in developed countries it was estimated at around 345 million of euros annually (OECD 2008), whereas according to various surveys in India and Africa, 20-50% of wells contain nitrate levels greater than 50 mg/l and in some cases as high as several hundred milligrams per litre (FAO 2006). In Rwanda the water pollution problem could be very severe because as outlined by the UNEP – UNDP report (2008) Rwanda is one of the countries with the lowest level of water in the world.

Table 12 representing costs of health disease from pesticides use in some African countries from agriculture can be useful to understand the future needs of the Rwanda national budget in terms of additional funds that will be needed to tackle the environmental impact of intensification. Currently our econometric results show that Rwanda has not completed yet transition towards an intensive agriculture. The Rwanda State of Environment and Outlook (2008) claims that the country does not show environmental problems like salinisation from irrigation yet. This could be explained by the fact the percentage of irrigated land in Rwanda is still very low.

Table 12. Hidden costs of pesticides in Africa.

Country	**Estimated external costs**	**Date of the study**
Zimbabwe	Cotton smallholders lost US$3-6 per year in acute health effects, equivalent to 45-83% of annual pesticide expenditure. Time spent recuperating from illnesses attributed to pesticides averaged 2- 4 days.	1998-1999
Cote d'Ivoire	Average US$2-5 pesticide-related health expenses incurred by cotton and rice growing households. Cotton farmers suffer at least one adverse health effect 20% of the time.	1996-1997
Ghana	Cotton and cowpea smallholders lost average 15-21 days off work due to pesticide illness, equivalent to	2003

	US$17-35 in daily farm labour rates. Medical treatment and work loss costs cotton farmers up to US$90 per season. 33-60% farmers suffer pesticide-related ill health each season.	
Niger	Health costs, livestock losses and costs of obsolete stocks disposal = US$2 per hectare treated.	1996
Mali	Annual national poisoning health costs= US$0.25-1.5 million Costs to farming from ineffective pest management due to pesticide resistance and destruction of natural pest control organisms = US8.5 million.	2000

Source: Food and Fairness Briefing n.2

However in the near future further public funds will be needed to deal with negative impacts of intensive agriculture. This is a worrying policy insight if we consider that in terms of national public budget there is already a huge funding gap to implement the CIP without incorporating explicitly negative effects of the CIP on the environment. Our discussion shows that the funding gap calculated by the MINAGRI through the Agricultural Investment Plan could be underestimated if it does not capture some of external costs of intensive agriculture.

Finally, about climate change, we should remark that the set up of mechanisms for carbon sequestration to incorporate transboundary externalities could become an opportunity to promote sustainability and at the same time to boost income in the country. During the first five-year commitment period (2008–2012) of the Kyoto Protocol, afforestation and reforestation projects will be eligible for crediting under the Clean Development Mechanisms (CDM)[5]. Other sink activities, such as forest conservation and soil C sequestration, are not eligible. Still, soil C sequestration could become eligible for crediting under the CDM during post Copenhagen agreements periods. The delay of the carbon sequestration practices in Clean Development Mechanisms is due on the fact that massive scientific evidence is still missing on the potential reduction of emissions deriving from environment friendly land management practices (Ringius 2002). ***An effort (also in terms of national public budget) should be promoted in Rwanda to explore this issue through funded research programs***.

[5] The Clean Development Mechanism (CDM), defined in Article 12 of the Protocol, allows a country with an emission-reduction or emission-limitation commitment under the Kyoto Protocol (Annex B Party) to implement an emission-reduction project in developing countries. Such projects can earn saleable certified emission reduction (CER) credits, each equivalent to one tonne of CO2, which can be counted towards meeting Kyoto targets.

Preliminary studies show that for 48 tropical and subtropical developing countries with a central price of 10$ per ton, the gain from reforestation of degraded land, slowing of deforestation and land management activities could generate a 16.8$ billion gain for all these countries with a 3% discount rate (Niles et al. 2002). An international engagement of the GoR for the inclusion of sustainable agriculture for CDMs projects could be a good strategy to pursue a double dividend in terms of land productivity conservation and additional gains deriving from carbon markets. The GoR is already working to exploit opportunities from Clean Development Mechanisms. A recent CDM promoted by World Bank, Electrogaz and GoR through the Development Carbon fund will encourage electrification of the country through efficient lighting that will strengthen development, reduce emissions and generate additional income.

At the moment as land management practices cannot be counted as CDM, voluntary markets represent interesting tools to gain offsets with a particular focus on carbon sequestration. Voluntary carbon standard guidelines (2007) outline that many activities are eligible of producing carbon offsets:

- Soil C stocks can be increased by practices that increase residue inputs to soils and/or reduce soil C mineralization rates. Such practices include, but are not limited to the: adoption of notill; elimination of bare fallows; use of cover crops; creation of field buffers (e.g. windbreaks, riparian buffers); use of improved vegetated fallows; conversion from annual to perennial crops; and introduction of agroforestry practices on cropland. Where perennial woody species are introduced as part of cropland management (e.g. field buffers, agroforestry), C storage in perennial woody biomass may be included as part of emission reduction credits.
- Reducing soil N2O emissions generally involves enhancing the N use efficiency of targeted crops to reduce the amount of N added as fertilizer or manure. Examples of specific practices that improve efficiency while reducing total N additions include: improved timing of application (e.g., split application), improved formulations (e.g., slow release fertilizers, nitrification inhibitors) and improved placement of N.
- Reducing soil CH4 emissions is an applicable practice primarily in flooded rice cultivation. Practices that reduce CH4 emissions include: improved water management; and the use of rice cultivars with reduced capacity for methane production and transport.

A recent DFID – DEW POINT – Stockhom Environment Institute Report (2008) outlines that Rwanda emissions are almost 2.5 times higher than those previously estimated for 2002. This is primarily driven by much higher estimates for the largest emitting sources – N2O from soil

cultivation and CH4 from enteric fermentation. GoR should carefully think the option to consider these emerging carbon markets to promote development. Of course climate change friendly policies should be implemented in a wider context of public interventions as rightly highlighted by Diagana (2003):" However, promoting carbon sequestration alone to mitigate climate change and reduce net GHG emissions may not attract strong and direct farmer support and participation in SSA. This option has the potential under the CDM of the Kyoto Protocol (if adopted) to be a winning cause and fare better in the arid and semi-arid zones of SSA if addressed jointly with other pressing challenges such as land degradation, declining agricultural productivity, biodiversity preservation, in short the sustainability of agroecosystems. With right policy approaches and socioeconomic incentives, appropriate technologies and integrated management practices, the combined productivity and environmental effects can lead to win-win scenarios ensuring farmers' livelihoods, alleviating poverty and protecting the natural resource base". The socio – economic context is particularly relevant in the Rwanda case if we consider that the high population density with an average low income in this country risks to vanish the efforts promoted to alleviate soil degradation processes.

The discussion undertaken in this section clearly shows that an evaluation of the Rwanda CIP should be based on evidence and data that include a wider range of variables incorporating environmental issues. Recent interesting studies show that growth indicators that are based on GDP factors and do not include sustainability issues can be misleading in evaluating development of African economies. The Pearce-Atkinson indicator is a more formal sustainability indicator that incorporates elements of the genuine savings idea. Table 13 provides an illustration of its use. The indicator subtracts the ratio of manufactured capital depreciation to GDP and natural capital depreciation to GDP from the savings ratio, to yield a measure of net savings. Where this calculation is positive, then the economy is sustainable. For the countries in Table 13, soil degradation represents a significant share of the natural capital depreciation. Indicators such as this can highlight the loss in national wealth that results from soil degradation (FAO 2001).

Table 13. The Pearce-Atkinson sustainability indicator, selected sub-Saharan African countries (%)

Country	**Savings/GDP**	**Manufactured capital depreciation**	**Natural capital depreciation**	**Sustainability indicator**
Burkina Faso	2	-1	-10	-9
Ethiopia	3	-1	-9	-7
Madagascar	8	-1	-16	-9

Malawi	8	-7	-4	-3
Mali	-4	-4	-6	-14
Nigeria	15	-3	-17	-5
Ethiopia	24	-10	-5	9

Source: FAO 2001

5. Social sustainability

In this last section we will mainly focus on social sustainability of the CIP. The concept of social sustainability is very wide and would be outside the scope of this work to consider all aspects of social sustainability and to drive a deep analysis in this field. For this purpose we will just quickly analyse if the crops production target set by the CIP will be likely to be reached or not. This is very important as the elimination of malnutrition is a primary target to fight social exclusion and to promote sustainable development over time. Table 14 shows that the production in terms of kcal/day/person is currently well above the CIP target. This finding is very important for two reasons. First, this means that the action of the GoR to improve food security and increase production is providing positive results. National public investments are effective in promoting social sustainability. Second, if the emergency of food security is quickly overcome in the country this may encourage with more emphasis the adoption of sustainable agricultural practices rather than practices that just increase the crops output levels. In the next section we will quickly summarize the main technical conclusions and policy implications arising from our analysis of the Rwanda CIP.

Table 14. Rwanda CIP crops production targets and current production.

Target 2150 kcal/per day	2005	2006	2007	2008	2009
	1969	1889	1786	2251	2541

Source: MINAGRI (2010)

6. Technical Conclusions

In this Report we have applied a linear regression model technique to estimate the impact of sustainable inputs (soil protection and organic fertilizers), dirty inputs (chemical fertilizers,

pesticides), other inputs (traditional seeds, improved seeds, labour, equipment expenditures, hectares of arable land, irrigation rate) and socio – economic variables (education levels) on the level of production in 2008.

We find that only labour (expressed as number of workers) shows a positive and significant sign on the level of agricultural production. Our interpretation of this finding is that Rwanda, in spite of the progress made through the Crop Intensification Program is still a labour led agriculture economy.

We also find a negative and significant sign of the arable land hectares on the level of production. In other words provinces with a higher level of arable land in many cases show a lower level of agriculture production than provinces with lower level of arable land. We can explain this counter intuitive result by the different productivity properties of lands in different provinces but we have not enough data to confirm this hypothesis with empirical evidence. Previous literature stressed the importance of soil properties data in explaining crops production.

We do not find robust evidence that provinces adopting a high level of inorganic and organic fertilizers always show high levels of crops production. From the previous literature referring to Rwanda for inorganic fertilizers and to Zimbabwe for organic fertilizers we find evidence showing that the quality of fertilizers is crucial to obtain significant improvements on the level of production and could be heterogeneous across farms in Rwanda.

We also do not find evidence that provinces with a high level of pesticides households` expenditures, percentage of irrigated land, expenditures for traditional seeds and expenditures for improved seeds show high levels of crops production. We have provided evidence that investments and households` expenditures for pesticides, irrigation and improved seeds are very low across Rwanda provinces and this could be the reason why that their contribution to increase crops production is not statistically relevant yet. The non significance of the traditional seeds coefficient could also be explained by a heterogeneous quality of seeds across provinces.

We do not find evidence that provinces with a high percentage of protected soil always show a high level of agricultural production. This finding is supported by a previous peer reviewed published paper for a Rwanda case study claiming that soil protection measures may not increase productivity if complementary productivity measures are not undertaken by farmers (eg appropriate fertilisation).

The non educated percentage of agricultural workers coefficient is also found non significant in our estimations. In other words we do not find robust statistical evidence that provinces with more educated workers are more productive. This could be explained by the fact that experience (learning by doing) more than education in many cases affects production levels. Non educated people but with a long experience in the field could be more productive than people starting a farming activity after a university degree. It could be interesting to implement further research with the aim to understand the socio – economic factors that affect crops productivity.

Finally we conclude the paper by a short survey summarizing all the environmental costs that the Rwanda CIP could generate in the near future and that could represent a heavy burden for the Rwanda National budget. We divide environmental costs in market/non market externalities (distinction that is based on the fact that CIP can affect market or non market goods) and national/transboundary externalities (the distinction is based on the fact that CIP can affect Rwanda or other countries). We list those externalities and on the basis of the previous literature we try to quantify externalities costs where possible for African countries or Rwanda.

7. Policy recommendations

From our previous discussion and technical conclusions we can highlight some policy recommendations and insights that policy makers should consider to strengthen the future implementation of the Rwanda CIP:

- Soil conservation practices and sustainable agriculture are profitable but unfortunately the Rwanda Crop Intensification Program only partially incorporates targets that are compatible to sustainability issues. Whereas soil erosion practices are included (terracing in particular) to tackle soil degradation, no target is related to the adoption of sustainable management practices and the use of organic nutrients to promote productivity. A revision of the Crop Intensification Program to include the support of measures to preserve SOM would reconcile the Rwanda short term needs of food security and long term need of soil productivity.

- Terracing interventions are very useful to avoid soil erosions but should be carefully evaluated in terms of cost effectiveness in relation to other agro – forestry practices and in terms of their productivity. In this paper we quickly showed results of papers claiming that agro – forestry could be more cost- effective than terracing. If this evidence were consolidated in the literature the policy implications for Rwanda would be very relevant. In a country where there is a huge funding gap for

the CIP, the adoption of more cost effective measures against soil erosion would allow to use cost savings for other CIP targets such as investments for irrigation or the purchase of fertilizers. Cost savings for the replacing of terracing with agro – forestry measures could also be used to support sustainable management practices. Further research is needed to assess the effectiveness of public investments against soil erosion and to verify the best measures to control erosion in Rwanda.

- Targets should not only be set in terms of quantity of organic and inorganic fertilizers but also in terms of quality. Our results support findings of other studies claiming the poor quality of fertilizer in many Rwanda districts in terms of productivity. Quality targets would improve the effectiveness of subsidies for fertilizers and increase the gains from national public expenditure. The public budget funding gap that we have outlined in our Report imposes policy makers to evaluate with the greatest attention the value of money. Purchases of poor quality fertilizers are useless to boost agriculture production and represent a waste of national budget funds. In a country where only 17.7% of households implement expenditures for chemical fertilizers, a subsidy policy program aimed at increasing the penetration of inputs across farmers is vital for the country development. In this context it is crucial that the quality of inputs reaches an acceptable level. Possible solutions to this problem could be the arrangement of import contracts including specific clauses that unambiguously call for acceptable fertilizers quality or the creation of appropriate inspection government organisms that are able to check year by year the quality of inputs and select the most reliable countries/firms for business relationships.

- The Crop Intensification Program does not fully consider interventions and funding to avoid possible future damages from intensive agriculture and externalities from the use of chemical inputs. In our work we just mention externalities and we do not estimate costs but the impact of these costs could be very relevant for the Rwanda national budget in the near future. Government organisms, universities or robust consultancy activities should guarantee reliable estimations of intensive agriculture damages. MINAGRI and MINECOFIN should work with coordination to ensure that budget interventions compensate for the intensive agriculture negative effects. The Government could work ex ante or ex post to counteract these negative effects. A terracing system is a mechanism that avoids soil erosion ex ante, but depuration systems for water contamination deriving from chemical fertilizers could represent a useful ex post intervention. For every externality identified in the literature opportune cost – benefit analyses and studies for specific geographical areas would represent the best tool to inform policy makers about the most promising actions to avoid ex ante or incorporate ex post environmental social costs deriving from intensive agriculture.

- Policies aimed at promoting carbon sequestration and conservation practices could generate immediate gains in the current voluntary carbon markets or in the future if land use practices should be formally included in post – Kyoto emissions reduction agreements for carbon markets. In the field of climate change the GoR could fruitfully work in two different directions. From one side the GoR can push international organisations such UNFCCC and World Bank to introduce sustainable agriculture management practices in climate change international agreements. From the other side it could be useful to investigate if voluntary carbon markets currently represent business opportunities for Rwanda farmers. Even in this case it could be useful to implement opportune studies to investigate if investments for sustainable management practices are profitable if compared to value of carbon in those voluntary markets.

- Previous literature stresses that a step forward for agricultural development in Rwanda could be the introduction of targets aimed at promoting integrated soil fertility management practices. ISFM could be the concrete strategy to promote sustainable agriculture in Rwanda. ISFM calls for the use of a mix of mineral fertilizers and organic soil amendments. Pure organic farming could be another interesting land management option for Rwanda farmers just if the loss of short term productivity generated by a "radical" organic farming excluding chemical fertilizers were more than compensated by higher price premiums that organic farmers enjoy in the international market. However the commercialisation of high quality and environment friendly organic products require the full access of farmers in the international market circuit (certification system, transport, export). Organic farming could represent an interesting and profitable niche market for Rwanda farmers, but GoR should help to improve ability of farmers to export through appropriate support programs (eg funding support for conversion from conventional to organic farming, training, settlement of organic certification bodies). International aid for trade programs implemented by international organisations such as OECD could also play a relevant role in this context.

- Public investments may be addressed to improve the business conditions for farmers` private investments in soil conservation practices (eg. infrastructure, removal of credit constraints). The creation of a fruitful business environment represents an important condition that will affect economic choices of entrepreneurs and farmers. The market conditions should allow Rwanda farmers that try to maximize crops production in a forward looking perspective in the medium and long term all the opportunities to implement opportune investments for sustainable land management. An important role of the GoR will be to correct eventual market failures that may generate the lack of capital for entrepreneurs that want to push forward dynamic and interesting

projects of sustainable agriculture. International institutions such as the Development Finance Institutions should instead play a role in providing funding for big projects requiring a huge amount of capital such as transport and building.

In summary the effectiveness of the national public expenditures in the CIP can be improved and additional funds should be spent to incorporate more in depth agricultural sustainability targets and to tackle damages from intensive agriculture. This huge effort to promote crops production increase and inputs availability should be implemented in a context where the GoR and international institutions strengthen market conditions and business opportunities. A wide research and consultancy effort is needed to explore the best actions to decide when, where and how much to spend to promote the right policy measure in the agricultural and all the sensible economic sectors in a forward looking perspective. The future of the Rwanda economy will strongly depend on the full reconciliation between environment and productivity targets.

Acknowledgement

The work was commissioned by Poverty – Environment Initiative (PEI) but the views expressed in this publication are of the author and do not necessarily reflect views of UNDP and UNEP. A special acknowledgment to the PEI team in Rwanda, Alexandra Lowe and all the consulted people for the help and the useful information to complete this report.

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Appendix 1. Provinces and districts in Rwanda

Province	District
Kigali City	Nyarugenge
	Gasabo
	Kicukiro
South	Nyanza
	Gisagara
	Nyaruguru
	Huye
	Nyamagabe
	Ruhango
	Muhanga
	Kamonyi
West	Karongi
	Ngororero
	Nyabihu
	Rubavu
	Rutsiro
	Rusizi
	Nyamasheke
North	Rulindo
	Gakenke
	Musanze
	Burera
	Gicumbi
East	Bugesera
	Rwamagana
	Gatsibo
	Kayonza
	Kirehe
	Ngoma
	Nyagatare

Appendix 2. List of variables we have used in our regression analysis

Variable	Definition	Unit	Typology
Y	Value of crops production	Rwf	Continuous
LAND	Quantity of arable land	ha	Continuous
IF	Households expenditures for inorganic fertilizers	Rwf	Continuous
OF	Households expenditures for organic fertilizers	Rwf	Continuous
TS	Households expenditures for traditional seeds	Rwf	Continuous
IS	Households expenditures for improved seeds	Rwf	Continuous
LABOUR	Number of workers in agriculture	Number of people	Continuous
EQ	Households expenditures for agricultural equipment	Rwf	Continuous
PEST	Households expenditures for pesticides	Rwf	Continuous
IRR	Irrigated land	%	Continuous
NPS	Non protected soil from erosion	%	Continuous
NONED	Non educated agricultural workers	%	Continuous
PROV	Province		Categorical variable (dummy)

Appendix 3. List of consulted people and attended events.

Person	**Role**
Innocent Musabyimana	MINAGRI. Program manager Land Husbandry, Water Harvesting and hillside irrigation project
Elias Baingana	MINECOFIN. Director General of national budget
Venuste Ruhigana	RADA. Professional in soil analysis and conservation
Henk Breman	IFDC – Catalyst project
Bruce Smith	IFDC – Catalyst project
John Kanyangoga	Consultant
Yvette Mukarmewa	Director Member services and communication. Private sector federation.
John Bosco	Private sector federation. Program officer Agriculture association.
Norbert Sendege	Managing Director RADA.
Fabien Ntilivamunda	RADA. Fertilizers expert
Diane Karusisi	National Institute of Statistics Rwanda
Azene Bekele	MINAGRI. Technical advisor
Alex Mulisa	Consultant
Cornelius Kazoora	Consultant. Sustainable Development Centre
Steve Wiggins	Research fellow. Overseas Development Institute
Loraine Ronchi	World Bank
Celestin Ukozehasi	Researcher. University of Kigali.
Rose Mukankomeje	Director REMA

Attended events in Kigali.

27/4/2010 15h. First meeting of the agricultural intensification and privatization sub committee. Agricultural sector working group. Hotel Beausejour. Co chairs: Francois Nsengiyumva, crop intensification program director and Bruce Smith IFDC – Catalyst.

28/4/2010. Meeting with REMA team to understand the impact of the CIP on the environment.

List of acronyms

ISFM = Integrated soil fertility management

SOM = Soil organic matter

IFDC = International fertilizer development Center

CIP = Crop Intensification Program

WCED = World Commission Economic Development

MINECOFIN = Ministry of Finance and Economic Planning

MINAGRI = Ministry of Agriculture

GoR = Gouvernment of Rwanda

CDM = Clean Development Mechanisms

N = Nitrogen

P = Phosphorus

K = Potassium

C = Carbon