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The Effect of Livestock Production on Poor and Smallholder Farmers' Income in Rwanda. Case of 'One Cow One Family Program'

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"Are the poor just like you and me except in that they have less money, to invert Hemingway's famous line? Or is it useful to think of them as being subjected to different pressures from the rest of the population and therefore sometimes making choices that are very different?"

Abhijit V. Banerjee (2005)

United Nations University- World Institute for Development Economics (UNU-WIDER)

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List of Acronyms

$	US dollar
ATE	Average Treatment Effect
ATET	Average Treatment Effect for the Treated
ECD	Economics of Development
EDPRS	Economic Development & Poverty Reduction Strategy
GDP	Gross Domestic Product
Ha	Hectare
Hh	Household
HH	Household-Head
ISS	Institute of Social Studies
MFS	Mixed Farming System
MINAGRI	Ministry of Agriculture
MINECOFIN	Ministry of Finance & Economic Planning
NFP	Netherlands Fellowship Program
NISR	National Institute of Statistics of Rwanda
NNM	Nearest Neighbor Matching
NUFFIC	Netherlands organization for international cooperation in higher education
OLS	Ordinary Least Squares
PSM	Propensity Score Matching
RARDA	Rwanda Animal Resources Development Agency
Rwf	Rwandan Francs (Rwandan currency)
S.E	Standard errors
TB	Tuberculosis
TOD	Tabernacle of David Parish
UNDP	United Nations Development Program
WFP	World Food Program

Abstract

The paper analyzes the effect of rise in the number of livestock, cattle, on poor smallholder farmers' income in Rwanda through milk production and manure use as fertilizer. It collects primary data from both households that have received a cow and those on the waiting list of the program. By using PSM, the paper estimates crop difference between treated and control group as a function of manure use. Firstly, the result shows that there is a difference between the two groups in terms of crop production. However, the difference is displayed for limited crops. Land scarcity is a constraint for households to cultivate all these crops displaying difference; hence, lowering the effect of the program. Crop difference is small for the third quintile of land cultivated; hence, it casts light on the effect of the program for small landholders. Secondly, milk production does not cover the cost of feeding, specifically for the local breed called Ankole; thus, households resort to other means of feeding their cows. The cost of cow rearing affects the benefit from milk and the aggregate effect is lowered too. The most affected are households with less than 0.75 Ha which have benefited from Ankole cows. Thus, it highlights the implication of socio-economic conditions for gaining from any anti-poverty program.

Relevance to Development Studies

This paper contributes to development studies through its analysis of crop-livestock combination among poor and smallholder farmers by stressing on how it affects household's income. Analyzed separately, livestock and crop production can hide some important information to be considered for policies enhancement. The paper contributes by shedding light on the relationship between crop-livestock integration, smallholder farming, income and poverty. It highlights some facts for policies makers to break the poverty trap especially in rural areas.

Keywords

Mixed farming Systems, smallholder farming, Livestock, Income and Poverty

Chapter 1 : INTRODUCTION

The purpose of this research is to examine the effect of 'One Cow One Family Program' on poor smallholder farmers' income in Rwanda. The program aims at alleviating poverty by increasing households' production by combining livestock and crop.

Poverty alleviation is a long process and it has been a concern for the world and country policies for the last few decades (Ravallion 2004, Thomas 2000). While poverty can constrain economic growth, some countries have succeeded in fighting it though African countries, especially in Sub-Saharan Africa, seem to have failed (Bardhan and Udry 1999, Jayne et al. 2003, Ravallion 2004, Yamagata and Shiraishi 2009). Poverty in Sub-Saharan African is exacerbated by population rise specifically in rural regions characterized by agriculture as the main source of income (Gerhart 1986, Hirano 2009). Consequently, fighting poverty in Sub-Saharan Africa needs to focus on agricultural production improvement by using techniques that consider the effects of high population density on scarce agricultural land.

Rwanda is among the densely populated countries in Sub-Saharan Africa and has joined the process of combating poverty by initiating 'One Cow One Family Program'. The program aims at providing a cow to poor and smallholder farmers at households' level. The objectives of this program are related to increase households' income through milk sale and increment in crop production as a result of fertilizer use. Additionally, it aims to reduce malnutrition through milk consumption and promoting cohesion from passing on the first calf born to others in need. The program requires fulfilling strict selection criteria in order to be included. Those criteria[1] are defined at ministerial level; households are selected by community at village level and the scaling up of the program is determined by both local and central government budget constraint.

This program seeks to support poor households by making available fertilizer from cattle as a response to land fertility challenge. While households that benefit from this program have small land-holdings, lack of fertilizer seems to hinder also their agricultural production (Hirano 2009, Hyden 1986, Pell 1999, Powell et al. 2004). Since, chemical fertilizers are expensive; one way of increasing their production is the use of organic fertilizers from cattle's manure. Inversely, manure production from livestock depends on the type of livestock and mostly feeds. Thus, the combination of crop and livestock for poor and smallholder farmers may be hampered by their initial conditions. On one hand, they have to use the small piece of land for both cultivating crops and feeding the cow (Das and Shivakoti 2006, Thornton and Herrero 2001). On the other hand, access to chemical fertilizers is

[1] Criteria are discussed in chapter 2. See: http://www.rarda.gov.rw/IMG/pdf/ONE_COW_JULY2006_1_-2.pdf , Accessed on 26/08/2010, page 17.

limited by few means on their hand. Therefore, crop-livestock integration has to be analyzed carefully in the context of traditional smallholder farmers (Jayne et al. 2003, Norton et al. 2010).

When the program increases agriculture and livestock production, it will raise households' incomes. However, households will spend more on cattle feed thus negatively affecting their income. Furthermore, the program can have different results for households that benefit from it. Though they are poor, households are somewhat different. In the same vein, literature and empirical evidence show that poor female-headed households might be more vulnerable to poverty implications (Vecchio and Roy 1998). Consequently, fighting poverty must consider those aspects which can constrain efforts and thus reducing the expected results. Otherwise the process would have taken long time with fewer expectations. Based on issues raised, it is worthwhile to wonder specifically the extent to which the program has increased beneficiaries' crop production and what crops are mostly affected. Moreover, as the program distributes different types of cow, it raises the question about their different contribution to households' income by offsetting the cost of feeding the cow.

The analysis of the program's effect on households' income stresses on crop-livestock production integration. According to Norton et al. (2010:153) '*Mixed farming* usually involves a mixture of crops and livestock. Few farming systems in developing countries consist of just one commodity. However, what is meant by mixed farming is the integration of crops and livestock production'. Thus, 'One Cow One Family Program' is analyzed under Mixed Farming Systems (MFS) literature. The reason is that this literature considers advantages, opportunities and challenges of combining crop and livestock in order to decide what to produce at household's level.

For analyzing the effect of the program, the paper focuses on income because income is one of the poverty measurements and an indicator of standard living (Vecchio and Roy 1998:70-1). Even though the rise of income does not determine household's well being, it is believable that a household will hardly achieve a good standard level without an increase in income (Bigsten and Levin 2004). Therefore, this paper assesses the effect of the program on households' income by considering the rise of agriculture production resulting from fertilizers use. It also analyzes the benefit from milk production versus the cost of feeding the cow for determining how aggregate effect[2] outweighs the cost. Furthermore, it tries to determine the benefits and costs for differently headed households.

The paper contributes to existing literature by throwing light on the poverty alleviation program achievements. Moreover, the paper is among the first research evaluating the program under study specifically by using econometrics estimation for determining its contribution on households' income by considering the cost of feeding the cow also. This estimation seems to be important as it involves a control group in order to capture the counterfactual of the treated group. Hence, this paper brings insight on average treatment effect for the treated (ATET) than the average treatment effect

[2] By aggregate effect, the paper tries to combine the benefit from milk plus the benefit from cropping and then subtract the cost of feeding the cow

(ATE)[3](Imbens 2004:14). It adds also on the literature by bringing insights on crop-livestock combination for smallholder farmers, specifically in zero-grazing[4] structure. The findings of this paper can contribute to improving poverty alleviation programs by focusing on household's socio-economic characteristics.

In order to achieve its objective, primary data were collected from both households that have received cows and those waiting the scaling up of the program. The data collected concern mainly socio-economic conditions of the households, size, schooling, assets they possess, land cultivated, other types of livestock, crop production, sources of income and cost of rearing the cow. Additionally, information was obtained on milk produced based on different period of lactation and the price of milk from rainy season to dry season. The paper has used Propensity Score Matching (PSM[5]) for estimating the program's effect on crop production, while descriptive statistic has measured milk production and the cost of feeding the cow. Estimation results show that beneficiaries with cultivated land of less than 0.75 hectare would have benefited from other types of cow rather than local breed to increase their income.

However, this paper has some limitations to be pointed out because they may cast a shadow on its findings. As the program deals with poverty alleviation, it is believed that randomization and pre-intervention data collection tends to delay the program and has some drawbacks (Ravallion 2005). Thus, the paper has used only the current data collected because there was no baseline information. Additionally, the paper cannot claim to have captured all unobserved covariates of households. Hence, this missing aspect affects the results of the econometric model. Furthermore, as stated by literature, crop production is influenced by bio-physical and climate conditions. In this regards, this paper does not include some of these variables in crop production model. The reason is that, it would have taken longtime to get individual plot information. Therefore, I rely on district and sector dummy variables to capture the difference in terms of bio-physical and climate conditions.

The paper is structured as follows: A part from the introduction, the second chapter discusses background and poverty policies/programs in Rwanda, specifically one cow one family program perspectives and achievements. The third chapter concentrates on MFS and discusses crop-livestock combination and its effect on household's income. While chapter four describes data collection and methodologies used for estimating program's effect; chapter five reports the main findings and results and finally the conclusion as last chapter.

[3] The difference is that ATET is a difference between mean of the treated minus mean of the control after matching. ATE is a difference between the treated and the control before matching, often obtained from naïve estimation of the average treatment.

[4] Zero-grazing structure means that households cannot use a common place for grazing his cattle. It requires feed cattle by using grasses from your own means. This structure is driven by different reasons, especially land scarcity in Rwanda, environment degradation concerns experienced from common grazing in different areas. It has also an advantage of collecting manure easily from the cowshed.

[5] The paper has used Five Nearest Neighbors Matching (NNM) as one of the techniques of PSM. The idea of NNM is developed in chapter 4

Chapter 2 : BACKGROUND

The purpose of this chapter is to describe the process of poverty reduction in Rwanda by mainly considering 'One Cow One Family Program' which targets poverty alleviation.

2.1 Context

Rwanda is a small landlocked country with 26,338 km^2 with a distance of 1600 Km from the sea. The country has a high population of nearly 400 people per Km^2 characterized by rural agricultural population. 90% of the population lives as farmers, with an average of less than 1 Ha space for cultivation. 'Eleven percent (2,849 Km^2) of the country is occupied by lakes, rivers, marshes, towns, roads and built up areas'. Thus, the called green land is about 23,487 Km^2 to be used for cropping, grazing and natural vegetation. While agriculture is the main source of food and income, the density on land in rural area is around 684 people per km^2 of arable land. Agriculture employs nearly 100% women and 88% of men from the total active population in rural area (Rutunga et al. 2007:435, Verdoodt and Van Ranst 2006)[6].

Additionally, poverty in Rwanda is more related to land possession that consequently affects food security as primary need (NISR and WFP 2006). Furthermore, roughly 32.1% of households are female headed with 66% living under the poverty line[7]. Through vision 2020, Rwanda plans to reduce the level of poverty level from 60.4% to 30%; meanwhile, the country seeks to increase GDP per capita from 220$ to 900$ in 20 years (Republic of Rwanda 2000). Therefore, Rwandan poverty alleviation has to consider its social and economic characteristics to achieve these objectives. One of the bottlenecks to this process is land holding. The table 2-1 shows land ownership and proportion per range of space in Rwanda.

Table 2-1: Land holdings per household

No	Exploitation area	Households	Percentage
1	Less than 0.25 Ha	264,835	15%
2	Between 0.25- 0.50 Ha	430,235	25%
3	Between 0.50 – 0.75 Ha	282,059	16%
4	Between 0.75 – 1 Ha	204,445	12%
5	Between 1 – 2 Ha	320,619	18%
6	Between 2 – 3 Ha	78,555	4%
7	More than 3 Ha	47,462	3%
	Total	1,628,210	93%

Source: RARDA, 2006

As the table 2-1 reveals, 68% of the total households in Rwanda has less than 1 Ha. From this share, one can see that 56% have less or equal than 0.75 Ha space for cultivation which is very small as

6 The reader can also check the Economic Development & Poverty Reduction Strategy (EDPRS) 2008-2010, www.minecofin.rw (2007), p.12

7 This information is found on Rwanda-UNDP website: http://www.undp.org.rw/Poverty_Reduction.html , visited on 06/10/2010

compared to the average of households size in Rwanda which is nearly 5.5 persons (NISR and WFP 2006). Though, the country has made some steps in the area of land distribution, it seems that as land possession declines, poverty increases. This can be supported by the fact that most of Rwandans base their lives on agriculture production. Therefore, lack of land may worsen poverty for households that rely on agriculture as the main source of food and income.

Though poverty characteristics are likely to be similar in Rwandan rural areas, it has some heterogeneity especially in terms of vulnerability of which different households are exposed. The most vulnerable households are female headed households, isolated head of household (widows, divorced or separated), households headed by illiterate people, household-headed by chronically ill people and households led by elderly people, above 65 years (Ibid). Thus, policy makers must take into consideration these individual characteristics of households in designing and implementing policies. One of these policies is one cow one family program which is among the largest in the country and discussed in the next section.

2.2 One Cow One Family Program

Although Rwanda has different poverty alleviation programs at different levels and implemented in various ways, this paper focuses on the 'One Cow One Family Program'.

2.2.1 Overview[8] and Objectives

As stated above, this program aims to fight poverty in Rwanda by increasing crop and milk production. It has been adopted by ministerial cabinet decree on 12/04/2006 and it is expected to end in 2017. The program provides a cow to a poor household for supporting crop production via manure use as fertilizer. The cow is also expected to provide milk for sale or consumption to reduce malnutrition. The program targets 257,000 poor households classified as such by the Ministry of Economic Planning and Finance in 2002 and it has the following objectives:

- Reduce poverty because the cow gives milk for consumption and the surplus can be sold and then generate income;
- Support crop agriculture by providing manure used as a fertilizers
- Contribute to soil protection because farmers are advised to plant pastures on terraces to reduce soil erosion and use them for feeding the cow
- Promote social cohesion by passing on the first heifer to another household
- Reduce malnutrition through milk consumption as malnutrition is an eminent concern

[8] The main ideas is found in RARDA (2006)

In order to benefit from the program a household is required to fulfill strict conditions which are considered as the minimum requirements for allowing the cow to facilitate the achievement of the objectives. The following are required conditions:

- The beneficiary should not be owning a cow
- The beneficiary should own less than 0.75 Ha of land
- The beneficiary should have prepared at least 20 acres of pasture (Napier for grasses) or households that are close to each other should have set aside and planted pasture
- Have a simple structure to house the cow (cowshed)
- The beneficiary must show the mechanisms for water harvesting and conservation for the animal
- The beneficiary must have at least two pits near the homestead and shows good care for the environment
- Household selected have to control soil erosion on his land or the ability to show where anti-erosion measures will be constructed, it will be accorded special advantage
- The head of the household must be integral, attending gacaca courts (community justice) and other government programs
- The head of the household have to cultivate the suitable crops to his particular area (RARDA 2006).

The selection process of beneficiaries is done at community level (*Umudugudu*). Members of the community meet, based on criteria discussed; they select households that deserve to benefit from this program. The selection process is attended by local leaders and in some cases by ministry staff. In most cases, the selection is done once and the beneficiaries are randomly listed. As a matter of impartiality and due to budget constraints, beneficiaries are to be given the same chance of benefiting from the program. The first household on the list is the first served if the household satisfies the defined criteria. Therefore, lists of beneficiaries are updated every time there is a need to provide cattle. The update is again done at community level because some of the households selected at the beginning may have moved out of criteria through other interventions. However, there has been some misallocation cases related to nepotism.

Before obtaining the cow, all beneficiaries are trained on basic skills about pasture establishment, housing, feeding, watering, disease detection and control. Furthermore, technicians select the cow for distribution and test them on health issues, that is, animals have to be TB and Brucella negative and are then synchronized and inseminated. Furthermore, cows are monitored by sector veterinary staff. The training of farmers is supposed to be continuous until the beneficiary has passed on gift to another household. The type of cow distributed would produce 10 liters of milk from which nearly 7 liters are sold. The lactation length is expected to be 9 months and this cow could produce 20 tons of manure per year. The quantity of manure will help as fertilizer and it is a combination of droppings, urine and grass bedding.

Moreover, officials have tried to estimate in money terms the benefit of this program[9]. The benefit comes from milk sale plus the quantity of manure estimated through a shadow price. For a household whose cow produces 10 liters, it is expected that 7 liters are sold and valued at Rwf 200[10] per liter. The value of the milk during lactation length is estimated at Rwf 378,000. Additionally, the benefit from manure is counted for 20 tonnes equivalent to Rwf 10/kg of manure; that is Rwf 200,000 ($357). Subtracting the cost of drugs estimated per year to Rwf 55,000 ($98), beneficiary will benefit nearly $582 for only milk production and $939 including manures' shadow price. The point of the paper is that the calculation is very ideal because it takes the extreme of benefit from milk production and even manure value seems to be extreme because it counts for manure rather than crop increment. This analysis may be misleading as it excludes the cost of feeding the cow. This benefit has been analyzed further in this research by considering the type of cows and the effect of manure is captured through crop difference between treated and non-treated.

2.2.2 Program's Cows Distribution

Since the program has started in 2006, it has distributed nearly 88,001 cows up to 2010-11. The tables below summarize distributed cows from 2006 up to 2010-11 per Provinces and per race.

Table 2-2: Distributed cows per Provinces

Provinces/year	2006	2007	2008	2009	2010	2010-11	Total
North	648	1,384	3,567	6,557	411	-	12,567
East	102	4,191	12,189	6,094	1,745	-	24,321
West	463	3,005	3,552	16,151	304	104	23,579
South	1,561	5,028	8,924	9,764	363	393	26,033
Kigali	236	331	467	375	92	-	1,501
Total	**3,010**	**13,939**	**28,699**	**38,941**	**2,915**	**497**	**88,001**

Source: RARDA, 2010

The table 2-2 summarizes the number of cows distributed in 5 provinces of Rwanda. It is obvious that cows distributed have increased from 2007 to 2009 as the percentage moves from 16% to 44% per year, but the percentage started to decrease to 3% in 2010. From the beginning, as explained by officials, the government has distributed many cows of local breed in order to achieve more households targeted. Additionally, development partners have also begun to intervene by distributing cows, mostly local breed. Accordingly, local breed represented 74% of the 94% known types of cows distributed till 2010. However, by 2009, the program has stressed on distributing other type of breeds for facilitating households to produce more milk; thus the number distributed has declined.

[9] Estimation is obtained from a booklet obtained from Rwanda Animal Resources Development Agency (RARDA)

[10] The conversion is done by considering the official rate of $1= Rwf 555.

The idea behind that decrease was the promotion of breeds that can produce more milk as compared to local breed. Officials I contacted have acknowledged that local breed and cross breed produce little quantity of milk and this can negatively affect the results expected from the program. Consequently, the program has decided to provide improved breeds like Jersey, Friesian and Pure Sang for increasing milk production. Importantly, improved breed was not the only priority after 2009 but also establishing monitoring and control framework for constraining mismanagement that occurred. The next table shows different types of cows distributed, even though some information on improved breed is missed.

Table 2-3: Distributed cows per race

Race/year	2006	2007	2008	2009	2010	Total	%
Local breed (Ankole)	0	10,837	19,961	30,128	0	60,926	73.7
Cross breeds	200	2,376	7,330	8,741	704	19,351	23.4
Pure sang	139	0	1408	72	-	1,619	2
Jersey	0	381	-	-	-	381	0.46
Friesians	0	345	-	-	-	345	0.41
Total	339	13,939	28,699	38,941	704	82,622	

Source: RARDA, 2010

2.2.3 Program's Misallocation and Redistribution

Though the program has distributed a large number of cows, targeting error was high. Some cows were misallocated and given to undeserved households. The reasons will be discussed below. The next table summarizes recovered and redistributed cows per Provinces.

Table 2-4: Misallocated, recovered and redistributed cows

Provinces	Cow Distributed up to 2009	Misallocated	% of misallocated	Recovered and redistributed	% of redistributed
North	12,371	4,086	38	4,041	99
East	22,840	9,342	45	9,135	98
West	6,822	2,646	39	2,494	94
South	11,698	4,054	34	4,049	99
Kigali	988	404	41	404	100
Total	54,719	20,532	38	20,123	98

Source: RARDA, 2010

The table 2-4 shows a mis-target as one of the most failure aspects of this program. The program has reached nearly 88,001 households during the last 5 years has spent roughly Rwf 7.95 billion from government funds[11]. However, a misallocation was 38% of the total cows distributed until 2009. This aspect has been discovered at the end of 2009 while the program has already reached 54,719 beneficiaries. For the total of the 30 districts of Rwanda, on average every district has misallocated nearly 684 cows[12]. Additionally, this misallocation has different degrees among different districts. Three districts have nearly tripled this average; while 5 of them seem to be around the average. It is important

[11] The paper could not obtain other partners budget spent for this program. The amount is for the government side only

[12] For details, see appendix A (tables 2.1 & 2.2).

to note that Bugesera[13] is among these districts that have tripled the average, 41.3%; while Kamonyi District has a half of this average, 19.4%. As, the two districts are the research areas of this paper, it appears that, at district level, they have managed the program differently.

Since 3 years of the program implementation, it is tricky to determine all causes behind that misallocation. During this research, I tried to find out what the main causes of this misallocation are. By discussing with some of the community leaders and some beneficiaries, it was found that the selection criteria were tough to be meet by poor households. It seemed that community decision was fairly done in accordance with the conditions one would require to fulfill before receiving the cow. On the other hand, nepotism, influence of leaders and lack of monitoring and coordination system were factors among other things that have influenced this misallocation. Paradoxically, some households that were considered as undeserving the program by recovering process have again been listed for the program as poor. It can be proved that criteria inconsistency is implicitly recognized by the draft report about the exercise of program's cow recovering where the report recommends that 'for the program to benefit the people it is intended to help move out of poverty, there should be "*Igikumba*" model of animal husbandry where a group of people with no land or little land can collectively own a cow and share its benefit with the support of Districts and RARDA' (RARDA 2010:11).

The paper considers that the program's conditions are difficult to meet for poor households. It sound that, though some requirements such as land protection are important for stabilizing agricultural productivity (Rutunga et al. 2007), the program has set up criteria without considering the capacity of poor household to fulfill to these conditions (Pell 1999:346). For instance, protecting land against erosion can be an action that requires strong labor or money. Thus, the program would have expected that all poor cannot manage to protect their land. Secondly, one can think how the poor could establish water harvesting and conservation mechanism. Moreover, it would have been better to check the implication of considering integrity as a condition for benefiting from the program because it happens that a poor will somewhat misbehave just due to its background or with connection to poverty. Though selection criteria may facilitate the program to achieve its objectives; by requiring such conditions, the program may exclude some poor households.

The paper esteems that relying only at criteria defined could not suffice to identify the possibility of the household to rear the cow. Additional households' characteristics would have been determinant to select poor who deserve the program. In addition, the program has considered poverty as having the same implications on all households (Pell 1999). Some important aspects of poverty were not considered while they can shed light on what would be the best intervention for dealing with their poverty.

[13] Bugesera district is part of Eastern province, with an area of **1,337 Km²**; while Kamonyi is part of Southern province, with an area of **655.5 Km²**.

Chapter 3 : ANALYTICAL FRAMEWORK AND LITERATURE REVIEW

This chapter aims to review the theory on Mixed Farming System (MFS) in order to investigate whether crop-livestock combination can contribute to increasing smallholder farms' income through different activities of their assets.

3.1 MFS Perspectives

Without a detailed discussion on poverty alleviation perspectives, strategies and implication of policy choice (Bardhan and Udry 1999:132), the paper analyzes the one cow one family program under income redistribution perspective and its implementation as social-safety net strategy aiming to increase assets ownership (Dagdeviren et al. 2004, Dollar and Kraay 2004, Hill 1993, Moser 1998, Ravallion 2004, Shorrocks and Hoeven 2004). Therefore, the use of the cow can enhance the way of mixing assets for better production. The idea introduced matches closely with MFS for the long run use of cattle.

For the sake of clarification, it is worthwhile to highlight that farming system approach is a way of approaching agriculture in order to understand its components and parts. As stated by literature, 'A farming system is any of unit(s) engaged in agriculture production as it wedded in a social, political, economic and environmental context' (Brush and Turner II 1987:13). Furthermore, human, technical and institutional are main factors that determine what sub-system farming to be applied in given region and explain the decision of what can be produced (Norton et al. 2010). Farming system is divided into different sub-systems, shifting agriculture, pastoral nomadism and settled agriculture. From different farming sub-systems, MFS is under settled agriculture and existed for long time (Scoones and Wolmer 2002). Characterized by a combination of crops-livestock in order to maintain soil fertility, MFS is seen as a traditional way of dealing with agriculture, though, it is somewhat considered as efficient and riskless among other traditional agriculture means (Ibid). This interaction is mostly undertaken under evolutionary model[14], considering that population rise tends to scarce land but also, it can be seen as a means of supplement human labor (Brush and Turner II 1987:18, Powell et al. 2004). The next section discusses crop-livestock integration and its advantages on households' production.

[14] MFS is an evolutionary approach based on the evolution of population at different time of period as compared to land per capita holdings. Land tenure becomes a concern if the population is still increasing, thus inducing land scarcity. The use of manures, fodder and crop residues are considered as alternatives. See Scoones and Wolmer (2002:6-12) for more details.

3.2 Livestock, Agriculture Production and Mixed farming System

Agricultural productivity constitutes a concern for smallholder farmers and a pillar for food security in developing countries. Thus, the role of livestock[15] in MFS is determinant, especially in a context of land scarcity, for agriculture production sustainability. Smallholder farmers choose MFS because it provides manure for soil fertility and hence contributing to increasing agriculture production. Therefore, livestock can increase or sustain agricultural productivity because livestock manure is a cheaper source of fertilizers as compared to chemical fertilizers for the rural poor households (Norton et al. 2010, Powell et al. 2004, Scoones and Wolmer 2002). However, manure application can cause negative effect of burning crops in case of low and erratic rainfall if not well applied. Hence, skills of manure application are important (Herrero et al. 2009, Powell et al. 2004).

Organic fertilizers from livestock cannot completely be substituted for inorganic fertilizers as literature shows that the combination of both seems to be more productive (Pell 1999, Powell et al. 2004). Additionally, crop-livestock integration does not require only land and livestock but it requires users to have some technical skills for making the combination efficient. This mixture depends on collection of manure, storage, conservation and spreading technique (Herrero et al. 2009). Thus, livestock is determinant in MFS because increasing agriculture production has different implications on households' livelihoods. Some of these implications are reducing hunger, improving food security, change in health situation, and increase in income; hence poverty reduction (Ter Braak et al. 2009).

Besides providing manures for improving agriculture, livestock is a source of milk and meat. The two products are important in human life as they contribute to strengthening human physical capital. The increase of population and urban areas has been seen as a key factor of raising demand of milk and meat (Hemme and Ndambi 2009). Consequently, the increase of demand would profit livestock producers if they manage to seize these opportunities. Furthermore, milk consumption is important for poor households, though they hardly access them, as stated by Ndambi discussing the case of some African countries (Ibid). Worthwhile, one can consider that providing livestock, its products consumption are socio-cultural determined and mostly constrained by lack of income. Moreover, while probably inapplicable for smallholders, livestock can be a source of draught power (Das and Shivakoti 2006).

Moreover, livestock constitutes an asset for production and a means of insurance against shocks. It can serve for religious and social obligations too (Powell et al. 2004). The asset aspect seems to be overlapped with the way livestock is combined with agriculture. But livestock can be seen as an

[15] For the purpose of this paper, livestock discussed is cattle (cow).

asset that provides money; for example by selling it and then get money for different production matters. In this case, livestock is considered as less valuable and easily sold as compared to land. In terms of insurance mechanism, livestock is considered as a buffer stock when an unexpected shock occurs. For many idiosyncratic shocks, livestock are supposed to be practical for solving the problem as household can resort on it for dealing with the shocks.

3.3 Mixed Farming System and Household's Income

Livestock contributes to households' income in different ways. One way is increasing agricultural productivity of smallholder farmers through soil fertility or draught power. Additionally, livestock can contribute to increase income by counting the value of milk sale, meat or livestock as an asset (Hemme and Ndambi 2009). Furthermore, money gained can serve also for increasing production through purchase of some fertilizers inputs (Ashby and Pachico 1987, Powell et al. 2004, Thornton and Herrero 2001). The contribution of livestock to households' income seems to be very important for smallholders who cannot increase their productivity by other means. Literature shows that MFS can be more profitable for small farmers as compared to large scale farmers and hence contribute to eradicate poverty. As supported by literature, milk productivity increases as the farm size declines; thus, medium and small scale farmers are likely to produce at the same level (Das and Shivakoti 2006, Ter Braak et al. 2009).

Therefore, the rise of income can contribute to poverty reduction as Gerhart (1986:59) states that 'if we are concerned about eradicating poverty in either urban or rural area sector of the developing countries, we must be concerned with increasing agricultural productivity', hence income increase. However, crop-livestock integration can have some limitations as the land get scarce. Spreading manure or plowing will certainly require a minimum land. Therefore, land will serve as a source of livestock feeding meanwhile as cropping source; hence, narrowing both livestock and crop production (Herrero et al. 2009, Pell 1999). The last dimension leads this paper to consider that the expenditure on livestock can be hampered by land scarcity, specifically for smallholder farmers (Jayne et al. 2003).

The contribution of livestock to agriculture productivity and increase in household's income depends on capacity of rearing livestock. For livestock to be as productive as intended there are many requirements to be met in terms of feeding and rearing, especially when land becomes scarce. Experience has shown that in many countries, scarcity of land is accompanied by different strategies of land tenure or land management. Among these strategies common grazing or transhumance[16] is

[16] Transhumance in this context is the seasonal movement of people with their livestock over relatively short distances, typically to higher pastures during off-peak grasses season. Probably the movement goes from the highland to lowland during the dry season.

forbidden (Ashby and Pachico 1987:217, Das and Shivakoti 2006). Banning common grazing seems to push farmers to move to zero-grazing structure as it is in Rwanda. The zero-grazing framework implies that households have to spend more on livestock feeding, shed and medication from their own means. Furthermore, land scarcity affects the capacity of feeding livestock; thus reduction of livestock number (Das and Shivakoti 2006). Reducing the number of livestock creates a problem of reducing assets and means of insurance (Brown et al. 2008). In some cases, household can decide to switch from more spending livestock to less ones. The other solution is to increase food availability by improving pasture of livestock. All these aspects must be considered for analyzing the role of livestock towards increasing income.

Livestock management capacity can be analyzed through possibility of getting grass by either using own land, money to purchase or labor availability to collect some roadside grass, dry maize stover, banana leaves or stalks. Less feeding affects livestock production like milk or meat as their weights reduces (Herrero et al. 2009). Money availability to purchase grass can emanate from milk, meat or some livestock (calves) sale, off cropping production or off-farm activities. These are different sources of income, especially for poor households in rural areas. However, using own land for cultivating grasses or collecting it in public spaces requires labor availability with opportunity cost. Collecting roadside grass from different public places, it requires unreliable grasses availability because that grass could not be sufficient for feeding livestock or just because it is not available or forbidden.

Livestock feeding may imply child and women labor because they are so concerned with that kind of work in rural household's division of labor; meanwhile, it seems more beneficial to men (Hopklns 1987:237, Mederios et al. 2010, Mupawaenda et al. 2009). Labor availability raises a concern of households' heterogeneity. Some households will face a problem of getting labor to be used for different purpose, include livestock feeding. These households can also suffer from lack of income diversification and thus being incapable of providing to livestock requirements because the control over income resources, in many cases, is dominated by male (Vecchio and Roy 1998). One example is female headed household with a large dependency ratio. These are aspects to be deeply analyzed to understand the role of livestock in a MFS.

3.4 Summary

This chapter analyzes how livestock can increase income of smallholder farmers through different combination of their assets. This increase can either be achieved by agricultural or livestock production. By considering different characteristics of poor smallholder farmers, especially in rural area, it appears that the role of livestock is important as it provides organic fertilizer. Lack of fertilizers hinders their productivity and reduces their expected income. An alternative solution to lack of inorganic fertilizers is the use of manure from livestock as organic fertilizers. Additionally, livestock can increase households' income through milk and meat production. Though livestock in MFS is important, it has some limitations for smallholder farmers.

Some of the limitations found in the literature are related mostly to the capacity of feeding and managing livestock. Households' socio-economic characteristics are largely the main constraints. The paper has discussed the capacity of feeding and managing livestock due to land scarcity, labor availability, and capacity of generating money to purchase grasses. In conclusion, literature shows that livestock can help to reduce poverty but should not be taken as a blueprint. Thus, it requires considering household specific context, otherwise, the effect of livestock cannot lead to expected results.

Chapter 4 : DATA COLLECTION AND EMPIRICAL STRATEGY

The purpose of this chapter is to explain the process of sampling and the methodology applied to estimate the effect of the 'One Cow One Family Program' on beneficiaries' income.

4.1 Process of Sample Determination

This paper uses primary data collected at households' level for estimating the effect of the program on households' income in Rwanda. However, some technical data like names and location of those beneficiaries, date of receiving cows and type of cow have been obtained from public offices. For reaching the objective of this paper, it required a collection of primary data from households by using a questionnaire[17] in two different districts, Bugesera and Kamonyi. The selection of the two sample district was driven by pragmatic reasons. Nonetheless, the two districts present one advantage to be considered for the analysis of this paper as Bugesera seems to be lowland, while Kamonyi is somewhat middleland. This characteristic seems important as highland faces leaching and nutrient loss; it can have a structure of land protection from which Napier grasses may be planted as compared to lowland (Herrero et al. 2009, Rutunga et al. 2007).

From the district level, a next administration level is the Sector entity. Sectors[18] were randomly selected because it would have been hard to collect primary data around the whole district. This paper has collected data from 3 sectors out of 12 in Kamonyi district, which are Nyarubaka, Musambira and Nyamiyaga. In Bugesera 4 out of 15 sectors were sampled which were Kamabuye, Mareba, Nyarugenge and Mayange. The number of sectors selected was also driven by practical reasons, based on the possibility of reaching households living in different places, as the settlement in Rwanda seems to be scattered.

The sample size analyzed in this paper is 333 households[19] from the two districts. The sample was randomly selected without replacement by using the list of cow's beneficiaries with small pieces of paper having the same number as these on the list, in order to determine which household will be in the sample. The sample size was also pragmatically determined as the two districts have many beneficiaries of the program and many others who are on the waiting list. The next table summarizes the sampling process per district.

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17 For more details, see appendix D-1 but the questionnaire was translated into Kinyarwanda (local language) for data collection

18 These are lower levels of public administration from the district and it is the implementation level of many government's programs.

19 The sample is composed by 210 households who have received cow and 123 households as control group.

Table 4-1: Households sampled

District		Households analyzed			Households excluded in the analysis				
		Treated	Control	Total	Cows recovered*	Cows dead**	benefit from other interventions*	Disappeared**	Total
Bugesera	Male	66	42	108	3	1	2	6	12
	Female	29	10	39					
Kamonyi	Male	62	43	105	2	2	1	2	7
	Female	53	28	81					
Total		210	123	333	5	3	3	8	**19**

Source: Author's calculation of sampling process summary

*****: households excluded were under control group sampled; ******: Households were under treated group sampled

The paper has used 2007 and 2009 lists of beneficiaries of the sectors selected and the waiting list of 2010-11 as they have already been selected to receive the cow. The treated population of both years was 353 and 369 for Bugesera and Kamonyi respectively. The control population was 106 and 123 in Bugesera and Kamonyi respectively. It is important to note that few days after the collection data, 144 cows were distributed in Kamonyi District as it will be reported in the table in appendices.

As livestock/cattle production in this context depends on milk production, 2007 and 2009 lists of beneficiaries were used for sampling because of expecting that the probability of calving is large for cows distributed in 2007. The research preferred 2009 list because it contains different breeds distributed than 2007, as the latter has mostly local breeds. For measuring the effect of this program, it requires to analyze the effect from different breeds. By including different breeds, the sampling process tries to find out the difference between households that have benefited cows in 2007 and 2009 as compared to the control group. However, some cases were excluded[20] in this analysis because of different reasons as reported in table 4-1.

A control group was required in order to ensure that the effect of cattle would not be gained from other variables other than the program. The paper has used 2010-11 waiting lists from the same sectors as a control group. The waiting list seems to have same characteristics with the treated because all of them were randomly listed by referring to the same criteria (Ravallion 2005:9). Moreover, the reader can recall that the program targets around 257,000 households, but it has nearly reached 34%; this percentage is so close to the first quartile, which implicitly means that this quartile might have large probability of having common characteristics. Additionally, data collection happened after the process of recovering and redistribution of misallocated cows. The paper considers that the remaining beneficiaries are similar in terms of socio-economic characteristics.

[20] Cases excluded are those reported in table 4-1. Some have their cows recovered and then I have found them on the list. The rest have got their cow dead, receiving cows from other interventions or I couldn't found them as they might have moved to other places.

4.2 Choice of Variables and Questionnaire

For reaching paper's objectives, I elaborated a questionnaire containing questions on households' socio-economic conditions, crop production, livestock production, expenditures on cattle, households' assets. The questions focused on the program's objectives[21] to capture their expected outcomes. The questionnaire concentrates on different crop produced for two different seasons, that is 2009B (March-June) and 2010A (September-January). Crop production of different crops was collected for all households in the sample to measure the difference between treated and control group. Between the two seasons, there is another called 2009C which seems to be unproductive because it is a really dry season.

Furthermore, the paper was also interested in milk production and cattle's expenditures, feeding, water and medication. Milk production was collected by considering lactation length and different periods from to peak to off-peak. The paper covers household's assets, other types of livestock, other sources of income and their amount, manure management and use, households' members and size, level of schooling of households' members. The idea was to cover as many variables as possible that make difference of households. The choice of variables has been driven by theory[22] and the Rwandan context. The variables used are reported in appendix C, table5.1 for OLS and PSM models. The paper expects that as these variables are controlled, by assuming that ecological and climate conditions are captured in district and sector dummies, the rest of effect can be attributed to the program. However, as a limitation, this assumption emanate from the lack on such data.

4.3 Descriptive Statistics of the Sample

The summary statistics of the dataset analyzed in this paper shows that most of the variables are similar for the two groups, treated and the control. After performing a T-test for all variables, it appears that means are not statistically different for most of variables, except the mean of crop production outcomes[23], variables related to cow and the variables reported in table 4.2. The purpose is to check whether the program is randomly affected to households selected. The table below shows the variables that have difference in mean while not related to expected outcomes of the program.

[21] The paper is interest on crop and milk production, on one hand; and feeding, medication and cowshed costs on the other hand.

[22] See (Thornton and Herrero 2001) for details.

[23] The crop outcomes with differences in mean are beans, cassava, peanuts and banana during the two seasons under study.

Table 4-2: Variables with differences in mean for the two groups

No	variables	Mean treated (1)	Mean control (2)	Difference (1)−(2)	T statistic
1	Ha of Napier grass planted	.1479524	.2299187	-0.0819663**	2.3470
2	Chemical fertilizers use	.2190476	.0894309	.1296167*	1.7813
3	Crop trader as source of income (Rwf per term)	309.5238	2154.472	- 1844.948***	2.8356
4	Helper masonry as source of income (Rwf per term)	1393.333	2979.675	- 1586.341*	1.8461
5	Numbers of pigs per household	0.1428571	0.3658537	-0.2229965***	3.6421
6	Trees plantation (Ha)	0.0284857	0.0164228	0.012063**	2.0649
7	Number of bicycles per household	0.3333333	0.2439024	.0894309*	1.7208

Source: Author's calculation from the dataset by using ttest x, by (treatment dummy variable)

*****: mean different at 10%; ******: mean different at 5% and *******: mean different at 1% level of confidence

From table 4-2, the T test reveals that the treatment is unlikely random because they are some variables with differences in means even though they seem to be unsystematic. As households have on average some differences, OLS can lead to inefficient estimates; thus the paper has reported it for comparison purposes with PSM. The details on T test are reported in the appendix B, table 4.1. As this section deals with descriptive statistics, the next table summarizes some characteristics related to households' size, members per age cohort and level of schooling.

Table 4-3: Households' size and level of schooling

Variables	Mean treated & Standard Errors	Mean control & Standard Errors
Head of Household Age	44.6 (11.8)	44.7 (10.5)
Household-Head education level (non education: 31 % of the sample)	.3047619 (.4614064)	.3170732 (.4672394)
Household-Head education level (Primary education: 60.4 % of the sample)	.595238 (.4920188)	.6178862 (.4878915)
H Members between 19 to 35 years	.8762 (1.2076)	.7967 (1.0936)
H Members between 35 to 50 years	.1905 (.4608)	.252 (.5521)
Size of the Household	5.6286 (2.1443)	5.5122 (1.5959)
Household's member in primary School	2.119048 (1.631074)	1.918699 (1.0112)
Household's members in secondary School	.4095238 (.7910412)	.3333333 (.7090361)

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard errors in brackets

Table 4-3 reveals that the households' size is 5.6 and 5.5 respectively for the treated and the control group. As it appears, the average age shows that the households' head are likely to be old in the context of Rwanda and this can be the cause of poverty in some circumstances. Household-head average age is 44.6 and 44.7 respectively for treated and the control group. The level of schooling for household-head is too low, less than primary for 91% of the respondents. Households in sample have nearly one child (male and female) at primary school level. The upper school levels (secondary, technical and university) seem to be very low in terms of average. Even though households have on average one member for the three category of age[24], 6-11 years; 12-18 years; 19-35 years, the level of school reported looks critical. The paper's focus on age cohort is reported in table 4-3 as they constitute households' labor for different activities. The next table and figure depict means in terms of areas cultivated and the main crop production outcomes.

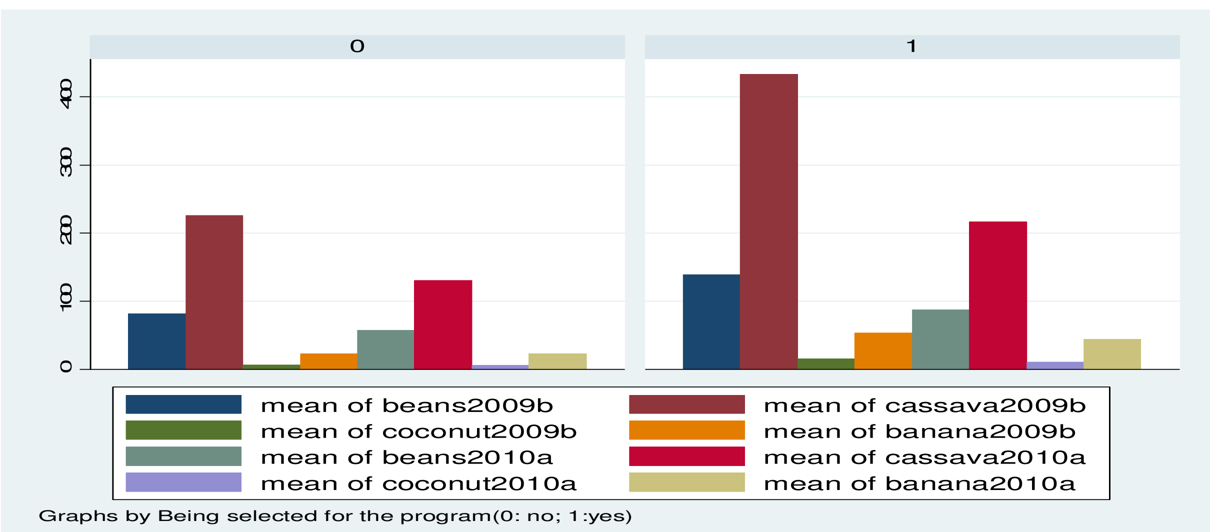
Table 4-4: Areas cultivated per seasons

variables	Mean & S.E 2009B: Treated	Mean & S.E 2009B: Control	Mean & S.E 2010A : Treated	Mean & S.E 2010A: Control
Ha cultivated/season (Hillside)/Season	.779 (.6596)	.7389 (.5755)	.7858 (.7149)	.7385 (.5788)
Ha of marshland cultivated/Season	.0182 (.0309)	.0153 (.0252)	.0165 (.03)	.015 (.0251)
Ha Progressive terraces (Land protection)/ Season	.5898 (.637)	.6351 (.6156)	.5898 (.637)	.6351 (.6156)

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard errors in brackets

Table 4-4 reports that areas cultivated on average are the same for the two groups and seem to be small. The table means that, on average, households under this program have cultivated less than one hectare as the selection criteria requires. However, the maximum land cultivated ranges between 3-5 Ha. The paper could not to capture the causes of this difference in the land.

Figure 4-1: Average crop production during season 2009B



Source: Author's calculation from the dataset by using sum syntax from stata 11.1. (0: control group; 1: treated group)

Figure 4-1 reports average outcome of crops that display the difference in mean. Obviously, the treated has yielded more, for the two consecutive seasons, as compared to control group. Cassava crop seems to display the large difference for the two seasons, followed by beans, banana and peanuts. It is

[24] See appendix B, table 4.1 summary statistics details.

important to note that other outcome variables are attached to this paper as appendices[25]. The difference in crop was expected resulting from manure use as fertilizers. The table 4-5 describes household's use of fertilizers.

Table 4-5: Use of fertilizers

Variables	**Mean & S.E (treatment=1)**	**Mean & S.E (treatment=0)**
Household use fertilizers (any kind 0:no; 1: yes)	.9905 (.0974)	.3577 (.4813)
Household use manures as fertilizers (0:no; 1: yes)	1 (0)	.3577 (.4813)
Household use chemical fertilizers (0: no; 1:yes)	.219 (.7762)	.0894 (.2865)
Times of spreading manures per season	1 (0)	.3577 (.4813)
Manures and chemical fertilizers mixed (0: no; 1:yes)	.119 (.3246)	.0569 (.2326)
Quantity of manure used per season in Kgs	805 (361.7)	290 (406.4)
Quantity of chemical fertilizers used per season in Kg	2.8429 (8.6095)	1.8415 (7.5548)

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard errors in brackets

Table 4-5 shows that 44 households in the control group have reported to use manure as fertilizers. However, they have on average reported to mix manure with chemical fertilizers less as compared to treated group as well as quantity. Though some untreated have used manure, their crop outcome is not different from the other members of this group. From the point of view of farmers, as Napier grass are planted for protecting lands against erosion; they exchange it for manure. Furthermore, from table 4-5 it comes out treated households use likely the same technique of spreading, conservation and storage of manure. They spread once before cropping season; storage of manure is a combination of grasses with droppings into the cowshed[26].

[25] See appendix B, table 4.2 for more details

[26] All households have pits to store manure from the cowshed. Droppings combined with urine and rest of grasses seem to improvement fertilizers

Table 4-6: Households' source of income and assets

Variables	Mean & S.E (treatment=1)	Mean & S.E (treatment=0)
Working as paid cropper last quarter (Rwf)	4838.095 (13768.85)	3203.252 (9066.204)
Number of goats/Household	.8714 (1.075)	.9268 (1.2425)
Number of Sheep/Household	.0667 (.3463)	.0244 (.1549)
Number of poultry/Household	1.1238 (1.6322)	1.1463 (1.5186)
House's roof and materials of construction (0:renting; 1:adobebricks+tiles;2: adobe bricks+ iron sheets;3:Trees+tiles;4:trees iron sheets; 5:Grass-thatched houses)	1.7667 (.9165)	1.6829 (1.1896)
Numbers of phone in the Household	.6095 (.6108)	.5041 (.5636)

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard errors in brackets

The table 4-6 gives an idea on households' assets in terms of other livestock rather than cattle, housing and one of the income sources, working as paid cropper. The means of the two groups are not different from each other after performing the T test. Thus, households have similar conditions on average. Additionally, households have few assets on average. For instance, households have nearly one goat; poultry and one phone per two households. House's roof and materials of construction are adobe bricks, trees with roof in tiles or iron sheets even grass-thatched. Moreover, crop trader and helper masonry reported in table 4-2 and paid cropper are the limited sources[27] of income for these households. Therefore, the three sources of income reported by respondents, only crop trader might be regular; while the two other are temporary because they depend on some weather conditions.

The summary statistics of variables regarding cow expenditures are discussed in chapter 5 as they are analyzed as part of the result discussion. The detailed summary statistics for all variables are reported in the appendices.

4.4 Model Specification and Econometrics Concerns

This paper has used econometric technique for estimating the effect of the program on households' income. It has estimated one model to assess the effect of the cow on agriculture production. This model specification is based on models and ideas by Pell (1999), Powell et al. (2004), and Thornton and Herrero (2001). Their common point states that economic, ecological and social subsystems are important for assessing the impact of crop-livestock integration and none of the three must be ignored. The subsystems encompass aspect related to land slope, land depth, rainfall, temperature, and manure nutrient and farmer management as important factors for agriculture productivity.

[27] Their standard deviations are so wide as compared to mean. The reason is related to its distribution (Some gain more, while others obtain less) and few have reported to get income from these sources: 20; 38 and 60 respectively for crop trading, helper masonry and paid cropper.

Even though bio-physical and climate conditions are important, this paper assumes that these conditions are similar in a given district, especially when including sector fixed effect. This statement is supported by Tang et al. (1992:213) stipulating that 'Climate and soil are fixed properties for a given region and, in combination with management, characterize the land quality level'. Moreover, Rwanda has introduced a fitted crop policy supporting the selection of crops based on temperature and rainfall regimes (Verdoodt and Van Ranst 2006). Thus, a crop production model includes land management and socio-economic variables of households.

PSM is the methodology preferred for evaluating this program, while OLS has been used for comparing the results. The choice of this method is driven by the fact that one cow one family is an anti-poverty program that involves a purposive placement. Such placement can complicate the identification of all characteristics, observable and unobservable determining the program's selection. Consequently, the difference between the control and treated groups may be biased by the unobservable characteristics that influence the outcome through parametric models estimation. Therefore, this aspect can lead to suspect the validity of a linear regression model (Chase 2002, Imbens 2004, Ravallion 2005). Accordingly, PSM tries to match units for estimating the difference between the two groups rather than relying on parametric models; thus, reducing selection bias from unobserved heterogeneity.

PSM, as a non-parametric method, tries to correct the bias due the non-similarity of compared characteristics of units. As stated by Ravallion (2005:26),

> *This method aims to select comparators according to their propensity scores, as given by* $P(Z) = \Pr(T = 1 \backslash Z)(0 < P(Z) < 1)$*, where Z is a vector of pre-exposure control variables (which can include pre-treatment values of the outcome of indicator)'.The values taken by* Z_i *are assumed to be unaffected by whether the unit* i *actually receives the program.) PSM uses* $P(Z)$ *(or a monotone function of* $P(Z)$ *to select the comparison units.*

For a non-experimental assignment, comparators' characteristics may differ from the treated to the control groups. Hence, PSM constructs a balancing score called 'propensity score' based on the logistic probability assigned for each unit in the sample through logit regression. The likelihood is determined by conditional probability of being treated or not, given unit's characteristics. Thus, the method compares the units based on their balancing scores and finds close units of untreated to be compared to treated unit. The region where treated units can find similar untreated units is called common support region and it is the one that interests the PSM (Frölich 2007, Harding and Morgan 2006, Hirano et al. 2003, Imbens 2004, Rosenbaum and Rubin 1983).

For evaluating a non-experiment program, PSM generates a kind of social experiment analogue in which everyone has the same probability of being selected for the program[28]. Additionally, as pipeline[29] comparison, in this case PSM can solve the problem of missing baseline, non-randomization of interventions and leads to efficient estimates as long as the full set of covariates is matched with the propensity score (Galasso 2004, Hirano et al. 2003, Imbens 2004, Ravallion 2005:37-8, Rosenbaum and Rubin 1983). However, PSM does not indicate variables to be considered for evaluating a program, the quantity, quality and choice of variables are an important aspect and determined by theory or facts of the program (i.e economic, social and political factors of the placement).

Though the paper prefers PSM, the method has some pitfalls. Failing a baseline, it requires the outcomes to be independent towards the participation to the program given the set of variables, Z_i; thus, the outcome will also be independent towards the participation propensity score(Hirano et al. 2003, Ravallion 2005). This strict exogeneity requirement of all covariates may, sometimes, not hold. Hence, there is a bias room on PSM estimates as long as all unobservable differences among households cannot be captured. Secondly, the quality of data may be a source of concern for this method as the respondents do not record their production; thus affecting their accuracy. As PSM has different techniques, none of them is advised as the best; thus, one can rely on comparing their estimates. It is also possible to worry about unobservable covariates, as they are hardly controlled though comparators are similar in terms of their propensity score (Harding and Morgan 2006:50-1, Mattei 2009:258, Ravallion 2005, Todd et al. 1998:262).

Agriculture production model: PSM model

(1) $ATET = E(Y_{ij}^1 - Y_{ij}^0 \setminus se = 1, Z_i) = E(Y_{ij}^1 \setminus se = 1, Z_i) - E(Y_{ij}^0 \setminus se = 1, Z_i)$

Where,

$ATET$: Average Treatment Effect for the treated

Y_{ij}^1: Crop revenue outcome i (say different crops cultivated)/season j if treatment=1

Y_{ij}^0: Crop revenue outcome i (say different crops cultivated)/season j if treatment=0

$se = 1$: Unit i is selected for the program

Z_i: Conditional variables (social-economic and land management characteristics).

PSM models are estimated by using total crop revenue per season or revenue/crop/season.

The paper tries to capture the difference of the outcome after the program being implemented as compared to the hypothetical situation of non intervention. As it is impossible to observe the two

[28] For details, the reader can check Ravallion (2005:29-9)

[29] Pipeline comparison uses 'as a comparison group people who have applied for a program but not yet received it'. For details, the reader can see Ravallion (2005:37-8).

outcomes at the same time, the difference can only be estimated by measuring the counterfactual aspect of the treated group through the outcome of the control group. From equation (1), it easy to estimate $E(Y_{ij}^{1} \setminus se = 1, Z_i$, while $E(Y_{ij}^{0} \setminus se = 1, Z_i)$ cannot be observed at the same time. Thus, it is advisable to estimate the counterfactual by using the control group conditional on a full set of covariates. The next step is to estimate the counterfactual by assuming independent covariates versus the outcomes. As stated by the literature (Todd et al. 1998:264) 'the outcome of self-selected nonparticipants $E(Y_0 \setminus D = 0, X)$ is often used to approximate $E(Y_0 \setminus D = 1, X)$'. In the case of this paper, D stands as conditional treatment, se.

(2) $E(Y_i^0 \setminus se = 1, Z_i) = E[(Y_i^0 \setminus se = 0, Z_i)$.

Because PSM has different techniques, this paper has used Nearest Neighbor Matching (NNM). This technique tries to find a non-treated unit j which is nearest to treated unit i in the distribution of the propensity score, $p(X)$ given the covariates. Thus, it seeks to minimize $\| p(X_i) - p(X_j) \|$.

Even though the paper has mainly reported NNM[30]-PSM, it has estimated also Kernel[31] matching and OLS models for robustness check. OLS models are estimates as follows:

- **Total crop revenue per season**:

$$Y_{ij} = \alpha_{0j} + \alpha_{1j} T + \alpha'_{3j} X_{ij} + \varepsilon_j, \text{ where } Y_{ij} = \sum_{k=1}^{8} y_{kj} \text{ and } y_{kj} = s_{kj} * p_{kj}$$

Y_{ij}: Total output per season, ($i = 1....333$; $j = 1,2$)

T: Dummy variable for treatment (treated=1; control=0)

X_{ij}: Control variables

ε_j: Error terms per season

s_{kj}: Quantity produced from different crops ($k = 1...8$)

p_{kj}: Price/crop/season

- **Crop revenue outcome per crop**

$$y_{kj} = \beta_{0j} + \beta_{1j} T + \beta_{3j} X_{ij} + e_{kj}$$

y_{kj}: Output per crop per season, ($k = 1...8$)

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30 NNM compares units from treated group to the closest in control group based on their propensity score assigned (Harding and Morgan 2006:32)

31 Kernel uses 'all control cases, but weights each control case based on its distance from the treatment case' (Harding ,and Morgan 2006:33) for details

- **Milk production estimation**

Milk production has been calculated by using the cost-benefit analysis. The reason is that, milk production can only be observable for the treated group because all households in the control group are on the waiting list and do not own a cow. The cost-benefit analysis is based on what the household has spent for feeding, water, medication and cowshed versus to milk production; bearing in mind that the effect of manure has been captured through agriculture production. This estimation needs only to use summary statistics from Stata 11.1 as costs and benefits are identifiable. The estimation of benefits has considered two approaches[32], the short run considering all treated households and long run approach taking only calved cows. The paper goes further by estimating the effect of the cows by considering the type of cow.

  - **Cost function**: Annual average cost of feeding because other costs are somewhat unpredictable or fixed
  - **Benefit function**: average milk production per day for different lactation periods times lactation length

- **Aggregate effect cow on household's income**

The aggregate effect of livestock on household's income is analyzed by adding up the difference from agriculture production, plus the benefit from milk, subtracted by the cost of feeding a cow. The analysis has considered the shadow price of grass as the cost of feeding the cow.

4.5 Limitation of the Paper

The methodology used to assess the effect of the program on households' income has some limitations. Firstly, for the scope and time allocated to this paper, it would not be possible to collect bio-physical and climate information on each household's plots. Though, the paper supports that household's plot information would capture largely the effect of bio-physical characteristics; nonetheless, such information was unavailable at the district administration offices. Therefore, the paper expects to capture this effect by district and sectors dummy variables. To test this statement, the paper has used rainfall[33] information at district level of 2009B season and proxies[34] of temperature, land slope, average humidity and thermo-radiation production to check the model sensitivity. It comes out that when these variables are included with district dummy in the model, the model maintains only one variable and

[32] The cow is analyzed in beneficiary's perspective and productive asset , i.e, the cow is received for free from the government; thus, its cost is not included in this model. Its value is also excluded as an asset, it will serve for production.

[33] Rainfall information is found in Operationalization of harvests and agricultural markets monitoring project (unjp/rwa/018/unj) magazine. Website: http://amis.minagri.gov.rw/sites/default/files/user/Bulletin_Mai_2009_-_EN.pdf, visited on 12/10/2010

34 The point is based on how Bugesera is lowland, while Kamonyi is middleland. Based on this aspect, I used information from Mbonigaba et al. (2009), caractérisation physique, chimique et microbiologique de trois sols acides tropicaux du Rwanda sous jachère naturelles et contraintes á leur productivité, Biotechnol. Agron. Socc Environ, 13(4):545-558

others are dropped. Secondly, the coefficient and level of significance were the same, whatever variable is included.

The program was implemented without baseline data on households' characteristics. Without a baseline information, the paper assumes that the only difference between treated and control groups is the intervention and expects strict exogeneity of control variables; even though, this cannot always be the case (Ravallion 2005). Additionally, the paper suffers from estimating residues effect on land fertility. This shortcoming is explained by the fact that crop residues can be used for different purposes among the two groups, feeding the cow or used as nutrients (Norton et al. 2010:138-40, Powell et al. 2004). Given the Rwandan context and based on respondents' information, the paper considers that almost all residues are used for both groups to the same extent. Moreover, livestock is socially valued as it makes the bearer to get a consideration in the community (Norton et al. 2010, Rufino et al. 2007). This aspect seems to be beyond the scope of this paper.

In summary, this chapter has discussed the process of sampling and methodologies applied for estimating the effect of 'One Cow One Family Program' on households' income. The paper has found that households' characteristics are likely similar, despites some variables displaying differences in mean. Consequently, the program has been assessed by relying mostly on PSM as long as the literature shows that they are efficient. However, OLS is used for comparing different results and robustness checking.

Chapter 5 : DISCUSSION OF RESULTS

This chapter discusses the findings of different estimations of the program's effect on households' income. The findings are reported in the next sections.

5.1 Livestock Production and Expenditures

Livestock analysis deals with weighted cost of feeding and milk revenue. As the price of Napier grass and milk depends on seasons, the rainy season has a lower price as compared to the dry season. Thus, the paper has weighted average prices by number of months[35] of each season. The procedure leads the paper to obtain the average price of milk per liter and the cost of a heap of grass. For understanding what types of cow the paper deals with, the table 5-1 summarizes the number of cows per race, those calved and the average lactation length.

Table 5-1: summary of cows, calved and Lactation length

Type of cows	Number of cows	Percentage per race	Number of Calved	Lactation length/Months
Jersey	11	0.05	6	6.5
Friesian	39	18.6	29	6.5
Cross breed	21	0.1	8	8.3
Local breed (Ankole)	139	66.2	90	6.6
Total	**210**	**100**	**133**	

Source: Author's calculation from the dataset of summary statistics using Stata 11.1

The table 5-1 shows that Ankoles represent 66.2% of the treated group, while Friesian occupies 18.6%. However, the rate of calving is high for Friesian, 74.3% followed by Ankole, Jersey and cross breed with respectively 64.7%; 54.5% and 38.1%. Additionally, average lactation length seems to be similar for all breeds, expect for cross breed with 8.3 months. The next table summarizes the benefit and cost of cows.

Table 5-2: Summary of livestock related costs

Variables	Mean if treated=1 (Short Run)	Mean: cow calved (Long Run)
Grass heap's Average cost (weighted by price per season) in Rwf	140.6 (25.2)	138.2 (26)
Annual grass heap's cost: (Average heap consumption/day*Average price/heap*30*12) in Rwf	**138,537** (42,886)	**141,970** (46,334)
Total milk per lactation (Average milk/day*30 days* lactation length) in liters	414 (572)	654 (599)
Total Revenue Milk (Avmilkday*30*milkpr*Lactation length) in Rwf	**60,604** (83,765)	**95,690** (87,902)
Total revenue of milk with 10 months lactation length (Average milk*30 days* average milk price*10 months) in Rwf	**83,616** (102,820)	**132,024** (101,485)
Observations	210	133

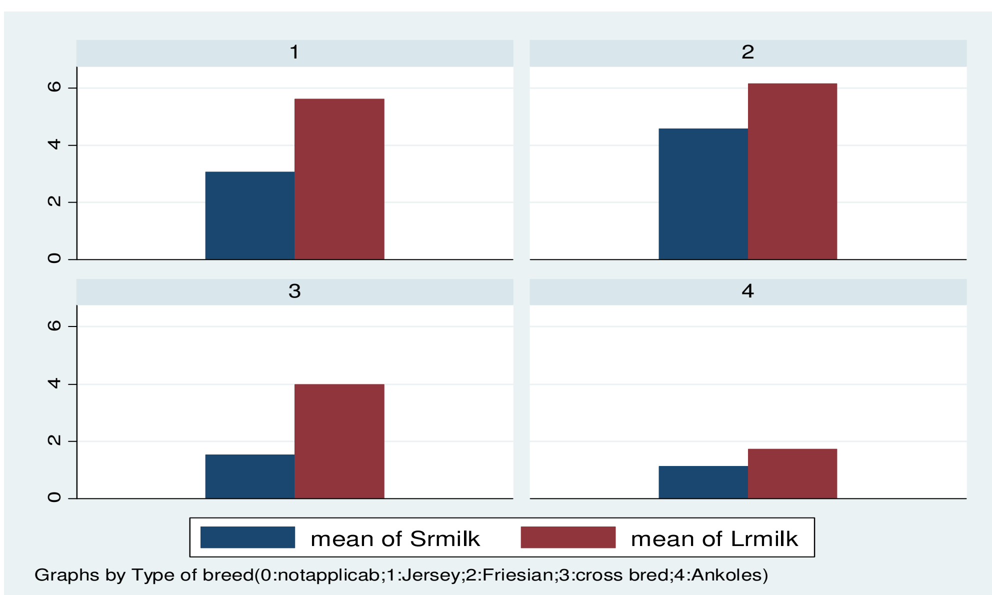
Source: Author's calculation from the dataset of summary statistics using sum syntax in Stata 11.1

[35] Rwanda has approximately 8 months of rainy season and 4 for dry season. The weighting has considered this aspect for obtaining the average price of heaps or liter of milk.

Livestock production as summarized in table 5-2 indicates that annual total cost of feeding a cow is Rwf 138,537; while the total revenue from milk is nearly Rwf 60,600 when considering treated group. Though this analysis deals with the short term, it sheds light on how costly rearing a cow is. The negative difference of Rwf 77,937 has to be covered by other means in order to feed the cattle. Additionally, the long run analysis assumes that all cows will calve based on the reported lactation length; it results on negative difference of Rwf nearly 46,280. Therefore, households have to resort on other sources of income, where crop sale is one of the options as stated by respondents. Additionally, as feeding is one of the costs, households spent nearly 234 hours per year for water collection as reported by respondents. Valued in money terms, the time spent for collecting water is nearly Rwf 35,000[36] converted in terms of hours worked per day.

The estimation has also analyzed the benefit and cost by taking different types of cow[37]. This estimation reveals that the gap is large mostly for cross and local breed's beneficiaries. The short run difference is nearly Rwf 100,000 and 82,000 respectively for Ankole and cross breed; while the long run negative difference of Ankole is around Rwf 82,000. Nonetheless, the long run milk production can cover the cost of feeding as they display positive difference approximated at Rwf 54,750; 24,000; 26,500 respectively for Friesian, Jersey and cross breed. Obviously, the quantity of milk produced is a drawback, especially for local breeds (Mapekula et al. 2009); hence, covering feeding expenditures is complicated. The figure 5-1 summarizes the average milk per race per day.

Figure 5-1: Average milk per type of cow type (liters)



Source: Author's calculation from the dataset by using Stata 11.1.

Srmilk: Short Run Analysis (All cows); **Lrmilk**: Long Run Analysis (Cow has calved).

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36 The estimation is based on the rate of casual workers in Rwanda which is approximately Rwf 1200 per day, i.e 8 hours of work.

37 The reader can see the appendix B, table4.3&4.4 for details on costs and benefits per cows, short run and long run analysis.

The paper has estimated the effect of the program considering the average milk produced within 10 months lactation length (Ilatsia et al. 2007, Mapekula et al. 2009) for checking the effect of this length on household's income. This estimation indicates that Ankole breed has a negative gap of nearly Rwf 60,500; while other types have a positive one. The paper expects that 10 months lactation length can be reached because some cows have 12 months lactation length reported. Therefore, many conditions have to be fulfilled in order to achieve this long run estimation and the short run casts light on what the impact of the program will be.

Even though the cost of feeding seems to be high to the extent that benefit from milk tends to be negative, feeding cattle in the context of Rwanda tells another story. As told by a respondent, the household used to combine cultivated Napier grass and roadside grass collected from public areas (forest, wetlands and even alongside the road). In this regard, respondents have recognized that they regularly collect a heap of roadside grass and combine it with Napier grass from their farms or purchased. 80% of respondents have reported to collecting such roadside grass. Thus, on average the time spent on roadside grass is one hour and half per day (Das and Shivakoti 2006:158). Collecting roadside grasses is motivated by cost reduction of feeding; though, it increases time allocation opportunity cost. On the other hand, roadside grasses are constrained during dry season and it affects even the cost of Napier grass to increase during this season.

Nonetheless, the reasons for combining roadside and Napier grasses are differently explained by farmers. Some argue that the combination increases the quantity of milk and makes it to be tasty as compared to Napier grass only. Secondly, collecting grasses seems to maximize their time allocation because they have small space to cultivating. Thus, they feel unoccupied for many times; so grasses collection does not alter their time management. This aspect has been acknowledged by local leaders and government officials as having an interesting effect because most of beneficiaries allocate optimally their time rather than rambling. But the explicit reason could be the lack of space to cultivate or purchasing grasses possibility by themselves as long as the time spent on roadside grasses can be allocated elsewhere and bring more income. However, there is a possibility that this combination of grass can harm milk production and cattle health (Rufino et al. 2007, Ter Braak et al. 2009:452).

Furthermore, roadside grasses and water collection may have an effect on child and women labor (Hirway 2010, Pearson 2000:386). Respondents have recognized that in some cases, children collect water and roadside grasses for feeding their cows. In this sample, 42 households have recognized that children spend on average one hour and half per day to collect roadside grasses. Additionally, in the Rwandan context, it is believed that water collection is a child or woman task. Thus, cow rearing might have increased time allocated by children and women. Though child work is out of paper's scope, it is discussed as part of cattle management and it can be subjected to further research of its effect on child schooling. From the previous analysis, the next section discusses crop production estimation.

5.2 Estimation of Crop Production

The paper has used NNM-PSM to estimate crop production difference between treated and control group. The findings are replicated in table 5-3 for the independent variable of interest, treatment. As stipulated, the dependent variable is the sum of each crop quantity produced multiplied by its price per season. Thus, the total revenue is the sum of all crop revenue produced during a season, 2009B or 2010A. The table 5-3 summarizes the main findings from PSM estimation.

Table 5-3: Crop revenue effect on households' income/Season

	Five Nearest Neighbor Matching: ATET				**Off support[38]**		**On support**	
Dependent variables	Treated (1)	Control (2)	(1)-(2)	T statistic	Untreated	Treated	Untreated	Treated
Crop revenue for season 2009 B	168,565	98,165	**70,400** (15,297)	4.60	0	35	123	168
Crop revenue for season 2010 A	123,223	71,800	**50,850** (16,019)	3.17	0	39	123	164

Source: Author's calculation from dataset used by using Stata 11.1 Standard errors in parentheses

Table 5-3 depicts the effect of the program on household's income from crop production. The result of this estimation performed by the PSM, five nearest neighbor matching (NNM) reveals that households treated have benefited nearly Rwf 70,400 during 2009B and Rwf 50,850 during 2010A. This difference can be attributed to the program because all households are expected to be in similar conditions after matching on set of covariates. Even though the paper has not controlled for climate and bio-physical characteristics, it assumes that their effects is the same at district level (Pell 1999, Tang et al. 1992). The findings are statistically significant and supported by the balancing test whose results are reported in appendix C, table 5.5. Thus, from this estimation, it seems that one cow one family program has influenced crop revenue of its beneficiaries. However, this effect is displayed by some crops as reported in the next table. The results for other crops can be found in the appendix B, table 4-2.

[38] For details on propensity Score histogram, the reader can check Appendix C figures: 5.1 & 5.2.

Table 5-4: PSM estimation of program's effect on total crop's revenue

Dependent variables	2009B Season				2010 A season			
	Difference in mean	T-statistic	On support		Difference in mean	T-statistic	On support	
			Control	Treated			Control	Treated
Beans Crop revenue (Rwf)	12,087 (3,224)	3.75	123	168	6,092 (3,521)	1.73	123	164
Cassava crop revenue (Rwf)	45,660 (8,949)	5.10	123	168	33,578 (11,783)	2.85	123	164
Peanuts crop revenue (Rwf)	5,424 (1,675)	3.24	123	168	4,813 (2,037)	2.36	123	164
Banana crop revenue (Rwf)	2,035 (1,123)	1.81	123	168	1,424 (724)	1.97	123	164

Source: Author's calculation from the dataset used by using Stata 11.1. Standard errors in parentheses

The table 5-4 indicates that the effect of program depends on type of crops because PSM reveals that almost four out of eight crops display the difference during the two cropping seasons. This stresses the importance of the program on these crops, specifically for districts under this research. Additionally, the sum of individual crops revenue effect seems to be low compared to the seasonal total crop revenue. This can be attributed to the estimation process comparing individual crop to total revenue from crop. Therefore, the reasons that determine such effect solely on some crops can be explained by many factors.

Although this paper's objective is to determine whether treated group could move out of poverty; worthwhile, it discusses shortly the process through which the program has had an effect on cropping. As the table shows, cassava, beans, banana and peanuts are crops that display differences between control and treated groups. By listening to farmers' explanation, there are three reliable reasons from which one can attribute the effect of the program on these crops. Firstly, the carrying distance from the village to the farm is determinant factor for spreading manure. In this regard, (Reck and Drechsel 1997:9) state that 'the major drawback for intensive organic farming in Rwanda is the availability of land and the labor needed to produce, obtain, or transport significant amounts of biomass'. Thus, household needs means and capacity to transport manure from their place to the field; explaining the reason of having on average many bicycles as compared to control group.

Secondly, there are some crops that need to mix organic with chemical fertilizers due to how they are cropped. Consequently, crops like potatoes, maize and rice are mostly cultivated in wetland; distant from the village and they often require chemical fertilizers that constitute a challenge for poor households (Powell et al. 2004). Thirdly, suitable crop policy per region seems to play an important role. Therefore, sorghum seems to take this advantage into the two regions though it is significant only for 2010A season. Cassava crop is somewhat obligatory cultivated and it has large difference among treated and control. Additionally, some crops like maize are intensively subsidized by the government by providing fertilizers; hence, households would not differ in case of subsidies. It is important to notice that many households do consume without record; hence, potatoes production estimation is done gradually for daily consumption. Respondents have recognized that its estimation differ from other crops in general.

Nevertheless, this whole effect cannot be achieved for all households in this sample. As land is a tough constraint for smallholders (Reck and Drechsel 1997), households do cultivate few of crops analyzed. Therefore, only 24 and 14 households during have respectively cultivated the four crops with difference in 2009B and 2010A. Otherwise; the summary statistics shows that 78 and 34 have cropped beans, cassava and groundnuts during the two seasons. Cassava and beans combined have been cropped by respectively 168 and 99 households during the seasons. The number becomes large if one considers solely one crop such beans and cassava as they are the main food and somewhat cash crop in Rwanda. Beans have been cultivated by 196 and 165 households; while, 180 and 116 households have cultivated cassava during the two seasons. Consequently, land constrains affects the program and may narrow the benefit from crop production. The next table depicts the effect of the program on the third quintiles of hillside land and household-head sex.

Table 5-5: Effect of the program on land third quintiles and different household-head sex

Dependent variables	**2009B Season**				**2010A season**			
	Difference in mean	T-statistic	On support		Difference in mean	T-statistic	On support	
			Control	Treated			Control	Treated
Third quintiles (0.75Ha): Crop revenue	43,680 (13,768)	**3.17**	73	103	15,791 (15,776)	1.00	71	103
Female-headed Household: Crop revenue	33,721 (33,083)	1.02	38	34	26,364 (35,192)	0.75	38	24
Male-headed Households: Crop revenue	72,558 (18,422)	**3.94**	85	97	75,947 (19,117)	**3.97**	85	97

Source: Author's calculation from the dataset used by using Stata 11.1. Standard errors in parentheses

As this paper expected to deal with households who own at most 0.75 Ha according to program's selection criteria, it has found that some households have cultivated more than the expected space by borrowing or renting land[39]. Thus, as the paper is interested on the effect of the program to this land owned, it breaks the hillside area cultivated into quintiles to capture the space required by the program. The stress on non-marshland area is driven on how marshland areas belong to the public management and its use is decided by public officials. Hence, households can face unexpected decision from officials about the use of marshland.

The results from table 5-5 show that for both seasons, the effect of the program on households whose maximum of land cropped lies below 0.75 hectare is small as compared to upper quintiles. The effect of the program gets reduced during 2009B season and even statistically insignificant for 2010A season. Even though, the effect has a positive sign, it sounds that the difference between the two

[39] These households may have used more inputs during cropping process other than family labor as assumed by this paper when considering crop inputs.

groups is thin such that they are likely to be the same in terms of crop production. Therefore, this estimation reveals that the effect of the program seems to be positively related to land cultivated (Eyhorn 2007, Jayne et al. 2003:260). That is, the larger the land cultivated, the greater the effect. This explains that marginal land is used for different purposes, grazing and cropping cannot produce differently, though it obtains fertilizers. Therefore, land owned by the beneficiary needs to be reviewed for the objective of program. The effect can be worse for female-headed household with small land.

As table 5-5 indicates, the effect of the program seems to be insignificant for female-headed households during the two seasons. However, the common support region of female-headed households estimation is small; thus, the results need a carefully interpretation because small sample size may bias findings. While significant for male-headed households, 2010A season estimate increases as compared to the total crop revenue model. Hence, it seems that running a model combining all households makes the effect of the program to decline, specifically for 2010A season. Therefore, it is possible to question the effect of this program on female-headed households. This paper considers female-headed households those headed by widows or women who never get married but have children. In this case, these households might be constrained by land access as their average cultivated differs downward by nearly 25% (Carswell 2002:130, Vecchio and Roy 1998:60). In addition, family labor can be squeezed for female-headed because they gain 50% less for the three other source of income (Mupawaenda et al. 2009, Vecchio and Roy 1998:19). However, other factors may explain this difference; the scope of this paper allows pointing some tracks from the respondent.

5.3 Robustness Check

The robustness check seeks to compare results from different techniques and see their difference. This comparison deals with OLS and Kernel Matching compared to NNM-PSM. While OLS use a functional form for estimating the effect of the program, 'kernel matching constructs the counterfactual for each treatment case, using all control cases, but weights each control case based on its distance from the treatment case' (Harding and Morgan 2006:33, Todd et al. 1998). The comparison of each treated unit, based on their propensity score, to all control units in the region of common support is the main difference between kernel and nearest neighbor matching. By doing so, kernel matching gives the estimates that draw the resemblance of all units under the region of support. The closeness of kernel and nearest neighbor matching sounds that all units in the common region support are similar to the extent of five nearest neighbor units in the case of this paper. The table 5-6 summarizes the results for total crop revenue per season.

Table 5-6: Effect of the program on total crop revenue/Season (models comparison)

Dependent variable	Kernel Matching				NNM-PSM		OLS	
	Difference in mean	T-statistic	On support		Difference in mean	T statistic	Coefficient of treatment	T-statistic
			Control	Treated				
Crop revenue for 2009B season	68,106 (15,144)	4.50	123	168	70,400 (15,297)	4.60	73,212*** (10,218)	7.2
Crop revenue for 2010A season	49,908 (16,020)	3.12	123	164	51,423 (15,990)	3.22	44,617*** (11,617)	4.0

Source: Author's calculation from the dataset used by using Stata 11.1. Standard errors in parentheses.

*** Statistically significant at 1% level of confidence

From the results reported in table 5-6, the effect of the program on households' income looks likely similar for Kernel matching, NNM and OLS. The similarity of models is supported by how all three models estimate are significant and close to each other, with probably closer standard errors for Kernel matching model and NNM. Additionally, the support region is the same for kernel and nearest neighbor matching. The difference can result from estimation technique used by each model to measure the effect of the program. The reader reminds that OLS uses unmatched observations and might have inconsistent estimates as stipulated above. Kernel matching estimates are slightly small compared to NNM but statistically not different for 2010A season. Thus, one could expect to obtain large differences if households' characteristics are different. Hence, households that have benefited from this program are somewhat similar and the treatment has a degree of randomness.

Thus, based on the robustness[40] check of its findings, the paper considers that the effect is attributable to the program. Besides limitations, the writer argues to rely on PSM estimates as long as the paper has controlled households' characteristics affecting the outcome. The table5-7 summarizes the comparison between the three techniques on land quintiles and household-head sex.

Table 5-7: Program effect on third land quintile and household-head sex (comparison of models)

Dependent variable	**Kernel matching**				**NNM-PSM**		**OLS**	
	Difference in mean	T-statistic	On support		Difference in mean	T statistic	Coefficient	T-stat
			Control	Treated				
Third quintiles (0.75Ha): Total crop revenue 2009B	45,384 (13,675)	**3.32**	73	103	43,680 (13,768)	**3.17**	48,608*** (9,735)	**4.99**
Third quintiles (0.75Ha): Total Crop revenue 2010A	11,135 (15,626)	0.71	71	103	15,791 (15,776)	1.00	18,414* (10,965)	1.68
Female-headed Household: Total crop revenue 2009B	49,216 (38,759)	1.27	38	33	33,721 (33,083)	1.02	42,485** (17,053)	**2.49**
Male-headed Households: Total crop revenue 2009B	73,565 (18,138)	**4.06**	85	97	73,234 (18,417)	**3.98**	82,663*** (14,368)	**5.75**
Female-headed Household: Total crop revenue 2010A	27,251 (40,827)	0.67	38	24	26,364 (35,192)	0.75	15,023 (18,711)	0.80
Male-headed Households: Total crop revenue 2010A	72981 (18,721)	**3.90**	85	97	75,857 (19,117)	**3.97**	62,330*** (16,106)	**3.87**

Source: Author's calculation from the dataset used by using Stata 11.1. Standard errors in parentheses.

*** Statistically significant at 1%, ** at 5% and * at 10% level of confidence.

[40] The paper has also estimated bootstrap standard errors for OLS, NNM and Kernel matching. All of the bootstrapped S.E are significant. Bootstrap technique allows one to gather many alternative versions of the single statistic that would ordinarily be calculated from one sample. See Appendix C (5.5)

The report from table 5-7 also indicates the similarity for the three different techniques used in checking robustness of the findings. The only large difference is displayed by OLS as expected; nonetheless, it is not as alarming. The different techniques still reveal that the third land quintile benefit less as compared to the upper quintiles[41]. Additionally, 2010A season seems to be insignificant again for this quintile. Though OLS displays a significant estimate at 10% level of confidence, its estimates are expected to be biased. Moreover, male-headed households are likely to benefit largely as compared to their peers female-headed. Kernel matching also shows that there is no difference between the treated and the control considering the female-headed households. As stipulated above, estimates of female-headed may result from estimation problems because the sample size is small.

In the same vein, the paper has found an interest in briefly discussing the effect of district and sectors' fixed effect as they capture the influence of bio-physical and climate conditions on crop production. As the reader can see in the appendices[42], Bugesera district dummy coefficient, though insignificant, is negative for both seasons. This sign reflects biophysical and climate characteristic of Bugesera as compared to Kamonyi district. The latter seems to be fertile after controlling for other characteristics (Verdoodt and Van Ranst 2006). Secondly, season 2010A displays a small difference as compared to 2009B. This could be explained by the fact that 2010A is a short crop season and close to the dry season in Rwanda; thus, farmers are faced with this as a common problem. Many respondents have confirmed that 2010A was inconvenient for crop production due to the dry season length. Furthermore, sectors' fixed effect is positive and significant for all dummies during 2009b season, revealing that the effect of soil and climate is positively related to crop production. However, the coefficients are negative and insignificant for 2010A season, meaning that this effect is mostly related to rainfall quantity.

5.4 Aggregate Effect on Households' Income

The aggregate effect of this program on households' income can be considered through the two approaches used in estimating milk production. The first considers the short run effect by analyzing all beneficiaries in the sample. The long run effect considers that all cows will calve and produce milk. For estimating program's aggregate effect, both approaches have included the difference in terms of crop production between the two groups under study. Though the paper has a limitation on inputs' cost for cropping, it assumes that poor and smallholder farmers do rely on family labor as the main input for cropping (Hemme and Ndambi 2009:991, Norton et al. 2010:262). Thus, by controlling for households' socio-economic characteristics, especially the age falling under the active labor force, one may

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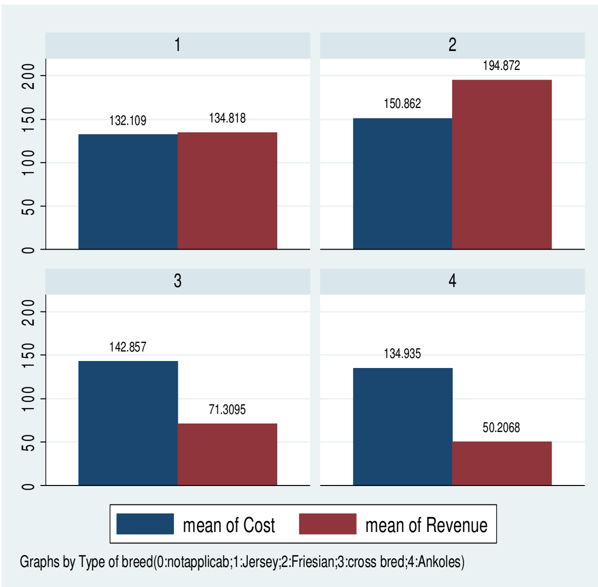
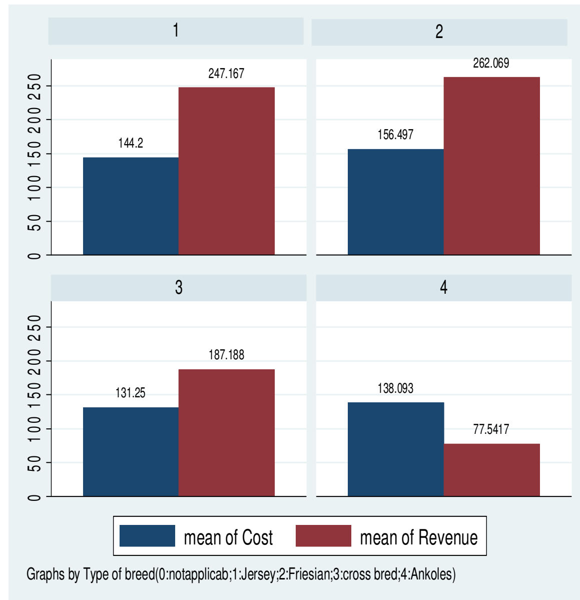
[41] For 2009B season, Kernel matching and NNM estimates are not statistically different each other.

42 The effect of district and sectors' fixed effect is reported in appendix C, table 5.1 the result discussed is from OLS model of the two seasons.

consistently think to have controlled the most part of crop inputs cost for smallholder farmers. The figure 5-2 shows the gap to be filled by other means for feeding the cow.

Figure 5-2: Short run and Long run analysis of milk benefit (10 months lactation length)[43]

Short run milk comparison of cost and revenue in thousands of Rwandan francs	**Long run milk comparison of cost and revenue in thousands of Rwandan francs**
	

Source: Author's calculation from the dataset by using Stata 11.1.

Mean of cost: the cost of feeding cow (Rwf); **mean of revenue**: revenue from milk (Rwf).

The figure 5-2 has considered 10 months of lactation length. From this figure, it appears that the cost outweighs benefit in the short run for both cross and local breeds. The gap between cost of feeding cattle and milk benefits is respectively nearly Rwf 70,000 and 80,000. In the long run, local breeds' beneficiaries have nearly a difference of Rwf 60,000 to be compensated by other sources of income. The short run shows a gap roughly equal to crop benefit from season 2009B. Furthermore, even the long run gap of local breed is slightly equal to crop benefit for 2009B season. The challenge is how to finance the gap of feeding cows. In this regard, 56% of beneficiaries have reported to resort to crop sale as the main source for feeding the cow, 24.8% borrow money; while 19.5% use income from milk sale. Hence, local breed beneficiaries seem to gain an amount equal to crop difference of season 2010A.

The aggregate effect becomes critical when considering households with less than 0.75 Ha. This quintile gains only nearly Rwf 44,000 for 2009B season because 2010A is statistically insignificant. Therefore, if the household has benefited local breed, it might be unable to cover feeding costs for both short and long run even though it adds up the crop difference. This is a puzzle for this program

[43] The graph depicts different types of cow, i.e 1: Jersey; 2: Friesian; 3: Cross breed and 4: Local breed. The graph compares cost of feeding (left) and milk production (right) for each type of cow.

because it aims to help households with at most 0.75 Ha. The implication is that these households would have benefited different types of cow than Ankole.

With regard to results in figure 5-2, the program seems to be interesting for beneficiaries of Cross breed, Jersey and Friesian cows. Households with Jersey and Friesian, in the short run, can cover the cost of feeding the cow by using milk sale even get a surplus. Moreover, in the long run these breeds can add an income of respectively Rwf 56,000; 102,000 and 106,000. Considering the average household, the annual per capita income increase in the short run is roughly $11[44]; 15; 37; 50 for Ankole, cross breed, Jersey and Friesian beneficiaries respectively. While the long run seems to be promising if all cows would calve and have 10 months lactation length, the annual per capita effect is approximately $19; 54; 67; 69 for respectively Ankole, cross breed, Jersey and Friesian. However, improved breeds require higher health conditions as compared to local ones, even though they seem to bring more income (Brown et al. 2008:187, Mapekula et al. 2009). Thus, the program has to consider this aspect and see how poor smallholder farmers can manage the cow before they produce milk.

The two approaches estimation has ignored medication cost, water consumption, and cowshed even though they seem to be unpredictable, time consuming and constant respectively in the context of smallholder farmers in Rwanda. Therefore, these costs are required conditions and have direct effect on the cow's milk production as they are part of its management. Many respondents have claimed that cowshed is expensive especially for households which cannot construct it by themselves. The average cost of cowshed is reported to be nearly Rwf 22,000[45] and it seems that this average is low according to conditions in which those cowsheds are as observed by the writer. Such cowsheds illuminate about housing conditions for some cattle under the program.

Even though this estimation has excluded some aspects of cow management, respondents have explained that local breed are less milk productive but they require few conditions as compared to improved breeds. Mostly, the cost of medication, water consumption and cowshed, improved breed are very demanding; although they produce more milk on average. The key question is what breeds to choose between the less milk productive with less requirements and the more milk productive with more conditions. The scope of this paper allows the writer to rise solely some challenges do face the beneficiaries of this program. The issue leads households to prefer cross breed as it is somewhere in the middle but the choice of improved can be an ideal as long as farmers are guaranteed cow management until it produces milk.

In summary, the chapter has discussed the findings of the paper and found that quantity of milk produced is the determinant factor for the aggregate effect of the program. Additionally, the program

[44] The effect is estimated by taking the total amount converted in dollar terms ($1=Rwf 600) divided by 5.5 average household size. The rate of currency conversion is nearly equals to that of market in Rwanda ($1=Rwf597), for details see http://www.igihe.com/, accessed on 15/10/2010.

45 The amount is roughly $ 37 by converting at Rwf 600=$1.

influences some crops difference. One of the reasons could be the distance between the village and farms, crops that do not require mixing chemical with organic fertilizer. The list can be extended by further research. However, this effect gets lowered when considering households which have cultivated 0.75 Ha. Expressing that land is a major constraint of crop production, though fertilizers available. The estimation has found that initial land fertility difference among districts may thinly affect crop production.

Chapter 6 : CONCLUSIONS

This paper has discussed the effect of the 'One Cow One Family Program' on beneficiary households' income by comparing treated and control group. The cow distributed to poor smallholder farmers aimed at increasing milk and crop production through fertilizers availability. By using control group, the effect of the program on crop production has been estimated by using NNM-PSM, while Kernel matching and OLS were used for comparing estimates. The paper has used descriptive statistics to estimate milk production and feeding cost as these costs are incurred by the treated group. The combination of crop difference and the benefit from milk deducted by the feeding cost constitutes the aggregate effect of the program. In the short and long run, aggregate results show that the program has a positive effect on households' income without including medication, cowshed and water costs.

The paper has found that livestock influences some crops production to increase; and different reasons may explain this difference. District's difference, distance from village, crops requiring combination of fertilizers, crop suitable policies are discussed as reasons affecting the difference in terms of crop between treated and control. There may be other reasons influencing the difference; the scope of the paper leaves the point to further research. However, as districts are not randomly selected, it can limit findings generalization to the whole country. Therefore, the findings throw light on crop-livestock combination challenges for poor and smallholder farmers in Rwanda and sub-Saharan Africa in general.

Furthermore, though lactation length is estimated at 10 months, the aggregate effect seems to be differentiated by type of cows. The program has small even insignificant effect for the third quintile of land cultivated, 0.75 Ha. The range is between $30-45 annual per capita income raise for other types of cow in the long run. The minimum is for cross breed, while the maximum is for Friesian. However, this estimation leads to negative effect when analyzing households that have benefited from local breed cows. These smallholder farmers may have lost probably between $12-5 respectively for short and long run per person/year (Jayne et al. 2003:270-1). Surprisingly, these are households targeted by the program with land criteria not exceeding 0.75 hectare. Accordingly, the result advises that the program would have distributed other breeds than local ones to these households.

As milk production is one of the means to compensate the cost of feeding the cow, the weight will be cumbersome if the cow takes long time before calving. Consequently, the cost will outweigh the benefit, especially for local cows' beneficiaries with small land. Thus, households would hardly compensate the cost of feeding the cow by relying on crop benefit. Nevertheless, though the analysis has excluded the value of the cow[46], households expect to have cows in the long run conditional on the

[46] The cow is considered as a productive asset, while it has its own value.

rate of calving; thus, they can sell some of them. However, the increase in number of cows will depend on households' capacity of rearing them. The rate of calving seems also to be slow because in the sample analyzed, 20.5% of the respondents have passed on to another beneficiary while 61% have benefited from the program since 2007.

Bio-physical and climate information are considered as limitation of this paper. The paper assumes that including district and sectors' fixed effect has narrowed this limitation because sampled households are likely from similar conditions in a given sector; thus, the crop difference may be attributable to program. The findings tell little about intra-households gains from the program; while some costs in terms of time spending may affect some groups in the households. This aspect is subject to further research and exploration. Therefore, the paper cannot guarantee the generalization of the findings but the results cast light on the weight of the cow rearing for smallholder farmers.

In conclusion, without considering the land ownership criteria, on average the program decreases poverty as it increase households' income. However, the pace seems to be slow when considering its daily per capita income contribution. Household's path from poverty will depends on how far the household is vis-à-vis the poverty line. Finally, the contribution depends on the rhythm of improving local breeds through insemination stated by officials as one of the priority to support households under the program (Ilatsia et al. 2007:125). Therefore, the paper still claims that there is a need of deepening this research for understanding some shadow areas pointed out. For instance intra-household benefit from the program is unclear as researchers have not yet undertaken this analysis in Rwanda. Consequently, lacking this analysis seems to cast shadow on intra-household's poverty alleviation process. Thus, the paper assumes that any impact of the program will affect all members as a unit; while, households' members may benefit differently from a program intervention and depending on how a policy/program is implemented (Norton et al. 2010:190-2, Thomas 2000:13).

Appendices

Appendix A

Table 2.1: Cows misallocated per district

No	District	Distributed cows	Undeserved beneficiaries	% of cows misallocated	Cows recovered	% of recovered and redistributed
1	Gasabo	431	171	39.7	171	100
2	Kicukiro	305	153	50.2	153	100
3	Nyarugenge	252	80	31.7	80	100
	Kigali Province	**988**	**404**	**41**	**404**	**100**
4	Bugesera	4,721	1,950	**41.3**	1,811	92.9
5	Gatsibo	5,862	2,094	35.7	2,094	100
6	Kayonza	1,221	234	19.2	234	100
7	Kirehe	3,853	1,330	34.5	1,330	100
8	Ngoma	1,323	1,251	94.6	1,251	100
9	Nyagatare	3,574	1,336	37.4	1,275	95.4
10	Rwamagana	2,286	1,147	50.2	1,140	99.4
	East Province	**22,840**	**9,342**	**45**	**9,135**	**98**
11	Karongi	1,203	439	36.5	411	93.6
12	Ngororero	1,198	400	33.4	400	100
13	Nyabihu	726	364	50.1	252	69.2
14	Nyamasheke	554	67	12.1	67	100
15	Rubavu	901	522	57.9	513	98.3
16	Rusizi	652	341	52.3	341	100
17	Rutsiro	1,588	513	32.3	510	99.4
	West Province	**6,822**	**2,646**	**39**	**2,494**	**94**
18	Gisagara	1,573	836	53.1	836	100
19	Huye	1,280	455	35.5	455	100
20	Nyaruguru	2,694	1,046	38.8	1,046	100
21	Muhanga	699	345	49.4	345	100
22	Ruhango	548	118	21.5	113	95.8
23	Nyanza	1,280	304	23.8	304	100
24	Nyamagabe	1,890	613	32.4	613	100
25	Kamonyi	1,734	337	**19.4**	337	100
	South Province	**11,698**	**4,054**	**34**	**4,049**	**99**
26	Gicumbi	5,179	2,113	40.8	2,074	98.2
27	Musanze	445	291	65.4	289	99.3
28	Burera	1,778	669	37.6	669	100
29	Rulindo	1,766	611	34.6	611	100
30	Gakenke	3,203	402	12.6	398	99
	North	**12,371**	**4,086**	**38**	**4,041**	**99**
	Total	**54,719**	**20,532**		**20,123**	

Source: RARDA, 2010

Table 2.2: Distribution of all cows per district

Province	District	Cows distributed								Total
		Yr 2006	Yr 2007	Yr 2008	Yr 2009	Initiative	Sum2009	Yr 2010	Yr 2010-11	
NORTH	BURERA		197	1,847	1,628		1,628	140		3,812
	GAKENKE		132	255	468		468	94		949
	GICUMBI		478	942	704		704	70		2,194
	MUSANZE		252	93	606		606	49		1,000
	RULINDO		325	430	2,487		2,487	58		3,300
	S/Total	**648**	**1,384**	**3,567**	**5,893**	**664**	**6,557**	**411**	**-**	**12,567**
EAST	**BUGESERA**		**218**	**4,574**	**516**		**516**	**24**		**5,848**
	GATSIBO		1,074	2,425	1,641		1,641	1,004		6,144
	KAYONZA		344	871	928		928	-		2,143
	KIREHE		1,006	470	494		494	219		2,189
	NGOMA		545	1,660	56		56	463		2,724
	NYAGATARE		591	701	1,780		1,780	-		3,072
	RWAMAGANA		413	1,488	410		410	35		2,346
	S/Total	**102**	**4,191**	**12,189**	**5,825**	**269**	**6,094**	**1.745**	**-**	**24,321**
WEST	KARONGI		710	443	1,430		1,430	15	25	2,623
	NGORORERO		645	885	601		601	51	-	2,182
	NYABIHU		173	420	618		618	46	-	1,257
	NYAMASHEKE		65	142	567		567	51	25	850
	RUBAVU		333	307	372		371	33	-	1,044
	RUSIZI		319	618	316		316	72	54	1,379
	RUTSIRO		760	737	1,816		1,816	36	-	3,349
	S/Total	**463**	**3,005**	**3,552**	**5,720**	**10,431**	**16,151**	**304**	**104**	**23,579**
SOUTH	GISAGARA		818	1,332	3,839		3,839	-	-	9,828
	HUYE		942	1,102	339		339	48	-	2,770
	KAMONYI		**676**	**1,119**	**446**		**446**	**34**	**144**	2,865
	MUHANGA		528	1,042	431		431	31	25	2,488
	NYAMAGABE		664	1,101	1,183		1,183	30	40	4,201
	NYANZA		308	750	361		361	41	25	1,846
	NYARUGURU		881	1,991	1,926		1,926	163	100	6,987
	RUHANGO		211	487	42		42	16	59	857
	S/Total	**1,561**	**5,028**	**8,924**	**8,567**	**1,197**	**9,764**	**363**	**393**	**26,033**
KIGALI CITY	GASABO		217	233	56		56	33	-	595
	KICUKIRO		100	114	70		70	26	-	380
	NYARUGENGE		14	120	172		172	33	-	511
	S/Total	**236**	**331**	**467**	**298**	**77**	**375**	**92**	**-**	**1,501**
GRAND TOTAL		**3,010**	**13,939**	**28,699**	**26,303**	**12,638**	**38,941**	**2,915**	**497**	**88,001**

Source: RARDA, 2010

Appendix B

Table 4.1: T-test

VARIABLES	Randomization test				Variables	Randomization test			
	Control	**Treated**	**Difference**	**T test**		**Control**	**Treated**	**Difference**	**T test**
District dummy (Bugesera)	.5772358	.547619	.0296167	0.5239	Share of members at university	0	.0571429	-.0571429	**-1.8198**
Mareba Sector dummy	.1544715	.1714286	-.016957	-0.4011	Hillside land cultivated during 2009 B season	.7388618	.7790476	-.0401858	-0.5619
Kamabuye Sector dummy	.1382114	.0952381	.0429733	1.2033	Hillside land cultivated during 2010 A season	.7384553	.7857619	-.0473066	-0.6237
Nyarugenge Sector dummy	.1300813	.1380952	-.0080139	-0.2058	Marshland cultivated during 2009B season	.0152846	.0182381	-.0029535	-0.8997
Musambira Sector dummy	.2113821	.1809524	.0304297	0.6786	Marshland cultivated during 2009B season	.0149593	.0164762	-.0015168	-0.4723
Nyamiyaga Sector dummy	.2439024	.1619048	.0819977	1.8366	land protected/progressives terraces (Ha)	.635122	.5898095	.0453124	0.6343
Household-head sex	.6910569	.6095238	.0815331	1.4962	Space with Napier grass planted (Ha)	.2299187	.1479524	.0819663	**2.3470**
Household-head age	44.66667	44.61429	.052381	0.0407	Use of chemical fertilizers	.0894309	.2190476	-.1296167	-1.7813
HH write and read Kinyarwanda	.6829268	.7238095	-.0408827	-0.7908	Mixture of manure and Chemical fertilizers	.0569106	.1190476	-.062137	**-1.8609**
HH level of education(no education: 31% of sample)	.3170732	.3047619	.0123113	0.2339	Quantity of chemical fertilizers/Season	1.841463	2.842857	-1.001394	-1.0708
HH level of education (primary: 60.4%)	.6178862	.5952381	.0226481	0.4067	Crop trader as source of income/term	2154.472	309.5238	1844.948	**2.8356**
HH marital status (married: 62% of the sample)	.6341463	.6047619	.0293844	0.5306	Helper masonry as source of income/Term	2979.675	1393.333	1586.341	**1.8461**
HH marital status (Widows: 27% of the sample)	.2439024	.2809524	-.0370499	-0.7357	Working as paid cropper: source of income/Term	3203.252	4838.095	-1634.843	-1.1756
H's Children between 0 to 5	.7723577	.7904762	-.0181185	-0.1835	Number of goats/household	.9268293	.8714286	.0554007	0.4282
H's children between 6 to 11	.9837398	1	-.0162602	-0.1373	Number of sheep/household	.0243902	.0666667	-.0422764	-1.2803
H's children 12 to 18	1.065041	1.090476	-.0254355	-0.2248	Number of pigs/Household	.3658537	.1428571	.2229965	3.6421
H's members between 19 to35	.796748	.8761905	-.0794425	-0.5996	Number of poultry/Household	1.146341	1.12381	.0225319	0.1247
H's members between 35to50	.2520325	.1904762	.0615563	1.0921	House roof and construction materials	1.682927	1.766667	-.0837398	-0.7191
H's members above50	.0731707	.1142857	-.041115	-1.1366	Area with trees plantation (Ha)	.0164228	.0284857	-.012063	**-2.0649**
Household size	5.512195	5.628571	-.1163763	-0.5229	Number of phones/Household	.504065	.6095238	-.1054588	-1.5640
Share of members in Primary	1.918699	2.119048	-.2003484	-1.1560	Number of bicycle/Household	.2439024	.3333333	-.0894309	**-1.7208**
Share of members in Secondary	.3333333	.4095238	-.0761905	-0.8808	Number of radio/Household	.7560976	.7809524	-.0248548	-0.5202
Share of members in technical school	.0813008	.047619	.0336818	1.1859					

Source: Author's calculation from the dataset by using ttest in stata 11.1.

Table 4.2: Summary of crop production/season (Kg)

Variable	**Control (1)**	**Treated (2)**
Sorghum production under 2009B season	54.9512	57.3
	(110.0371)	(109.768)
Maize production under 2009B season	35.252	32.481
	(71.5887)	(70.0515)
Beans production under 2009B season	81.4797	139.1238
	(80.1001)	(153.7414)
Cassava production under 2009B season	225.6504	432.7143
	(261.9973)	(389.0256)
Potatoes production under 2009B season	140.9919	148.8333
	(340.4539)	(287.0372)
Peanut production under 2009B season	6.9431	15.1619
	(14.3877)	(25.5268)
Rice production under 2009B season	7.8862	23.0476
	(47.0307)	(119.9491)
Banana production under 2009B season	23.2927	53.0286
	(66.0316)	(132.3883)
Sorghum production under 2010A season	21.8293	41.119
	(66.8932)	(112.583)
Maize production under 2010A Season	34.3902	25.381
	(104.4376)	(78.3081)
Beans production under 2010A season	57.0976	87.1857
	(64.8702)	(102.4363)
Cassava production under 2010A Season	130.3415	216.2381
	(218.8513)	(413.7787)
Potatoes production under 2010A Season	95.3659	105.5714
	(224.7614)	(207.0184)
peanut production under 2010A season	6.122	10.7333
	(13.0608)	(25.4569)
Rice production under 2010A season	8.5366	19.0476
	(41.6796)	(110.1328)
Banana production under 2010A Season	23.252	43.881
	(67.8776)	(117.3646)

Source: Author's calculation from the dataset by using sum syntax from stata 11.1.
Standard errors in brackets

Table 4.3: Crop price/Season (Rwf)

Crop prices/Rwf	2009B	2010A
Maize	170	160
Cassava	200	300
Rice	500	550
Potatoes	100	70
Banana	80	70
Beans	200	300
Sorghum	150	155
Peanuts	700	800

Source: Author's computation from district information

Table 4.4: Difference of milk total expenditures and returns/ types of cows

Variable	**Mean variables for treated / per cow race**				**Mean variables per cow race & calved**			
	Treated=1 & Jersey type	Treated=1 & Friesian type	Treated=1 & cross breed type	Treated=1 & Ankoles type	Calving>0 & Jersey	Calving>0 & Friesian	Calving>0 & Cross breed	Calving>0 & Ankoles
Average milk/day for 3 lactation period)	3.0606	4.5726	1.5238	1.1235	5.6111	6.1494	4	1.7352
	(3.5709)	(3.29)	(2.179)	(1.0572)	(2.8861)	(2.1558)	(1.4987)	(.8122)
heap Average cost (weighted by price per season)	138.7879	129.0598	132.619	145.1199	140.5556	129.1954	122.9167	142.2593
	(16.8999)	(25.8278)	(25.866)	(24.2908)	(19.4841)	(24.1754)	(26.6332)	(26.007)
Annual heap cost: (heap-day*price/heap*30*12)	**132,109.1**	**150,861.5**	**142,857.1**	**134,935.3**	**144,200**	**156,496.6**	**131,250**	**138,093.3**
	(44271.56)	(49895.75)	(45561.26)	(39936.36)	(45349.31)	(55183.48)	(36062.45)	(43745.24)
Average milk price (dry+rainy seasons)	80	106.1538	60	97.0863	146.6667	142.7586	157.5	149.9444
	(77.1038)	(64.3946)	(79.0569)	(73.6716)	(12.5167)	(14.6742)	(17.5255)	(20.021)
Total milk per lactation (Avmilkday*30* lactationlength)	731.8182	944.6154	385.9524	244.3165	1341.667	1270.345	1013.125	377.3333
	(1080.563)	(781.3142)	(579.6154)	(276.5183)	(1163.347)	(632.3792)	(483.4174)	(260.3921)
Total Revenue Milk (Avmilk-day*30*milkpr*Lactationlength)	**108,513.6**	**134,020.5**	**60,047.62**	**36,296.94**	**198,941.7**	**180,234.5**	**157,625**	**56,058.61**
	(164156.8)	(113043.1)	(88852.96)	(41345.71)	(179741.6)	(93358.19)	(70560.89)	(39120.02)
Total revenue of milk with 10months lactation length (Avmilk*30*milkpr*10)	**134818.2**	**194871.8**	**71309.52**	**50206.83**	**247166.7**	**262069**	**187187.5**	**77541.67**
	(159445.3)	(142508.4)	(100870)	(47408.22)	(132374.7)	(96553.16)	(65430.41)	(36627.11)
Observations	11	39	21	139	6	29	8	90

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard errors in brackets

Table 4.5: Summary of variables related to fertilizers and cow rearing costs

Variable	Treated	Untreated	Variable	Treated	Untreated
HH use fertilizers (any kind 0:no; 1: yes)	.9905	.3577	Lactation length if the cow has calved (months)	4.2381	0
	(.0974)	(.4813)		(3.8749)	(0)
HH use manures as fertilizers (0:no; 1: yes)	1	.3577	Quantity of milk produced first 3 months	2.9571	0
	(0)	(.4813)		(3.3576)	(0)
HH use manure from neighbors (0:no; 1:yes)	.0143	.2846	Quantity of milk produced middle 3 months	1.8024	0
	(.1189)	(.453)		(2.5017)	(0)
HH use chemical fertilizers (0: no; 1:yes)	.1762	.0894	Quantity of milk produced last 3 months	.9571	0
	(.3819)	(.2865)		(1.6803)	(0)
Times of spreading manures per season	1	.3577	Milk price during rainy season	90.2857	0
	(0)	(.4813)		(70.3438)	(0)
Manures and chemical fertilizers mixing (0: no; 1:yes)	.119	.0569	Milk price during dry season	98.0476	0
	(.3246)	(.2326)		(77.1595)	(0)
Quantity of manure used per season in Kgs	805.1429	290.0813	Milk Market (0:not applicable;1:neighbors;2:traders)	.5857	0
	(361.7266)	(406.4168)		(.8095)	(0)
Quantity of chemical fertilizers used per season in Kgs	2.8381	1.8374	Numbers of cow for now	1.4762	0
	(8.6108)	(7.5557)		(.5006)	(0)
Manure price per kg in Rwf	12.4333	4.3984	Cowshed cost variables	21937.62	0
	(2.8466)	(6.1133)		(8866.882)	(0)
Household have a compost for manures store(0: no; 1:yes)	1	.1789	cost of medication for 6 last months	2604.286	0
	(0)	(.3848)		(4048.629)	(0)
Period of filling the compost per month	2.3929	0	cost of medication for 12 last months	2203.048	0
	(1.0326)	(0)		(4424.74)	(0)
manure quantity when the compost filled in Kgs	709.5952	.0081	Numbers of heaps consumed per day per cow	2.7571	0
	(437.977)	(.0902)		(.7659)	(0)
Household uses all manure (0: no; 1:yes)	.8048	.3252	Heap cost during dry season	390.9524	0
	(.3973)	(.4704)		(99.7079)	(0)
Use of extra manure (0:not applicable;1:store;2:give to neighbors	.481	.0732	heap cost during rainy season	226.1905	0
	(.802)	(.366)		(42.839)	(0)
collecting urine for fertilizers improvement (0:not applicable;1: through grass residues;3:digging a small pit)	1.3476	.0081	Who collected roadside grasses (0: not applicable ; 1:child; 2: wife; 3: Husband; 4: worker)	1.7857	0
	(.4873)	(.0902)		(1.152)	(0)
HH have had a cow before 2006 (0: no; 1:yes)	.1524	.0813	Collecting roadside last week(0:no; 1: yes)	.8095	0
	(.3602)	(.2744)		(.3936)	(0)
Passing on gift to another Hh (0: no; 1:yes)	.2048	0	Quantity of milk produced last week per day (if any)	1.6	0
	(.4045)	(0)		(2.3891)	(0)
Any cow sold after the program started (0: no;1:yes)	.0524	0	Quantity of milk sold last week per day (if any)	.7738	0
	(.2233)	(0)		(1.4344)	(0)
Price of the cow sold (if any)	3952.381	0	Time spent for collecting roadside grasses last week/minute/day	78.4762	0
	(19227.86)	(0)		(60.4929)	(0)
Source purchase grasses (0:not applica;1:milk sell;2:crop sell;3:milk sell;4:bor	2.0524	0	Quantity of water consumed per day per cow (liters)	26.2619	0
	(.665)	(0)		(13.1954)	(0)
			Cost of water consumed per day per cow (minutes)	38.9286	0
				(22.3483)	(0)
Observations	210	123	Observations	210	123

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard deviations in parentheses

Table 4.6: Extra-costs for cow management/category of respondents

Variable	Respondents	Mean if treated=1
Collecting roadside last week(0:no; 1: yes)		.8095
		(.3936)
Time spent by children to collect roadside grasses (minutes)/day	42	93
		(52.5)
Time spent by wife to collect roadside grasses (minutes)/day	58	98
		(45.3)
Time spent by husband to collect roadside grasses (minutes)/day	69	100
		(57.9)
Time spent by worker to collect roadside grasses (minutes)	4	64
		(31)
Average time spent for collecting roadside grasses (minutes)/day		78.5
		(60.5)
Quantity of water consumed per day per cow (liters)		26
		(13.2)
Cost of water consumed per day per cow (minutes)		39
		(22)
cost of medication for last 6 months (Rwf)		**2600**
		(4049)
cost of medication for last 6 months: Jersey in (Rwf)	7	4770
		(3115)
cost of medication for last 6 months: Friesian in (Rwf)	33	5450
		(7263)
cost of medication for last 6 months: Cross breed in (Rwf)	16	2294
		(2213)
cost of medication for last 6 months: local breed in (Rwf)	101	2940
		(3057)
cost of medication for 12 last months		2200
		(4425)
Observations		210

Source: Author's calculation from the dataset by using sum syntax from stata 11.1. Standard deviations in parentheses

Appendix C

Table 5.1: OLS 2009B and 2010A

VARIABLES	OLS09B (1)	OLS10A (2)	VARIABLES	OLS09B (1)	OLS10A (2)	VARIABLES	OLS09B (1)	OLS10A (2)
Treatment effect	73,212*** (10,218)	44,617*** (11,617)	Hh's members between 35 to 50	4,020 (11,133)	37,628** (17,056)	Number of sheep/household	29,313 (26,437)	64,696 (52,188)
District dummy (Bugesera)	-25,132 (31,424)	-10,858 (35,914)	Hh's members above50	-11,996 (13,050)	4,128 (20,795)	Number of pigs/Household	8,657 (10,335)	9,248 (14,069)
Mareba Sector dummy	**89,625***** (30,373)	-20,718 (30,170)	Hh members in primary	1,976 (3,936)	2,046 (7,387)	Number of poultry/Hh	4,511 (4,559)	2,189 (5,997)
Kamabuye Sector dummy	**119,830***** (35,588)	-25,275 (35,798)	Share of members in Secondary	8,936 (8,513)	10,484 (11,154)	House's roof and construction material	-9,627* (5,305)	5,088 (6,321)
Nyarugenge Sector dummy	**111,856***** (32,327)	-24,180 (29,996)	Share of members in technical school	-22,111 (23,727)	-22,669 (19,195)	Area with trees plantation (Ha)	85,568 (109,968)	142,704 (170,863)
Musambira Sector dummy	**36,470**** (16,107)	-11,689 (27,496)	Share of members at university	149.7 (16,803)	-14,548 (24,206)	Number of phones/Household	20,540** (9,836)	39,756** (17,867)
Nyamiyaga Sector dummy	**72,684***** (17,835)	48,279 (31,394)	Hillside land cultivated/ season	58,567*** (15,081)		Number of bicycle/Household	174.1 (14,013)	-8,181 (19,938)
Household-head Sex	4,716 (13,055)	-1,490 (19,174)	Marshland cultivated/ season	314,396** (133,795)		Number of radio/Household	455.6 (12,322)	-3,610 (15,002)
Household-head age	84.85 (589.3)	169.2 (659.3)	Space protected by progressives terraces (Ha)	31,215** (13,380)	60,480*** (18,843)	Hillside land cultivated/ season		9,960 (17,967)
HH write and read Kinyarwanda	-5,721 (14,415)	-2,723 (22,535)	Space with reeds planted (Ha)	-44,594* (25,080)	-38,256 (29,858)	Marshland cultivated/ season		632,009*** (224,344)
HH level of education	15,951 (10,497)	19,011 (15,443)	Mixture of manure and Chemical fertilizers	-69,441*** (24,561)	-96,903*** (31,792)	Constant	-25,993 (33,382)	4,040 (56,858)
HH marital status	-3,174 (4,017)	-8,303 (5,938)	Quantity of chemical fertilizers/Season	3,311** (1,315)	4,753*** (1,247)	Observations	333	333
Hh's Children between 0 to 5	-11,103 (8,235)	-9,466 (9,191)	Trading: source of income/term	-1.587*** (0.603)	-1.018 (0.839)	R-squared	0.560	0.385
Hh's children between 6 to 11	-8,130 (4,976)	160.8 (9,880)	Helper masonry: source of income/Term	2.305* (1.354)	0.468 (0.826)			
Hh's children 12 to 18	-5,407 (5,496)	-4,097 (8,517)	Working in cropping: source of income/Term	0.874 (0.558)	-0.133 (0.610)			
Hh's members between 19 to35	-6,453 (5,834)	-3,375 (7,749)	Number of goats/household	9,561* (5,711)	-1,694 (7,166)			

Source: Author's calculation from the dataset by using reg syntax from stata 11.1.

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Table 5.2: Crop revenue results of NNM-PSM

Variables/Characteristics	Mean Treated (1)	Mean Control (2)	ATET:Difference (1)-(2)	ATET: S.E	ATET: T statistic	Off support		On support	
						Untreated	Treated	Untreated	Treated
Sorghum 2009B crop revenue	8199.10714	8762.85714	-563.75	2461.9892	-0.23	0	35	123	168
Maize 2009 B crop rev	5566.4881	8133.69048	-2567.20238	1885.45112	-1.36	0	35	123	168
Beans 2009 B crop rev	26366.6667	14335	12031.6667	3223.40028	**3.73**	0	35	123	168
Cassava 2009 B crop rev	87250	41842.8571	45407.1429	8946.55754	**5.08**	0	35	123	168
Potatoes 2009 B crop rev	15360.119	11223.4524	4136.66667	4598.03115	0.90	0	35	123	168
Peanuts 2009 B crop rev	10091.6667	4694.16667	5397.5	1674.75701	**3.22**	0	35	123	168
Rice 2009 B crop rev	11130.9524	6636.90476	4494.04762	5348.36937	0.84	0	35	123	168
Banana 2009 B crop rev	4600.47619	2536.66667	2063.80952	1122.40726	**1.84**	0	35	123	168
Sorghum 2010A crop rev	6866.31098	4600.85366	2265.45732	2020.94557	1.12	0	39	123	164
Maize 2010A crop rev	3770.73171	5490.73171	-1720	2414.30082	-0.71	0	39	123	164
Beans 2010 A crop rev	23650.6098	17750.122	5900.4878	3484.27043	**1.69**	0	39	123	164
Cassava 2010 A crop rev	61189.0244	27142.6829	34046.3415	11797.5022	**2.89**	0	39	123	164
Potatoes 2010 A crop rev	7264.63415	6633.35366	631.280488	2434.04381	0.26	0	39	123	164
Peanuts 2010A crop rev	8487.80488	3569.7561	4918.04878	2034.93376	**2.42**	0	39	123	164
Rice 2010A crop rev	9289.63415	5332.31707	3957.31707	4766.41851	0.83	0	39	123	164
Banana 2010 A crop rev	2703.96341	1279.63415	1424.32927	724.535986	**1.97**	0	39	123	164

Source: Author's calculation from the dataset by using psmatch2 syntax from stata 11.1.

Table 5.3: OLS estimates for each crop revenue (2009B & 2010A season)

Variables	**2009B Season**		**2010A season**	
	Coefficient	Standard errors	Coefficient	Standard errors
Sorghum	1,876	(1,886)	**3,574****	(1,799)
Maize	-626.2	(1,433)	-1,175	(1,694)
Beans	**10,227*****	(3,037)	**6,323****	(2,831)
Cassava	**44,677*****	(6,915)	**25,924*****	(9,437)
Potatoes	**6,482****	(3,049)	2,342	(1,678)
Peanuts	**6,134*****	(1,419)	**4,078****	(1,706)
Rice	2,643	(4,096)	2,289	(4,039)
Banana	**1,800***	(930.0)	**1,262***	(652.9)

Source: Author's calculation from the dataset by using reg syntax from stata 11.1. Robust standard errors in parentheses

Table 5.4: Kernel matching model for crop revenue/season

Variables/Characteristics	Mean: Treated (1)	Mean: Control (2)	ATET: Difference (1)-(2)	ATET: S.E	ATET: T statistic	Off support		On support	
						Untreated	Treated	Untreated	Treated
Sorghum 2009B crop revenue	8199.10714	9360.34723	-1161.24009	2419.42064	-0.48	0	35	123	168
Maize 2009 B crop rev	5566.4881	7740.06792	-2173.57983	1825.15406	-1.19	0	35	123	168
Beans 2009 B crop rev	26366.6667	14611.19	11755.4767	3191.58106	**3.68**	0	35	123	168
Cassava 2009 B crop rev	87250	42004.1927	45245.8073	8975.36947	**5.04**	0	35	123	168
Potatoes 2009 B crop rev	15360.119	12347.4805	3012.63856	4463.43663	0.67	0	35	123	168
Peanuts 2009 B crop rev	10091.6667	5146.72687	4944.93979	1646.20086	**3.00**	0	35	123	168
Rice 2009 B crop rev	11130.9524	6511.83029	4619.12209	5256.33609	0.88	0	35	123	168
Banana 2009 B crop rev	4600.47619	2737.68454	1862.79165	1108.06412	**1.68**	0	35	123	168
Sorghum 2010A crop rev	6866.31098	4136.05918	2730.25179	1986.67897	1.37	0	39	123	164
Maize 2010A crop rev	3770.73171	5305.93497	-1535.20327	2255.61148	-0.68	0	39	123	164
Beans 2010 A crop rev	23650.6098	17475.0172	6175.59252	3425.73305	**1.80**	0	39	123	164
Cassava 2010 A crop rev	61189.0244	28233.7249	32955.2995	11997.3674	**2.75**	0	39	123	164
Potatoes 2010 A crop rev	7264.63415	6784.77181	479.86234	2291.61756	0.21	0	39	123	164
Peanuts 2010A crop rev	8487.80488	3649.70773	4838.09715	1998.70437	**2.42**	0	39	123	164
Rice 2010A crop rev	9289.63415	6524.67343	2764.96071	4604.88614	0.60	0	39	123	164
Banana 2010 A crop rev	2703.96341	1204.77934	1499.18407	819.896095	**1.83**	0	39	123	164

Source: Author's calculation from dataset by using reg syntax from stata 11.1.

Table 5.5: Bootstrap Standard Errors of total crop revenue models/Season (Robustness check)

Variables/Characteristics	Observed coefficient	Bootstrap: S.E	ATET: Z statistic	P>|z|	[95% Conf. Interval]
OLS: Crop revenue for season 2009 B	73212.4	10331.93	7.09	0.000	52962.19 - 93462.61
OLS: Crop revenue for season 2010A	44617.21	12825.11	3.48	0.001	19480.45 - 69753.96
NNM: Crop revenue for season 2009B	70399.88	17125.4	4.11	0.000	36834.7 - 103965.1
NNM: Crop revenue for season 2010 A	51423.26	15730.69	3.27	0.001	20591.67 - 82254.85
Kernel Matching : Crop revenue for season 2009B	68105.96	15641.95	4.35	0.000	37448.3 - 98763.62
Kernel matching : Crop revenue for season 2010 A	49908.04	17159.42	2.91	0.004	16276.19 - 83539.9

Source: Author's calculation from the dataset by using bootstrap reg or psmatch2 syntax from stata 11.1.

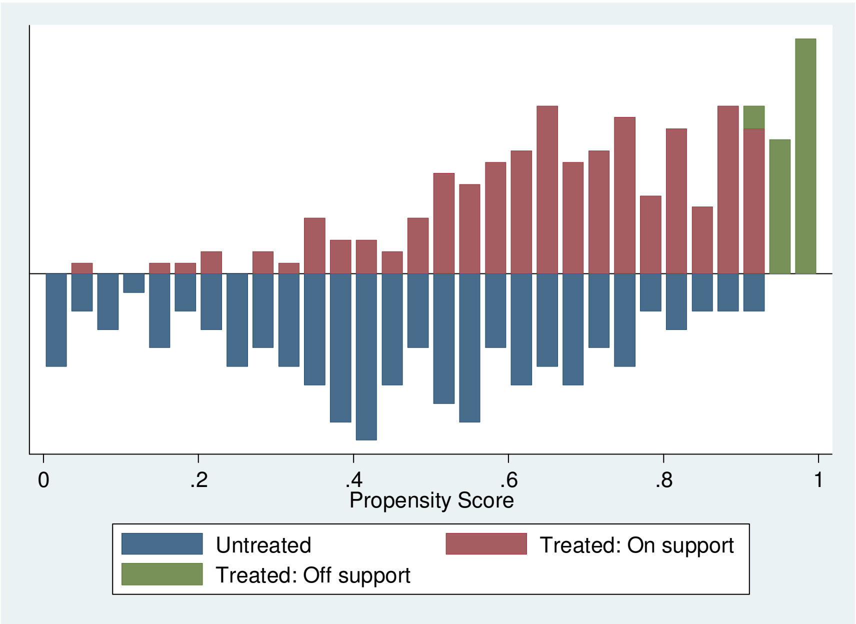
Table 5.6: Balancing Test of the Distribution (PSTEST)

Variable	**Sample**	**PSM 2009B season balancing test**				**PSM 2010A season balancing test**			
		Treated	Control	T test	p>t	Treated	Control	T test	p>t
District dummy (Bugesera)	Unmatched	.45238	.42276	0.52	0.601	.44828	.42276	0.45	0.654
	Matched	.45238	.53214	-1.46	0.145	.46341	.50244	-0.71	0.481
Mareba Sector dummy	Unmatched	.17143	.15447	0.40	0.689	.17734	.15447	0.53	0.594
	Matched	.19643	.25	-1.18	0.240	.20122	.22195	-0.46	0.647
Kamabuye Sector dummy	Unmatched	.09524	.13821	-1.20	0.230	.08867	.13821	-1.40	0.162
	Matched	.09524	.13571	-1.16	0.247	.09756	.14512	-1.32	0.188
Nyarugenge Sector dummy	Unmatched	.1381	.13008	0.21	0.837	.13793	.13008	0.20	0.841
	Matched	.16071	.14643	0.36	0.717	.16463	.13537	0.74	0.459
Musambira Sector dummy	Unmatched	.18095	.21138	-0.68	0.498	.17734	.21138	-0.76	0.449
	Matched	.20833	.23095	-0.50	0.618	.21341	.24878	-0.76	0.449
Nyamiyaga Sector dummy	Unmatched	.1619	.2439	-1.84	0.067	.16256	.2439	-1.81	0.072
	Matched	.19048	.18214	0.20	0.845	.19512	.19024	0.11	0.911
Household-head Sex	Unmatched	.60952	.69106	-1.50	0.136	.62562	.69106	-1.20	0.231
	Matched	.625	.68095	-1.08	0.283	.62805	.66341	-0.67	0.505
Household-head age	Unmatched	44.614	44.667	-0.04	0.968	44.419	44.667	-0.19	0.848
	Matched	44.44	44.227	0.17	0.869	44.439	44.637	-0.15	0.880
HH write and read Kinyarwanda	Unmatched	.72381	.68293	0.79	0.430	.72906	.68293	0.89	0.374
	Matched	.70238	.74048	-0.78	0.438	.69512	.72683	-0.63	0.528
HH level of education	Unmatched	.8619	.78862	0.88	0.381	.867	.78862	0.93	0.353
	Matched	.79762	.88214	-1.07	0.287	.79878	.84268	-0.55	0.583
HH marital status	Unmatched	2.181	2.0813	0.57	0.569	2.133	2.0813	0.29	0.768
	Matched	2.1905	1.975	1.32	0.187	2.1829	2.0232	0.97	0.335
Hh's Children between 0 to 5	Unmatched	.79048	.77236	0.18	0.855	.81281	.77236	0.41	0.685
	Matched	.78571	.84643	-0.66	0.509	.79268	.77683	0.17	0.864
Hh's children between 6 to 11	Unmatched	1	.98374	0.14	0.891	.99507	.98374	0.10	0.924
	Matched	.9881	1.1393	-1.31	0.191	1	1.0634	-0.55	0.582
Hh's children 12 to 18	Unmatched	1.0905	1.065	0.22	0.822	1.069	1.065	0.03	0.972
	Matched	1.1071	1.0286	0.72	0.469	1.1098	.99756	1.02	0.310
Hh's members between 19 to35	Unmatched	.87619	.79675	0.60	0.549	.84236	.79675	0.35	0.729
	Matched	.82143	.8381	-0.13	0.895	.79268	.90122	-0.86	0.388
Hh's members between 35to50	Unmatched	.19048	.25203	-1.09	0.276	.18719	.25203	-1.16	0.249
	Matched	.20833	.15238	1.14	0.253	.21341	.15854	1.09	0.275
Hh's members above50	Unmatched	.11429	.07317	1.14	0.257	.10345	.07317	0.88	0.378
	Matched	.10714	.0869	0.60	0.546	.10976	.09756	0.35	0.727
Share of Hh members in Primary	Unmatched	2.119	1.9187	1.16	0.249	2.133	1.9187	1.22	0.222
	Matched	2.0952	2.1548	-0.37	0.709	2.0915	2.0927	-0.01	0.994
Share of members in Secondary	Unmatched	.40952	.33333	0.88	0.379	.37931	.33333	0.54	0.589
	Matched	.3631	.34167	0.28	0.779	.36585	.38902	-0.29	0.771
Share of members in technical school	Unmatched	.04762	.0813	-1.19	0.237	.04433	.0813	-1.31	0.191

	Matched	.05357	.0869	-1.14	0.254	.05488	.07927	-0.84	0.401
Share of members at university	Unmatched	.05714	0	1.82	0.070	0	0	.	.
	Matched	0	0	.	.	0	0	.	.
Hillside land cultivated/ season	Unmatched	.77905	.73886	0.56	0.575	.787	.73846	0.63	0.526
	Matched	.70786	.7314	-0.38	0.705	.69409	.74827	-0.83	0.406
Marshland cultivated/ season	Unmatched	.01824	.01528	0.90	0.369	.01685	.01496	0.58	0.562
	Matched	.0178	.01482	0.97	0.333	.01707	.01482	0.73	0.467
Space protected by progressives terraces (Ha)	Unmatched	.58981	.63512	-0.63	0.526	.57345	.63512	-0.86	0.388
	Matched	.55095	.54674	0.07	0.948	.54	.56332	-0.36	0.723
Space with reeds planted (Ha)	Unmatched	.14795	.22992	-2.35	0.020	.14813	.22992	-2.32	0.021
	Matched	.15125	.12581	0.88	0.379	.14823	.14182	0.21	0.834
Mixture of manure and Chemical fertilizers	Unmatched	.11905	.05691	1.86	0.064	.11823	.05691	1.83	0.068
	Matched	.09524	.07857	0.54	0.589	.08537	.08537	-0.00	1.000
Quantity of chemical fertilizers/Season	Unmatched	2.8429	1.8415	1.07	0.285	2.8818	1.8415	1.10	0.274
	Matched	2.1905	1.3119	1.28	0.202	2.0366	1.5732	0.64	0.522
Trading: source of income/term	Unmatched	309.52	2154.5	-2.84	0.005	320.2	2154.5	-2.77	0.006
	Matched	386.9	402.38	-0.07	0.946	396.34	503.66	-0.42	0.672
Helper masonry: source of income/Term	Unmatched	1393.3	2979.7	-1.85	0.066	1441.4	2979.7	-1.76	0.079
	Matched	1211.9	500	1.76	0.080	1150	459.76	1.73	0.085
Working in cropping: source of income/Term	Unmatched	4838.1	3203.3	1.18	0.241	4807.9	3203.3	1.14	0.254
	Matched	5214.3	5117.9	0.07	0.947	5341.5	4841.5	0.34	0.731
Number of goats/household	Unmatched	.87143	.92683	-0.43	0.669	.867	.92683	-0.46	0.647
	Matched	.79762	.8869	-0.74	0.462	.79268	.95	-1.25	0.211
Number of sheep/household	Unmatched	.06667	.02439	1.28	0.201	.06897	.02439	1.33	0.185
	Matched	.05952	.02619	1.15	0.252	.06098	.02561	1.19	0.234
Number of pigs/Household	Unmatched	.14286	.36585	-3.64	0.000	.14778	.36585	-3.50	0.001
	Matched	.16071	.10714	1.23	0.221	.15854	.13171	0.59	0.556
Number of poultry/Household	Unmatched	1.1238	1.1463	-0.12	0.901	1.1379	1.1463	-0.05	0.963
	Matched	1.0714	1.0929	-0.12	0.905	1.0549	1.1866	-0.72	0.471
House roof and construction materials	Unmatched	1.7667	1.6829	0.72	0.473	1.7685	1.6829	0.72	0.470
	Matched	1.7917	2.1667	-2.88	0.004	1.811	2.1305	-2.45	0.015
Area with trees plantation (Ha)	Unmatched	.02849	.01642	2.06	0.040	.02922	.01642	2.16	0.031
	Matched	.0234	.02186	0.26	0.793	.02227	.0247	-0.39	0.698
Number of phones/Household	Unmatched	.60952	.50407	1.56	0.119	.59113	.50407	1.29	0.199
	Matched	.54762	.62143	-1.10	0.271	.53049	.62561	-1.43	0.153
Number of bicycle/Household	Unmatched	.33333	.2439	1.72	0.086	.33005	.2439	1.65	0.100
	Matched	.27976	.375	-1.86	0.063	.28659	.37195	-1.65	0.101
Number of radio/Household	Unmatched	.78095	.7561	0.52	0.603	.7734	.7561	0.36	0.721
	Matched	.75595	.8119	-1.25	0.214	.7561	.82317	-1.49	0.137

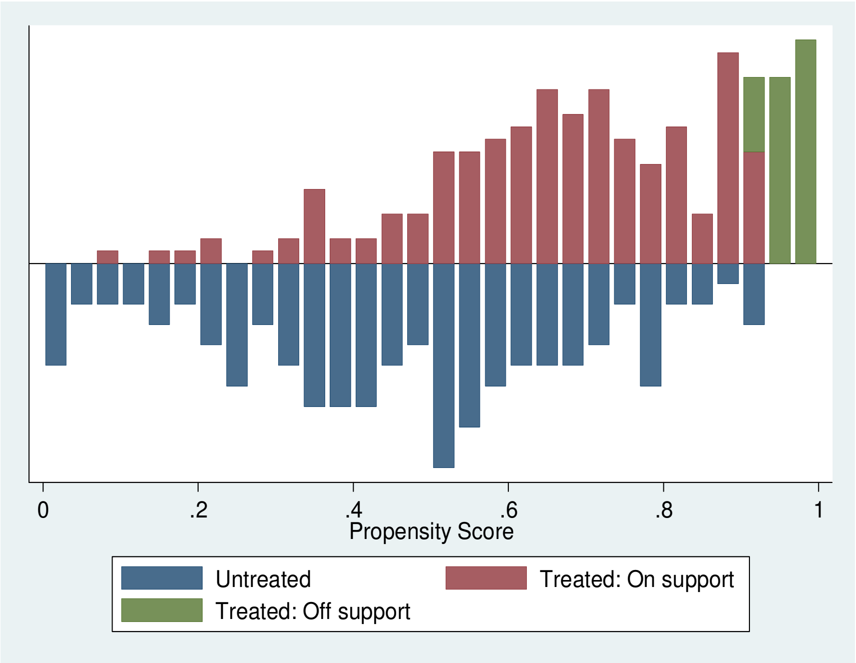
Source: Author's calculation from the dataset by using pstest syntax from stata 11.1.

Figure 5.1: Propensity Score Graph of total crop revenue 2009B Season



Source: Author's calculation from the dataset by using psgraph syntax from stata 11.1.

Figure 5.2: Propensity Score Graph of total crop revenue 2010A Season



Source: Author's calculation from the dataset by using psgraph syntax from stata 11.1.

Table 5.7: Treatment Propensity Scores/ variables/Season

Treatment	**2009B season**			**2010A Season**		
	Coefficient.	Std. Err.	z	Coefficient.	Std. Err.	z
District dummy (Bugesera)	18.2434	.8298384	21.98	17.84184	.8204818	21.75
Mareba Sector dummy	-20.15062	.599093	-33.64	-19.71548	.5939291	-33.20
Kamabuye Sector dummy	-21.53639	.	.	-21.06417	.	.
Nyarugenge Sector dummy	-20.24441	.6467013	-31.30	-19.80443	.6416845	-30.86
Musambira Sector dummy	-2.002975	.5963685	-3.36	-1.938495	.587987	-3.30
Nyamiyaga Sector dummy	-2.195824	.6180147	-3.55	-2.069807	.6048612	-3.42
Household-head Sex	-.7944175	.4955506	-1.60	-.7393464	.4917099	-1.50
Household-head age	-.0045507	.0144501	-0.31	-.0042301	.0143606	-0.29
Household-Head can write and read Kinyarwanda	-.0654286	.4440852	-0.15	-.1193778	.4408298	-0.27
HH level of education	-.0019426	.2892637	-0.01	.0429808	.2864096	0.15
HH marital status	-.0189167	.1605649	-0.12	-.0073389	.1598801	-0.05
Hh's Children between 0 to 5	.2461868	.2013213	1.22	.2345494	.1996282	1.17
Hh's children between 6 to 11	-.1663246	.1676387	-0.99	-.1453497	.1681069	-0.86
Hh's children 12 to 18	-.1892939	.1768243	-1.07	-.1871284	.1753174	-1.07
Hh's members between 19 to35	-.1177738	.1437342	-0.82	-.1098559	.1439284	-0.76
Hh's members between 35 to 50	-.6900084	.334034	-2.07	-.6786186	.3321512	-2.04
Hh's members above50	.7254833	.4901398	1.48	.726683	.4902744	1.48
Hh members in primary	.3164149	.1399111	2.26	.3169541	.1398467	2.27
Share of members in Secondary	.1897936	.2164271	0.88	.2148968	.2149904	1.00
Share of members in technical school	-.0777951	.5458614	-0.14	-.0820287	.5438453	-0.15
Hillside land cultivated/ season	1.354041	.508873	2.66	1.166441	.5054399	2.31
Marshland cultivated/ season	-4.191965	5.205898	-0.81	-3.862246	5.190112	-0.74
Space protected by progressives terraces (Ha)	-.8490306	.4491305	-1.89	-.7504518	.454999	-1.65
Space with reeds planted (Ha)	-1.178928	.5667009	-2.08	-1.009238	.5479395	-1.84
Mixture of manure and Chemical fertilizers	.8302566	.6428235	1.29	.7327438	.643071	1.14
Quantity of chemical fertilizers/Season	.0049994	.0238913	0.21	.0031004	.0236296	0.13
Trading: source of income/term	-.0001232	.0000514	-2.39	-.0001251	.0000514	-2.43
Helper masonry: source of income/Term	-.0000924	.0000345	-2.68	-.0000944	.000035	-2.70
Working in cropping: source of income/Term	.000012	.0000147	0.82	.0000134	.0000149	0.90
Number of goats/household	-.0283243	.1495299	-0.19	-.0595422	.1485195	-0.40
Number of sheep/household	1.182305	.6309099	1.87	1.179394	.628477	1.88
Number of pigs/Household	-1.158734	.319602	-3.63	-1.140538	.3159104	-3.61
Number of poultry/Household	.0566399	.0996649	0.57	.0569757	.0990979	0.57
House roof and construction materials	.054506	.1611045	0.34	.0618127	.1607956	0.38
Area with trees plantation (Ha)	4.442818	3.238327	1.37	4.447215	3.232678	1.38
Number of phones/Household	.0721265	.2674769	0.27	.0787644	.2669593	0.30
Number of bicycle/Household	.5844841	.3938126	1.48	.5994882	.3922609	1.53
Number of radio/Household	.0473841	.3486739	0.14	.0189015	.3466455	0.05
_cons	2.472531	1.164163	2.12	2.383065	1.151718	2.07

Source: Author's calculation from the dataset by using psmatch2 syntax from stata 11.1.

Appendix D

D-1: Survey Questionnaire

'The effect of livestock production on poor households' income in Rwanda. Case of 'One Cow One Family Program'

Introduction to the respondent

Moderately, we introduce to the respondent. I am NTANYOMA Rukumbuzi Delphin, a student doing a research for study/academic research program in Netherlands. You have been selected among the 'One Cow One Family Program' beneficiaries and those on the waiting list of the program. This questionnaire concerns collecting data on different households that have received the cow and others who are waiting to get a cow. We collect data about the socio-economic status of the household and taking information on household membership, living conditions, education, agriculture production, milk production and management of the cow. I really appreciate the participation of your household in this survey and I would like to ask you some questions about your household. Any information you provide will be kept strictly confidential and will only be used for study purpose. Participation in this survey is voluntary and you may choose not to answer any question or all of the questions. However, we hope that you will participate in this survey since your participation is very important.

Thank you so much.

Ntanyoma Rukumbuzi Delphin
Economics of Development participant
MA student at Institute of Social Studies,
Erasmus University of Rotterdam
The Hague, Netherlands

Questionnaire No:
Related to the selection sample number with following prefix
B for beneficiaries
C for control group

Section 1. General information[47]

1. Province………………………………………………………
2. District………………………………………………………
3. Sector………………………………………………………
4. Cell……………………………………………………..
5. Survey date………/…………/…………………………….

Section 2. Demographic characteristics

1. Head of the household/Spouse (partner) if applicable

No	Question	Response
1	What is the sex of the household head? (**F** if woman & **M** if man)	
2	What is your age (years)?	
3	Can you read or write in Kinyarwanda? (Yes or No)	
4	What is your level of education? (**N**: no education; **P**: primary, **S**: secondary; **T**: Vocational Training, **U**: University)	
5	What is the Marital Status of the household head? (**M**: Married; **P**: partner, **D**: Divorced; **W**: Widow or widower; **N**: never married; **L**: Living apart not divorced)	
6	What is the age of the partner or spouse (if applicable)?	
7	What is the level of education of the partner? (**N**: no education; **P**: primary, **S**: secondary; **T**: Vocational Training, **U**: University)	

2. Age of households' members

No	Question	Response	
		F	M
1	How many people are between 0-5 years		
2	How many people are between 6-11 years		
3	How many people are between 12-18 years		
4	How many people are between 19-35 years		
5	How many people are between 35-50 years		
6	How many people above 55 years		

3. Education of households' members

No	Question	Response	
		F	M
1	How many members of the household are at primary school + nursery		
2	How many members of the household are at secondary school		
3	How many members of the household are at vocational training		
4	How many members of the household are at university		

[47] The respondent is the head of the household.

Section 3. Land and agriculture production

1. What was the size of your cultivated land in 2009 B (estimation in Ha):

2. What was the size of your cultivated land in 2010 A (estimation in Ha):

3. What is the size of marshland cultivated in 2009 B (estimated in Ha)

4. What is the size of marshland cultivated in 2010 A (estimated in Ha)

5. Agriculture production per main crops:

No	**Question**	**Response**	
		2009B Season	**2010A** season
1	What was the production of ....in Kg		
2	What was the production of ....in Kg		
3	What was the production of ....in Kg		
4	What was the production of ....in Kg		
5	What was the production of .... in Kg		
6	What was the production of .... in Kg		
7	What was the production of ....in Kg		
8	What was the production of ....in Kg		

6. Is your cultivated land protected against the erosion? Yes or No:

7. What kind of erosion protection is?

a. Space with radical terraces in Ha:..

b. Space with progressive terraces in Ha:..............................

c. Space with Napier grasses in Ha:..

8. Use of fertilizers and manure management

Part I: Manure use

a. Do you use fertilizers in your cropland? **Yes or No**:.....................

b. What is the main source of fertilizers used?

i. Manures from your livestock (yes/no):.............................

ii. Manures from neighbors or relatives (yes/no):..................

iii. Chemical fertilizers purchased (yes/no):...........................

c. How many times do you spread fertilizers in your cropland during a season? ...

.... Manure: Chemical:

d. Do you combine manure with crop residues in cropland? **Yes or No**

e. How much do you spread per time/Kg? Manure: Chemical:

f. What is the price of manure/Rwf/Kg?:………………………

Part II: Manure production and management

No	Question	Response
1	Do you have compost for collecting manure? Yes or No	
3	How many days do you need for getting the compost filled?	**Days:**........
4	How many kilos do you think you disengage if the compost is filled?	**Kg**:...........
5	Do you spread all manure in your crop land? **Yes or No**	
6	If you do not spread all manure, where do you keep it when the compost is filled: (1: store; 2: grant to others; 3: other reason)	
	How do you manage to collect cow urine for making fertilizers improvement (1: capturing through grass residues; 2: digging a small pit)	

Section 4: Livestock and milk production

1. General information on livestock

No	Question	Response
1	Have you had a cow before 2006? **Yes** or **No**	
2	Have received a cow from the program? **Yes** or **No**	
3	When did you receive the cow from the program/ month and Year?	............../..........
4	What type of cow have you received? (**L**: Local; **C**: cross; **J**: Jersey; **F**: Frisone)	
5	How many times has it calved?	
6	What is the lactation length in months	From .... to ....
7	How much milk does your cow produce during lactation? lactation period interval: 3 Months/ estimated in Liters per day	first 3 months:
		middle 3 months:
		Last months:
8	What is the price of milk per liter (Rwf)?	Rain season:
		Dry season:
9	How many cows do you have now?	
10	How much did cattle shed cost in Rwf?	
11	How much have you spend for cow medication in last 6 months? In **Rwf**	
12	How much have you spend for cow medication last year? (**Rwf)**	
13	How many other livestock do you have?	Goats:
		Sheep:
		Pigs:
		Poultry:

2. **Cow feeding**

No	Question	Response
1	How many heaps of grasses have you used for feeding the cow last week/ per day?	
2	What could be the cost of one heap if you have bought it from neighbors? Rwf	**Rainy season**
3		**Dry season**
4	How many liters of milk have you produced per day last week if your cow is calving?	Liter/day:
5	How many liters have you sold last week?	
6	Have you last week collected roadside or forest grasses? **Yes or No**	
7	Who has mainly collected these roadside or forest grasses? (1: child; 2: wife; 3: husband; 4:worker)	
8	How many hours does she/he spend for collecting the roadside or forest grasses/day	Hrs/day:
9	How many liters of water per day does the cow get?	Liters/day:
10	How many hours have you spent collecting water for the cow last week/day.	Hrs/day:
11	What are the main sources of money for feeding your cow?	Milk sales:
		Off-farm activities:
		Borrowing:
		Others:

Section 5: Other sources of Income

	What are the main sources of income and how much did you earn/Last term?	**How much you earn/Frw**
1	……………………………………………….	
2	………………………………………………	
3	………………………………………………..	
4	……………………………………………….	

Section 6: Other assets of the households

No	Question	Response
1	Do you have your own house/Type of roof's house (0: renting; 1:Adob bricks+tiles; 2: Adob bricks+iron sheets; 3: trees+iron sheets; 4: trees+tiles; 5:Grass-Thatched houses)	
2	Do you have plantation of trees/ Space (Ha)	
3	Number of mobile phone of households' members	
4	Number bicycle of households' members	
5	Number of radio of households' members	

Section 7: Social network

No	Question	Response/Frw
1	Do you have a debt to repay for feeding the cow? How much?	
2	Do you have a debt to repay for cow medication? How much?	
3	Do you have any other debt to repay not related the previous one? How much?	
4	Have paid any debt for feeding the cow last month? How much?	
5	Have paid any debt for cow medication last month? How much?	
6	Have paid any debt last month not related to previous one? How much?	

Last comments

a. Have you passed on gift a cow to another next recipient household (yes/no)?....

b. Have you ever sold a cow from the time you have received from this program? For how much roughly if applicable (Rwf)?..

c. Who could be the potential clients of milk sales (1: neighbors; 2: traders)?.........................

d. What are the main challenges for managing the cow? ....

e. Do you have any support from other organization (Yes/no)………………………

f. Do you have any other comments? ....

Thank you so much for your participation

D-2: Bugesera authorization letter for data collection

REPUBLIKA Y'U RWANDA

Bugesera, kuwa 12/7/2010
N°............/1272....../05.07

INTARA Y'IBURASIRAZUBA
AKARERE KA BUGESERA

Bwana Munyamabanga Nshingwabikorwa
W'Umurenge wa…………………………..

Impamvu: Korohereza umunyeshuri kubona amakuru

Bwana Munyamabanga Nshingwabikorwa,

Nshingiye ku ibaruwa yo ku wa 24 Gicurasi 2010, yanditswe na Kaminuza yitwa "International Institut of Social Studies " yo mugihugu cya Holand yandikiye Akarere ka Bugesera igasaba ko twafasha umunyeshuri w'umunyarwanda uhigira icyiciro cya gatatu cya Kaminuza witwa NTANYOMA RUKUMBUZI Delphin kubona amakuru ajyanye na gahunda ya girinka munyarwanda ndetse n'umusaruro imaze gutanga ku baturage borojwe inka.

Nkaba nkwandikiye iyi baruwa ngira ngo ngusabe ku mworohereza kubona amakuru yose ajyanye n'iyi gahunda ndetse no gusura abaturage bamwe na bamwe bahawe inka muri iyi gahunda yavuzwe haruguru. Ku mugereka w'iyi baruwa urahasanga ibaruwa yandikiwe Akarere ndetse na "questionnaires" izakoreshwa mu gukusanya ayo makuru.

Ugire amahoro.

RWAGAJU Louis
Umuyobozi w'Akarere

D-2: Kamonyi authorization letter for data collection

REPUBULIKA Y'U RWANDA

Kamonyi, ku wa 06/07/2010
N°…122……/07.02/08

INTARA Y'AMAJYEPFO
AKARERE KA KAMONYI
B.P: 03 Muhanga
E-mail : kamonyidistrict@yahoo.fr

Madamu/Bwana Umunyamabanga Nshingwabikorwa w'Umurenge wa…………………………(Bose)

Impamvu: Korohereza umunyeshuli gukora ubushakashatsi

Madamu/Bwana,

Nejejwe no kubamenyeshako umunyeshuli witwa **Ntanyoma Rukumbuzi Delphin** yemerewe n'Akarere ka Kamonyi gukora ubushakashatsi kubirebana na gahunda ya Girinka mu mirenge itandukanye y'Akarere mu rwego rwo kurangiza gahunda yo kwandika igitabo cy'icyiro cya gatatu crime gutegura (masters program). Ubwo bushakashatsi bukaba burebana no gukusanya amakuru (*data collection*) mu ngo zahawe inka ndetse n'ingo zigitegereje kuzahabwa inka muri iyo gahunda.

Nkaba mbasaba kuzamworohereza mu rwego rwo gukusanya ayo makuru.

Mugire akazi keza.

RUTSINGA Jacques
Umuyobozi w'Akarere ka KAMONYI

Bimenyeshejwe :

- Madamu Umuyobozi w'Akarere Wungirije Ushinzwe Ubukungu, Imari n'Amajyambere
- Bwana Umunyamabanga Nshingwabikorwa w'Akarere
  KAMONYI

DUKORANE UMURAVA DUTERE IMBERE

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