MDP-IFAD RESEARCH REPORT

ASSESSING CLIMATE CHANGE ADAPTATION PRACTICE IN DAIRY PRODUCTIVITY AND PROFITABILITY IN NYANZA DISTRICT, RWANDA

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ACRONYMS

RDDP	**–**	Rwanda Dairy Development Programme
IFAD	**–**	International Fund for Agricultural Development
MCCs	-	Milk Collection Centres
MINAGRI	-	Ministry of Agriculture and Animal Resources

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EXECUTIVE SUMMARY

Dairy farming is an integral part of the livestock production system in Rwanda. It is essential for rural development, poverty reduction and it plays a key role in achieving food and nutrition security. The study has documented the impact of climate change in dairy farming. Climate change impacts among other things make water and land to become more limited for fodder production; and causes temperatures rise, requiring changes to forage feeding systems and these situations could affect the productivity and profitability of dairy farming. The overall objective of this study was to assess the effect of climate change adaptation practices in dairy productivity and profitability of smallholder dairy farming in Nyanza district of Rwanda. The specific objectives were profiling climate change adaptation practices adopted by dairy farmers; assessing the level of productivity and profitability of dairy farmers and to identify the constraints experienced by dairy farmers in climate change adaptation practices. Focus was on the effects of the adaptation practices on the profitability and productivity of dairy farming.

The study adopted survey instrument that included structured questionnaire, key informant interview and Focus group discussion. A simple random sampling technique was used to select 243 respondents. A validated structured questionnaire with variables on perception to climate change, fodder production and availability, milk production, disease outbreak, weather information, adaptation practices and constraints to climate change adaptation was used to collect the data. The data were scored, compiled, tabulated and subjected to various appropriate statistical tools like percentage, frequency, mean, standard deviation, percentage, correlation and multiple regression analysis to draw meaningful results and conclusion.

The study found out that climate change adaptation practices have affected dairy farming practices such as breeding, feeding, health and shelter management and milking process. A test of difference using the Mann-Whitney U test revealed that a statistically significant difference was observed in milk production before and during the RDDP ($p < 0.001$). Averagely, monthly income level of the dairy farmers was about 22,600 *Rwanda Francs* prior RDDP, a record rising to 33,000 *Rwanda Francs* since the commencement of RDDP; a statistically significant difference was observed in the income level of dairy farmers before and during RDDP ($p < 0.001$). The study also revealed the constraints of the farmers in adapting to climate changes. More than half of the farmers generally reckoned lack of awareness and knowledge about climate change adaptation practices has been a severe challenge to them (60%); majority also remarked limited knowledge on adaptation practices has been a severe challenge (64%).

In conclusion, dairy farmers in Nyanza district have experienced changes in climate and the farmers have adopted suitable adaptation practices that have improved their productivity and profitability. Therefore, there existed a relationship between the climate change adaptation practices and productivity and profitability. As a response to climate change, it is recommended that dairy farmers should invest in fodder development and conservation in order to sustain dairy herd productivity. Dairy farmers should also be empowered by government and other relevant institutions to modern adaptation practices to mitigate against the effects of drought, pest infestation, disease outbreak and occurrences occasioned by extreme weather variability.

Keywords: Climate change, Dairy farming, Productivity, Profitability, Rwanda

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Livestock farming is historically an integral part of the agricultural production systems in Rwanda. The country has made tremendous strides in rebuilding its livestock sector in the last two decades after the 1994 genocide during which an estimated 80% of cattle and 90% of small ruminants were decimated. Cattle population now stands at 1,349,792, comprising 615,631 (45%) local breeds (mainly Ankole), 439,414 (33%) dairy cross-breeds, and 294,747 (22%) dairy pure breeds (IFAD – RDDP, 2016). Rwandan modern diary industry was founded in 1994 after the end of the genocide and ever since then, the government of Rwanda, International Development agencies and the private sector has improved on the production of milk, collection as well as processing. The Girinka initiative also known as one cow per poor family has helped create a dairy sector in which very large numbers of farm families now participate (Klapwijk et al 2014). The dairy cattle development support project also supports construction of Milk Collection Centres (MCCs) across the country together with Girinka which provided rapid drive needed to move the industry forward.

Also milk collection in Rwanda has remarkable been upgraded in Rwanda over the last decade, efficient use of the physical infrastructure is undermined by a dominant 'informal' market (Ajmal et al 2016). There are dairy cooperatives in Rwanda which was established to progressively assume management responsibilities of MCCs as business units that were supposed to deliver services in milk bulking and marketing as well as farmers training, credit and veterinary services and inputs to cooperative members. In a pyramid-like structure, dairy cooperative are then further grouped at the district and federal levels, respectively into district unions and the National Dairy Farmers' Federation of Rwanda (Makoni et al 2014). The improved organisational capability, supported by the infrastructure investment in MCCs, was expected to help realise scale economies and improve quality control in milk supply chain.

The dairy sector still face challenge of supply of quality milk leading to a very low capacity utilisation, estimated at 20% at the industry level (Makoni et al 2014).

Climate change has substantial effects in all sectors of economy in Eastern Africa where farmers rely on rain fed agriculture (IPCC, 2007). There is direct impact and indirect effects of climate change to dairy production brought about by change in feed and fodder supply which affects livestock production system (FAO, 2004). Noticeable changes in mean temperatures and rainfall

patterns leading to extreme weather variability have been the impacts of climate change experienced in recent years. These impacts have also influenced changes in water availability, enhanced frequency and intensity of drought, floods, sea level rises pest and disease outbreak (Beddington *et al.* 2012; Thornton *et al.* 2012).

1.2 Significance of the Study

Some studies have explained the dimension and degree of climate change impact on agricultural production - animal husbandry and crop cultivation and food security. (Nardone et al., 2010; Berman, 2005; West, 2003; Kadzere et al., 2013; Wittman and Baylis, 2000). The research aims to assess the climate change adaptation practices in dairy production in Rwanda, especially the Rwanda Dairy Development Programme (RDDP). As well as profitability and productivity of dairy farmers in Rwanda.

This study was significant because it not only added to the already existing knowledge of the state of climate change adaptation on dairy productivity and profitability in Rwanda, it also gave a report of the constraints experienced by smallholder dairy farmers' in adaptating to suitable climate change adaptation practices. The knowledge gained will also provide critical input to designing, monitoring and management of similar programmes or projects by IFAD across Africa.

1.3 Research Objectives

The overall objective of this research is to assess climate change adaptation practices in dairy production in Rwanda.

The specific objectives are:

1. to profile climate change adaptation practices adopted by smallholder dairy farmers;
2. to assess the level of productivity and profitability of smallholder dairy farmers; and
3. to identify the constraints experienced by dairy farmers in adapting to climate change.

1.4 Research Questions

The study will focus its research questions on the following:

1. what are the adaptation practices adapted by smallholder dairy farmers in Rwanda?
2. what are the level of productivity and profitability of dairy farming on smallholder dairy farmers?
3. what are the constraints experienced by the dairy farmers in adapting to changing climate?

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CHAPTER TWO

BRIEF LITERATURE REVIEW

2.1 Review of Theory

Climate change impact on dairy productivity

Excessive heat, cold, humidity, wind and radiation influence dairy cows negatively (Martinsohn 2012). For example, feed intake, milk performance (milk quality and quantity) and conception rate are reduced, and the cows' immune status and well-being are impaired (Berman, 2005; Kadzere et al., 2013; Nardone et al., 2010; Wittman and Baylis, 2000; West, 2003). Indirect effect of climate change on dairy farming also exist as fodder crops are affected by reduced precipitation and rising temperatures, which can cause yield losses (Lobell and Field, 2007). Heavy or long-term precipitation events also constrain harvesting or pasturing and even lead to flooding. Pathogen infections – in plant production as well as in animal husbandry – can increase due to certain climatic conditions, and some new species may appear (Anderson et al., 2004; Chakraborty et al., 2000; Kadzere et al., 2013). While bio-physiological reactions of animals and plants are more or less well known, pathogen infections are highly multi-factored and only reveal good results through a complex structural approach with many variables (Kobourn et al., 2008). Empirical data sets are rare and scientific knowledge is thus still weak (Purse et al., 2005).

All animals have a range of ambient environmental temperatures known as the thermo neutral zone. This is the range of temperatures that are conducive to health, productive and reproductive performance (Larry 2014). The upper critical temperature is the point at which heat stress effects begin to affect the animal. There are a number of environmental factors that contribute to heat stress. These include high temperature, high humidity and radiant energy (sunlight). Heat stress can be simply defined as the point where the cow cannot dissipate an adequate quantity of heat to maintain body thermal balance.

A number of changes occur in the animal as a result of heat stress. These include:

1. Elevated body temperature – Body temperatures > $102^{o}F$ <$39^{0}C$> (normal is $101.5^{o}F$ <$38^{0}C$>).
2. Increased respiration rates > 70-80 per minute.
3. Increased maintenance energy requirement – Dairy cows will activate mechanisms in an attempt to dissipate the excess heat and maintain body temperature. The increased

respiration rate is one example. The maintenance energy requirement may increase by 20-30% in animals under heat stress. This decreases the intake energy available for productive functions such as milk production. Blood flow to the skin will increase in an attempt to dissipate heat. At the same time, blood flow to the core of the body will decrease.

4. Feed nutrient utilization – An increased loss of sodium and potassium is usually associated with heat stress. This is due to losses associated with the increased respiration rate. This can shift the acid-base balance and result in a metabolic alkalosis. There can also be a decrease in the efficiency of nutrient utilization.
5. Milk production- There is normally a decrease in milk production for cows under heat stress. This decrease can be either transitory or longer term depending on the length and severity of heat stress. These decreases in milk production can range from 10 to >25%. In the summer of 2005, many New York dairy herds reported decreases in milk production of 5 to 15 pounds per cow per day. If heat stress lowers milk production in early lactation dairy cows, potential milk production for the lactation will be decreased. Dairy cows in later lactation may recover slowly from the effects of heat stress.
6. Reproduction – Heat stress has also been reported to decrease reproductive performance in dairy cows. There are a number of changes in reproductive performance that have been reported. The effects on reproduction can be prolonged and impact the animal for months after the heat stress exposure. These include: - The length and intensity of the oestrus period decreases, decreased conception (fertility) rate, decreased growth, size and development of ovarian follicles, Increased risk of early embryonic deaths, decreased fetal growth and calf size.

2.2 Review of Methodology

According to Chaudhary and Bawa (2011) there was widespread feeling that weather was getting warmer, the water sources are drying up, the onset of summer and monsoon had advanced during last 10 years and there is less snow on mountains than before. Local perceptions of the impact of climate change on biodiversity included early budburst and flowering, new agricultural pests and weeds and appearances of mosquitoes. People at high altitude appear more sensitive to climate change than those at low altitudes.

Gajendra (2011) studied perspectives of farmers on effect of climate change on agriculture and livestock in Northern Karnataka region. He found that all the respondents observed changes in quantity of rainfall and 98.67 percent noticed changes in the distribution pattern of the rains over the

past 20 years. Majority (66.00%) of the respondents expressed that the distribution is unpredictable to the extent of variation in kharif, rabi and summer seasons. Majority of the respondents mentioned that there was an increase in temperature to the extent from the normal temperature during the kharif, rabi and summer seasons. Majority (72.00%)of respondents perceived that relative humidity is increasing in kharif of an extent of 15.75 percent and almost an equal proportion of farmers perceived that the region is getting drier of an extent 9.03 percent during rabi and 15.38 percent in summer. Almost all the farmers (98.67 %) perceived that there is increase in scorching sunshine hours during summer season to an extent of 21.21 percent. Population explosion, deforestation, gas emission by industries and automobiles were the major reasons perceived by the farmers to the changing climate.

Leiserowitz et al. (2011) on climate change communication and George Mason University centre for climate change communication conducted survey in America and reported that roughly half of all Americans said global warming is already causing the following events in the United States: coastline erosion and flooding (52.00 %); droughts (50.00 %); hurricane (49.00%); rivers flooding (48.00 %); and wildfires (45.00 %).

2.3 Review of Empirical Studies

Pynbianglang (2011) observed that majority (57.50%) of the respondents perceived that occurrence of drought had been increased, 27.50 percent perceived that there was no change in frequency of drought and only 8.15 percent perceived that occurrence of drought had been decreased.

(Okonya et al. 2013) studied farmer's perception of and coping strategies to climate change in Uganda and they that Ninety nine percent of all households interviewed had observed a change in the climate in the last 10 years. Drought and floods had the highest impact on crop production across agro-ecological zones. The smallholder farmer households studied had a high awareness of changes in rainfall and temperature and had taken measures to cope with effects of a changing climate.

(Rana et al 2013) study on the farmers' perception on locally idealised traditional weather cycle with climate change were analysed and compared for different agro climatic zones of Himachal Pradesh. Increasing temperature during summers, prolonged summer, delayed onset and uneven distribution of south west monsoon, delayed onset of winter, short winter periods, temperature above normal during winters, decreasing snow fall during winter, delayed snow fall were the main experiences of the farmers" regarding climate change across the elevated zones.

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CHAPTER THREE

MATERIALS AND METHODS

2.1 Study Area

The study was conducted in Nyanza district in the Southern Province of Rwanda. Its capital is Nyanza town, which is also the Sothern provincial capital. This is due to its peculiarity to climate change especially drought events.

Figure 1: Map of Nyanza district

2.2. Research Design

Only sectors where RDDP is ongoing were selected for the study. the study involved the use of structured questionnaire, Key Informant Interview (KII), Focus Group Discussion (FGD). Because

of language barrier, enumerators were hired to interpret the questions to the farmers for the KII and FGD.

2.4. Population, Sample Size and Data Collection

Nyanza district has population of more than 320, 000 people (according to 2012 national census) Nyanza is predominantly rural than urban with 7.9% urban and 92.1% rural. The labour force rate is higher among male than female in both urban and rural. The study was conducted in five sectors with a total population of 2,500 dairy farmers. Proportional sampling was used to get the sampling size using sample size estimator. The data collection methods used included administered questionnaire, interviews and conversations with stakeholders, and focus group discussions.

Table 1 Proportional Population Allocation to size

Sector	Location	Number of Dairy Farmers	Proportional Allocation to size
Busadamana	A	500	49
Busoro	B	200	19
Cyabakamyi	C	300	29
Mukingo	D	800	78
Nyagiozi	E	700	68
Total		2500	243

Proportion allocation to size (for location A) is given by: $\frac{500}{2500} * 243 \approx 49$

A focus group discussion was held at a village while two key informants' interviews were also conducted. In order to have a good representation of all the relevant groups, purposive sampling techniques were used in selecting the respondents for FGD and key informant interview. A structured questionnaire was administered to smallholder farmers to collect information on the effects of climate change adaptation practices on dairy productivity and profitability. In addition, the key informant interviews were conducted as part of in-depth interviews to acquire more information on the subject matter. This technique was used to acquire more information on the changes and adaptation strategies and the role of government and funding organisations in addressing the issue

of climate change. A FGD was conducted. Besides, field observation was also used to collect additional data and used to verify some of the information collected.

2.4.3. Sampling Size and Sampling Procedure

Survey samples was collected using probability proportionate size of RDDP beneficiaries. Data was collected and assessed from Nyanza District in the southern province based on the following criteria Current level of cattle population and milk production, ii) Current and projected market development potentials, including investments in milk collection centres, dairy processing plants, animal feed factories.
and Level of poverty, food insecurity and malnutrition

2.4.3.1 Sampling size and procedure

Sampling procedure was sourced from 243 small holder dairy farmers who are beneficiaries of RDDP. The sample size was determined using probability proportionate to size to select samples across 5 sectors in Nyanza district. The sectors are Busoro, Cyabakamyi, Mukingo, Nyagiozi and Busasamana.

2.4.3.2. Sampling of key informants

Purposive sampling was used to select those to be interviewed for Key Informant Interview. This sampling method was used because it gave an in-depth understanding and valid points for recommendation purposes. Key informant interview thus helped in getting detailed information on climate change and adaptation practices implemented, frequency and reliability of information received on livestock and dairy farming.

2.5 Data Management, Analysis and Presentation

The collected data were organized and prepared for analysis. The data was cross-checked and corrected during the data cleaning process. Then it was exported for analysis by Statistical Package for Social Sciences (SPSS) Data analysis was used to organise, inspect and transform data with the aim of highlighting required information, suggest conclusion and support decision. Analysis of the data collected helped to develop strong evidence from the investigations. Data was analysed using SPSS while data description was done using percentages, graphs and frequencies. Descriptive analysis such as proportions, percentages, frequency distributions and measures of central tendency mean and standard deviation were then used. Data summary and classification were done and presented using tables.

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CHAPTER FOUR

ANALYSIS RESULTS AND DISCUSSION

4.1` Socio - Economic Characteristics of Dairy Farmers

A total of two hundred and forty-three smallholder dairy farmers participated in the study. Information on their socio-demographics is presented on Table 1 and Table 2. A larger proportion of the respondents were male dairy farmers, with a fewer female dairy farmer proportion; 68% and 32% respectively. The average age of the enumerated farmers was 45 years, with a dispersion of 9 years; not more than 1% belonged to age group 20 – 29 years, 32% were in the group 30 – 39 years, about 32% were in the age group 40 – 49 years, 30% had ages lying between 50 – 59 years, while 5% were aged 60 years or higher. Most of these farmers indicated they had a man as head of their household, 64%; a few stated they had a woman as their head of household, 27%; while a male youth as head of household was only reported by 9%. Most of the dairy farmers had only attained the primary school (68%), 19% had no formal education, 12% extended their educational to secondary level, while just 1% indicated having a vocational training. A little more than half of the respondents indicated dairy farming was the main occupation of the household head (54%), about 45% of the household head were majorly occupied with crop farming, while 1% engaged in other things such as shop-keeping. Most of the respondents reported their spouses engaged in crop farming (67.5%), only a few had spouses who engaged in dairy farming (27.5%), other forms of occupation by the spouses was shop-keeping (2.5%), while the rest did not specify their spouses' occupation.

More than half of the farmers reported having privately owned land with titles (54%), a fewer than that had private lands without titles (40%), while the remaining reported having a communal land (5%). A massive portion of the farmers had household with not more than 5 persons (74%), those with household of size 6 – 10 persons were about 26%. 90% of the farmers reported up to 3 persons from their households were working, about 10% had 4 – 6 persons from their households who engaged in work. Report on the farmers size of land owned showed that about 10% had lands not reaching 1 hectare in size (10%), 84% had reported having a farmland size of 1 – 2 hectares, while 6% reported having more than 2 hectares of farmland. About 67% of the farmers reported having not more half of their land dedicated to dairy, 32% have had about half to 1 hectare of their farmland dedicated to dairy farming, while just 1% had more than 1 hectare designated for dairy.

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Table 2: Socio-Demographics of Dairy Farmers (1)

	Frequency (n = 243)	Mean & SD
Gender		
Male	166 (68.3)	
Female	77 (31.7)	
Age group		**[45.4 ± 9.2]**
20 – 29 years	3 (1.2)	
30 – 39 years	78 (32.1)	
40 – 49 years	77 (31.7)	
50 – 59 years	72 (29.6)	
60 years or more	13 (5.3)	
Head of Household		
Man	156 (64.2)	
Woman	66 (27.2)	
Male Youth	21 (8.6)	
Level of Education		
None	47 (19.3)	
Primary	165 (67.9)	
Secondary	28(11.6)	
Vocational training	3 (1.2)	
Occupation of Household Head		
Dairy farming	132 (54.3)	
Crop farming	109 (44.9)	
Others (Shop keeping)	2 (0.8)	
Occupation of Household Spouse		
Dairy farming	67 (27.5)	
Crop farming	164 (67.5)	
Others (Shop keeping)	6 (2.5)	
Unspecified	6 (2.5)	

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Table 3: Socio-Demographics of Dairy Farmers (2)

	Frequency (n = 243)	Mean & SD
Land Ownership Status		
Private with titles	132 (54.3)	
Private without titles	98 (40.3)	
Communal land	13 (5.4)	
Household Size		
1 – 5 persons	179 (73.7)	4.5 ± 1.9
6 – 10 persons	64 (26.3)	
Household Members Working		
1 – 3 persons	218 (89.7)	2.3 ± 0.9
4 – 6 persons	24 (9.9)	
7 or more persons	1 (0.4)	
Land Owned		
Less than 1 hectare	24 (9.9)	1.4 ± 0.7
1 – 2 hectares	204 (84.0)	
More than 2 hectares	15 (6.1)	
Size of Dairy Farmland		
Not more than half hectare	163 (67.1)	0.6 ± 0.3
0.51 – 1 hectare	77 (31.7)	
More than 1 hectare	3 (1.2)	

4. 2 Adaptation Practices Adopted by Farmers Before and During RDDP

The various adaptation practices adopted by the farmers prior and during the Rwanda Dairy Development Project (RDDP) were found in the course of this study.

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3.4.1 Breeding Practices

In terms of strategic breeding practices believed to be suitable for vulnerable climatic conditions, prior RDDP most of the dairy farmers reared the exotic breeds (57%), a few reared the crossbreeds (23%), while 19% reared the indigenous breed; during RDDP, the pattern of suitable breed changed slightly, as mist of the farmers (57%) reared the crossbreed, while 43% reared the exotic breeds. In dry periods or heat stress, before RDDP, most of the farmers practiced natural breeding (77%), while 7% practiced artificial breeding, and 16% practiced both; conversely during RDDP, most had been practicing artificial breeding (61%) in periods of dry season or heat stress, a few had been practicing both during RDDP (28%), while the least adopted breeding practice is the natural breeding (11%). In periods of cold condition, before their engagement with RDDP, most of the farmers practiced natural breeding only (70%), a few practiced both – natural and artificial breeding (20%), while 10% practiced artificial insemination only; since the commencement of RDDP, almost half of them practiced artificial insemination only (48%), about 27% practiced natural breeding only, while a quarter of them (25%) practiced both methods.

Table 4 Breeding Adaptation Practices Before and During RDDP

	Before RDDP	During RDDP
Suitable breeds under vulnerable climatic condition		
Exotic breeds	138 (56.8%)	104 (42.8%)
Crossbreeds (Jersey/HF)	58 (23.9%)	138 (56.8%)
Indigenous	47 (19.3%)	1 (0.4%)
Type of Breeding Practiced in Dry Season/Heat Stress		
Natural	187 (77%)	28 (11.5%)
Artificial Insemination	16 (6.6%)	148 (60.9%)
Both	40 (16.5%)	67 (27.6%)
Type of Breeding Practiced in Cold condition		
Natural	170 (70%)	65 (26.7%)
Artificial Insemination	24 (9.9%)	117 (48.1%)
Both	49 (20.1%)	61 (25.1%)

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3.4.2 Feeding Practices

In the periods of heat stress, feeding practices employed by the farmers before the RDDP were revealed to be; feeding more forage than concentrate (35%), feeding whatever is available (35%), while about 30% reported they fed their cattle with more concentrate than forage; a different arrangement was adopted since their time with RDDP, more than half fed their cattle with more forage than concentrate during heat stress, about one-third (34%) reported feeding their cattle with more concentrate than forage, while 8% indicated they had only fed them with what was available during heat stress. In the reverse season, during the wet season, most of the farmers had adopted more forage than concentrate feeding prior RDDP, about 34% relied on feeding them with what was available before RDDP, 22% reported feeding them with lesser forage than concentrate; about two-thirds (65%) had adopted more forage and less concentrate during RDDP, 31% adopted higher concentrate than forage since joining RDDP, while only 4% reported feeding cattle with whatever was available. Prior RDDP, most of the farmers 95% reported feeding the cattle anytime they wanted to, while since commencement of RDDP, majority of them had rather adopted a planned feeding schedule which included early hours feeding with plenty of water and dry fodder coupled with late hours feeding with plenty of water, leftover greenery and little concentrate. Prior RDDP, only 19% of the farmers affirmed they used a mineral mixture for their cattle as feed additives to help them cope with extreme weather conditions; during RDDP, up to 82% had started use of mineral mixture as feeding additives.

Before RDDP, fodders used by the farmers during drought situation included grazing the animals along roads or canals or open field (42%), about one-third of them reported use of crop residues or sugarcane in the drought times, 20% indicated they had used tree leaves or vegetable wastes as fodders for their cattle, while 5% reported they have had to resort to migration to other places. In the period of RDDP, more than half of the farmers (52%) had used crop residues or sugarcane as fodders during drought situation, 30% had been using tree leaves or vegetable wastes as fodders during drought situation, 16% reported allowing their cattle to graze along roads or canals or open field, while only 2% had resorted to migration to other places in periods of drought. Prior the commencement of RDDP, many of the farmers (76%) had practiced feeding the animals for maintenance to ensure their survival during extreme weather, not more than 21% confirmed they had fed their animals to maintain minimum production and growth in periods of extreme weather; reversely, since their engagement with RDP, more than half of the farmers (56%) had rather fed their animals to maintain minimum level of production and growth during extreme weather, not more than 41% reported feeding the animals for their maintenance and survival.

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Common sources of water during drought or dry seasons, before RDDP, were natural reservoirs (39%), well (32%) and pond (28%); during wet season, prior RDDP, 62% resorted to natural reservoirs as source of water for their animals, 21% used the pond, while 16% used the well. Since the beginning of RDDP, during drought or dry season, 45% used the pond, 33% used the natural reservoirs, 19% used the well as source of water for their animals; in wet seasons, the pond was still mostly used (43%), 30% used the natural reservoirs as water source, while a quarter (25%) used the well as their water sources. Before joining RDDP, the commonest form of practice was water provision at just twice daily, both during the dry and wet seasons, 68% and 74% respectively. Since joining the RDDP, most of the farmers had provided water for their cattle at convenience (*ad lib*), both during the dry and wet season 46% and 50% respectively.

Table 5: Feeding Adaptation Practices of the dairy farmers

Type of fodder provided during heat stress		
Feeding more forage and low concentrate	86 (35.4%)	140 (57.6%)
Feeding less forage and high concentrate	71 (29.2%)	83 (34.2%)
Feeding whatever is available	86 (35.4%)	20 (8.2%)
Type of fodder provided during wet season		
Feeding more forage and low concentrate	107 (44%)	157 (64.6%)
Feeding less forage and high concentrate	53 (21.8%)	76 (31.3%)
Feeding whatever is available	83 (34.2%)	10 (4.1%)
Feeding schedule followed during extreme heat and cold periods		
Early hours (plenty of water, dry fodder) + Late hours (plenty of water, leftover greenery, little concentrate)	13 (5.3%)	173 (71.2%)
Feeding anytime	230 (94.7%)	70 (28.8%)
Feed additives used to cope during extreme hot/cold weather		
Mineral mixture	46 (18.9%)	200 (82.3%)
No knowledge	193 (79.4%)	39 (16.1%)
Any other	4 (1.6%)	4 (1.6%)

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	Before RDDP	During RDDP
Fodders used during drought situation		
Use of crop residues/sugarcane	80 (32.9%)	126 (51.9%)
Use of tree leaves/vegetable waste	49 (20.2%)	74 (30.5%)
Grazing the animals along roads/canals/open field	102 (42%)	39 (16%)
Migration to other places	12 (4.9%)	4 (1.6%)
Feeding practices followed during extreme weather		
Feeding practices for maintenance of animal to ensure its survival	186 (76.5%)	100 (41.2%)
Feeding practices to maintain minimum level of production and growth	51 (21%)	136 (56%)
Any other	6 (2.5%)	7 (2.9%)
Source of water during drought/dry season		
Providing water from natural reservoirs	95 (39.1%)	81 (33.3%)
Well	78 (32.1%)	47 (19.3%)
Pond	67 (27.6%)	110 (45.3%)
Others	3 (1.2%)	5 (2.1%)
Source of water during wet season		
Providing water from natural reservoirs	150 (61.7%)	72 (29.6%)
Well	40 (16.5%)	62 (25.5%)
Pond	50 (20.6%)	105 (43.2%)
Others	3 (1.2%)	4 (1.6%)

3.4.3 Health Management Practices

Prior RDDP, most of the farmers (49%) did not engage in any health management practice despite adverse conditions, only 45% used preventive measures like vaccination; during RDDP, about 39% engaged in ethno-veterinary practices, 27% engaged in preventive measure like vaccination, 24% had practiced regular health check-up for their cattle, while only 10% had not engaged in any health management practice. Before RDDP, most of the farmers (78%) had not been practicing modification in their housing system in the face of change in climatic conditions, while 83% reported modifying their housing system when the encounter a change in climatic conditions.

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Table 6: Health Management Adaptation Practices before and during RDDP

	Before RDDP	During RDDP
Health Management under adverse conditions		
Preventive measures like vaccination	110 (45.3%)	65 (26.7%)
Ethno-veterinary practices	8 (3.3%)	94(38.7%)
Regular check-up	6 (2.5%)	59 (24.3%)
No practice	119 (49%)	25 (10.3%)

3.4.4 Shelter Management Practices

The commonest practice under extreme weather, before RDDP, was tying under shady trees during summer/hot times (57%), other practices were coverage of windows in winter (10%), use of sprinklers or mist in the summer (9%), use of proper ventilation (5%), wallowing (5%) and sue of bedding winter (3%); during RDDP, use of proper ventilation was the commonest practice adopted to cope with extreme weather condition (49%), other practices adopted since period of RDDP were use of bedding in winter (18%), tying under shady trees during summer/hot times, use of sprinklers or mist in summer, and coverage of windows in winter (7%).

Table 7 Shelter Management Practices

Modification done/followed in housing system during change in climatic conditions	**Frequency (n = 243)**	**Percentage**
Yes	53 (21.8%)	203 (83.5%)
No	190 (78.2%)	40 (16.5%)
Practices adopted to cope with extremes of weather		
Use of sprinklers/mist in summer	22 (9.1%)	20 (8.2%)
Use of bedding in winter	8 (3.3%)	43 (17.7%)
Coverage of windows in winter	25 (10.3%)	17 (7%)
Bathing during summers	4 (1.6%)	3 (1.2%)
Wallowing is done	11 (4.5%)	10 (4.1%)
Use of proper ventilation	12 (4.9%)	118 (48.6%)

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Tying under shady trees during summer/hot times	138 (56.8%)	29 (11.9%)
Keeping inside during daytime and tying outside during night	4 (1.6%)	-
Any other practice	19 (7.8%)	3 (1.2%)

3.4.5 Other Farming Activities

Before RDDP, while only 35% had modified their milking processes in face of climatic change, up to 88% had modified the processes since joining RDDP. With only 27% reporting modification in transportation processes in change of climatic conditions before RDDP, up to 94% affirmed their transportation processes changed with variation in climatic conditions since joining RDDP. While 35% reported their milk processing techniques changed when they encountered a change in climate before RDDP, since the commencement of RDDP such changes in milk processing techniques were reported by 86% of the farmers.

Table 8: Other Management Practices

	Frequency (n = 243)	**Percentage**
Modification in milking process during change in climatic conditions		
Yes	84 (34.6%)	215 (88.5%)
No	159 (65.4%)	28 (11.5%)
Modification in transporting process during change in climatic conditions		
Yes	65 (26.7%)	229 (94.2%)
No	178 (73.3%)	14 (5.8%)
Modification in milk processing process during change in climatic conditions		
Yes	85 (35%)	209 (86%)
No	158 (65%)	34 (14%)

3.5 Productive Performance of Dairy Farmers

Information on the productive performance of the farmers, as presented on Table 8, revealed that most of the respondents had just 1 dairy cattle (88%), about 16% had two, while only 1% of them

had three or more dairy cattle. Almost all of the dairy farmers reared a heifer (9%), 14% reared a bull, 1% reared a bull calf, while just 1 of the farmers reported rearing a heifer calf. The crossbreed was commonest among the farmers, with 43% indicating they reared a crossbreed cattle; 15% reported rearing an exotic breed; 3% reported having a local breed. Most of cattle reared by the dairy farmers were sourced through a government programme (64%); some claimed having inherited cattle (20%); while some others claimed having their cattle from local purchase (19%).

During RDDP, most of the dairy farmers (88%) had been milking their cows twice daily, while only about half (54%) milked their cows during twice daily; up to 45% milked their cows just once in a day prior RDDP, the rate of once a day cow-milking reduced to 10% during RDDP. About half of the dairy farmers (56%) confirmed milking their lactating cows two times a day before RDDP, a larger proportion, 83%, had similar record of twice daily milking for their cows in period of lactation since commencement of RDDP.

Before RDDP, the dairy farmers had averagely experienced dry periods of 3 days, while during RDDP the dry periods for cows have reduced to 2 days. Averagely, during RDDP, a dairy farmer recorded up to 6 litres per day, while before RDDP the average production was about 4 litres daily; a test of difference using the Mann-Whitney U test revealed that a statistically significant difference was observed in milk production before and during the RDDP ($p < 0.001$). Averagely, monthly income level of the dairy farmers was about 22,600 *Rwanda Francs* prior RDDP, a record rising to 33,000 *Rwanda Francs* since the commencement of RDDP; a statistically significant difference was observed in the income level of dairy farmers before and during RDDP ($p < 0.001$).

Table 9: Productive performance of dairy animals

	Frequency (n = 243)	**Percentage**
Number of Dairy Cattle		
One	202	83.1
Two	38	15.6
Three or more	3	1.3
Type of Cattle (*Multiple Response*)		
Heifer	241	99.2
Bull	35	14.4
Bull Calf	3	1.3

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Heifer calf	1	0.4
Type of Breed (*Multiple Response*)		
Crossbreed	104	42.8
Exotic breed	37	15.2
Local	7	2.9
Source of Cattle (*Multiple Response*)		
Government programme	155	63.8
Inherited	48	19.8
Local purchase	46	18.9

Information on the productive performance of the farmers, as presented on Table 10, revealed that most of the respondents had just 1 dairy cattle (88%), about 16% had two, while only 1% of them had three or more dairy cattle. Almost all of the dairy farmers reared a heifer (9%), 14% reared a bull, 1% reared a bull calf, while just 1 of the farmers reported rearing a heifer calf. The crossbreed was commonest among the farmers, with 43% indicating they reared a crossbreed cattle; 15% reported rearing an exotic breed; 3% reported having a local breed. Most of cattle reared by the dairy farmers were sourced through a government programme (64%); some claimed having inherited cattle (20%); while some others claimed having their cattle from local purchase (19%).

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was observed in milk production before and during the RDDP ($p < 0.001$). Averagely, monthly income level of the dairy farmers was about 22,600 *Rwanda Francs* prior RDDP, a record rising to 33,000 *Rwanda Francs* since the commencement of RDDP; a statistically significant difference was observed in the income level of dairy farmers before and during RDDP ($p < 0.001$).

The level of milk production during RDDP was dispersed across various background factors of the farmers, with a view to checking for possible statistically significant difference across the factor groups.

Milk production level was found to be statistically significantly different across age groups ($p = 0.039$), size of land owned by the farmers ($p < 0.001$), household size ($p < 0.001$), land ownership ($p = 0.001$) and size of dairy farm ($p < 0.001$). No significant difference was observed in the milk production level by the farmer's level of education ($p = 0.895$), gender ($p = 0.138$) and household head occupation ($p = 0.063$).

Notable was that farmers in the oldest age group had the highest level of production (9 litres per day); farmers who owned more than 2 hectares of land had the highest level of production (10.7 litres per day); farmers with household size of about 6 – 10 persons had more production level than those with 1 – 5 persons, 9 litres and 6 litres respectively; farmers who owned a communal land produced the highest level of milk (10 litres per day), while farmers with more than 1 hectare of land dedicated to dairy farming had up to 15 litres per day production level.

Table 10: Milking performance among dairy farmers; before and during RDDP

	Before RDDP	**During RDDP**
Number of cow-milking times per day		
Once	109 (44.9%)	24 (9.9%)
Twice	131 (53.9%)	215 (88.5%)
Three times	-	4 (1.6%)
Four times	3 (1.2%)	-
Number of cow-milking times during lactation		

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Once	89 (36.6%)	23 (9.5%)
Twice	136 (56%)	202 (83.1%)
Three times	1 (0.4%)	6 (2.5%)
Four times	12 (4.9%)	9 (3.7%)
Eight times	5 (2.1%)	3 (1.2%)

Dairy farmers who reared the crossbreeds under vulnerable conditions recorded an increment of 4,385 *RWF* in their income than those who opted for the exotic breed. Comparing with those who sourced water from the well, dairy farmers who had relied on water from natural reservoirs and pond during the dry seasons had more income level; an increment of 5,533 *RWF* and 5,303 *RWF* respectively. Farmers who fed their cattle with water twice or thrice a day during dry seasons had a lowered income level, as compared to those who fed their cattle at convenience; a reduction of 4,963 *RWF* and 7,545 *RWF* respectively. Those who adopted a modification in their housing system during climate change had their monthly income improved by 6,039 *RWF*. Comparable to farmers who adopted use of a proper ventilation, farmers who used a tie under shady trees during summer or hot times had 15,054 *RWF* more income; those who used a window coverage in winter had their monthly income rise by 14,389 *RWF*; those with bedding in winter had their income improve by 4,978.7 *RWF*; those who used sprinklers/mist in summer had an improvement of 3,488 *RWF* in their monthly income; those with did wallowing have only improved their monthly income by 891 *RWF;* while those who resorted to bathing during summers had a reduced income level by 14,826 *RWF*.

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Table 11: Productive performance and income among dairy farmers before and during RDDP

	Min.	Max.	Average	25th Percentile	75th Percentile
Dry periods for cows before RDDP	1	8	3	2	5
Dry periods for cows during RDDP	1	10	2	2	4
Daily milk production before RDDP (*litres*)	2	20	4	3	5
Daily milk production during RDDP (*litres*)	1	30	6	5	8
Monthly Income from Milk production before RDDP (*RWF*)	7,100	155,480	22,600	17,500	27,700
Monthly Income from Milk production during RDDP (*RWF*)	2,400	168,000	33,000	28,100	43,000

Table 12: Difference in production before and during RDDP

	Average milk production	**p-value**
Daily milk production before RDDP (liters)	4 litres	< 0.001
Daily milk production during RDDP (liters)	6 litres	

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The income of the farmers from milk production during RDDP was also distributed across various background factors of the farmers, with a view to checking for possible statistically significant difference across the factor groups.

Income from dairy production was established to differ across groups of the farmers' age ($p = 0.049$), size of land owned ($p = 0.002$), household head occupation ($p = 0.002$), household size ($p < 0.001$) and size of dairy farm ($p < 0.001$). No significant difference was observed in the income level by level of education of the farmers ($p = 0.802$), gender ($p = 0.110$) and land ownership status ($p = 0.319$).

Worthy of note from the factors where a significant difference in income was observed were; farmers in the oldest age group (60 years or higher) recorded the highest level of monthly income (44,766 *Rwanda Francs*); those with more than 2 hectares of land recorded a monthly income as high as 52,150 *Rwanda Francs*; farmers with household head majorly occupied with dairy farming had a higher income level than those whose head of household majorly focused on crop farming (39,286 *Rwanda Fracs* and 33,247 *Rwanda Francs* respectively); farmers with 6 – 10 persons in their household recorded a higher monthly income level than those with 1 - 5 persons; farmers who had more than 1 hectare of land dedicated to dairy farm had up to 84,666 *Rwanda Francs* as monthly income prior – which is the highest in the group.

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Table 13: Difference in production before and during RDDP

	Average monthly Income	**p-value**
Monthly Income from Milk production before RDDP (*RWF*)	22,600	
		< 0.001
Monthly Income from Milk production during RDDP (*RWF*)	33,000	

3.9 Climate Change Adaptation Constraints

The study also revealed the constraints of the farmers in adapting to climate changes, as presented on Table 15. More than half of the farmers generally reckoned lack of awareness and knowledge about climate change adaptation practices has been a severe challenge to them (60%); majority also remarked limited knowledge on adaptation practices has been a severe challenge (64%); no financial resources was acknowledged as a severe challenge posing threat to their adaptation practices (59%); the cost of producing forage crop was highlighted as a severe challenge by 70% of the farmers; 60% remarked inadequate veterinary extension service was a serious constraint to their adaptation strategies; about 69% complained about having less expertise among field extension personnel as a major threat to adapting new strategies; 67% indicated lack of training on adaptation has also severely impacted their chances of adapting to climate changes quickly.

More severe constraints to adaptation practices were: lack of government policies supporting adaptation for dairy farmers (63%); lack of farmers' access to improved forage crop varieties (73%); lack of water resources for growing forage crops and maintenance (74%); lack of institutional support for climate change adaptation (72%); non-availability of weather information (75%); lack of feedback or reporting system on climate change adaptation, between the extension workers, researchers and the farmers (80%); untimely receipt of needful information about climate change (83%).

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Table 14: Response on climate change adaptation constraints

Item	Percentage of Severity
Lack of awareness and knowledge about climate change adaptation practices	147 (60.5 %)
There is limited knowledge on adaptation practices	155 (63.8 %)
There is Lack of financial resources for adaptation practices	141 (57.6%)
There is high cost of forage crop production for climate change adaptation	171 (70.4 %)
Inadequate veterinary extension services	148 (26.3%)
Less expertise among field extension personnel on climate change adaptation	167 (68.7%)
Lack of training on adaptation to climate change adaptation	152 (62.6%)
Lack of government policies for climate change adaptation	154 (63.4 %)
Lack of access to improved forage crop varieties to cope up climate change	177 (72.8 %)
Lack of water resources for growing forage crops and maintenance of animals	176 (74.4 %)
Lack of institutional support for climate change adaptation	176 (72.4 %)
Non availability of weather information	182 (74.9 %)
Lack of feedback/reporting system on climate change adaptation (between extension, research and clients/end-users)	194 (79.8%)
Needed information about climate change is not received on time (contingency plans/ on credit/animal care management etc.)	203 (83.5 %)

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CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

4.1 Summary

Dairy farming in Rwanda is recognised as an instrument for social and economic development; it is economically and socially significant because of the multi-functionality of dairy animals performing output, input, asset and socio-cultural functions across the dairy farming value chain. Dairy sector plays a significant role in generating gainful employment in rural sector, improving livelihood besides providing cost effective and nutritious food to millions of people. Dairy farming therefore is an integral part of the livestock production system in Rwanda. It is essential for rural development, poverty reduction and it plays a key role in achieving food and nutrition security. The study has documented the impact of climate change in dairy farming. Climate change impacts among other things make water and land to become more limited for fodder production; and causes temperatures rise, requiring changes to forage feeding systems and these situations could affect the productivity and profitability of dairy farming. The overall objective of this study was to assess the effect of climate change adaptation practices in dairy productivity and profitability of smallholder dairy farming in Nyanza district of Rwanda. The specific objectives were profiling climate change adaptation practices adopted by dairy farmers; assessing the level of productivity and profitability of dairy farmers and to identify the constraints experienced by dairy farmers in climate change adaptation practices. Focus was on the effects of the adaptation practices on the profitability and productivity of dairy farming.

The study adopted survey instrument that included structured questionnaire, key informant interview and Focus group discussion. A simple random sampling technique was used to select 243 respondents. A validated structured questionnaire with variables on perception to climate change, fodder production and availability, milk production, disease outbreak, weather information, adaptation practices and constraints to climate change adaptation was used to collect the data. The data were scored, compiled, tabulated and subjected to various appropriate statistical tools like percentage, frequency, mean, standard deviation, percentage, correlation and multiple regression analysis to draw meaningful results and conclusion.

The study found out that climate change adaptation practices have affected dairy farming practices such as breeding, feeding, health and shelter management and milking process. A test of difference

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using the Mann-Whitney U test revealed that a statistically significant difference was observed in milk production before and during the RDDP ($p < 0.001$). Averagely, monthly income level of the dairy farmers was about 22,600 *Rwanda Francs* prior RDDP, a record rising to 33,000 *Rwanda Francs* since the commencement of RDDP; a statistically significant difference was observed in the income level of dairy farmers before and during RDDP ($p < 0.001$). The study also revealed the constraints of the farmers in adapting to climate changes. More than half of the farmers generally reckoned lack of awareness and knowledge about climate change adaptation practices has been a severe challenge to them (60%); majority also remarked limited knowledge on adaptation practices has been a severe challenge (64%).

4.2 Conclusion

Dairy farming in Rwanda is well structured, organised and managed by the government through the Ministry of Agriculture and Animal Resources (MINAGRI) the Dairy farmers in Nyanza district have experienced changes in climatic patterns especially, increasing dry spell which has contributed to increase in pest infestation, livestock diseases incidences, shortage of feed resources and overall reduction of milk production. However, farmers have adopted suitable adaptation practices in dairy farming that have positive effect on their productivity and profitability.

Dairy farmers should also be empowered by government and other relevant institutions to engage in modern adaptation practices in order to mitigate against the effects of drought, pest infestation, disease outbreak and occurrences occasioned by extreme weather variability. 3. There existed a relationship between the changing climatic patterns and dairy productivity in the study.

4. There existed a relationship between the climate change adaptation practices and dairy farming profitability/income

4.3 Recommendations

As a response to the effects of climate change, dairy farmers should invest in fodder development and conservation in order to sustain their dairy herd productivity. Adequate mechanisms should be put in place to minimize losses and damages of the dairy herd and dairy herd productivity occasioned by increased frequency of extreme rainfall and temperature in the study location. Dairy farmers should be empowered to adapt and mitigate against the effects of drought and emergence of new vectors and livestock diseases occasioned by extreme weather variability. The study also discovered that majority of the dairy farmers and value chain actors are not educated or are primary school leaver, it is therefore recommended that youths with formal education should be encouraged to be a part of the value chain

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Government should also increase investment in both formal and informal education so as to improve farmers' acceptance of modern farming climate change adaptation practices.

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APPENDIX
APPENDIX A: QUESTIONNAIRE

SURVEY QUESTIONNAIRE ON ASSESSING CLIMATE CHANGE ADAPTATIONPRACTICE ON DAIRY PRODUCTIVITY AND PROFITABILITY IN NYANZA DISTRICT, RWANDA

Dear Respondent,
I am a researcher currently assessing the impact of climate change on dairy productivity and profitability in Nyanza district of Rwanda. Kindly provide answers by ticking the right box below. All answers provided will be treated confidentially. Thank you.

Latitude: _____ Longitude _____ Altitude:_____

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1. Gender: Male ☐ Female ☐ 2. Age …… (years)
2. Who is the head of your household? Man ☐ Woman ☐ Male Youth ☐ Female Youth ☐
3. Level of education completed: None ☐ Primary school ☐ Secondary school ☐ Vocational/technical ☐ Diploma ☐ Degree ☐ Masters ☐ Ph.D. ☐
4. Household Size _____? 5. Number of household members working _____?
6. Main occupation of household head? Dairy Farming ☐ Crop farming ☐ Others_____
7. Main occupation of household spouse? Dairy Farming ☐ Crop farming ☐ Others___
8. What is the total land area owned by household? _____ (ha)
9. What is the total area of land allocated to dairy farming? _____ (ha)
10. What is the land ownership status in (Q8) above? Private with titles ☐ Private with no titles ☐ Communal land ☐ others (please specify): ……

SECTION B: DAIRY FARMERS' PERCEPTION ON CLIMATE CHANGE

S/N	Statement	SA	A	D	SD
1	There is change in the amount of rainfall				
2	There is change in rainfall pattern due to climate change				
3	There is change in environmental temperature due to climate change				
4	There is change in the number of rainy days due to climate change				
5	There is change in the amount of thunderstorm due to climate change				
6	There is increase in number of droughts due to climate change				
7	There is change in the pattern of cold winds and heat winds due to climate change				
8	Severe wind/thunderstorm due to climate change leads to injury and death of dairy animals				
9	Climate change affects milk production/yield of dairy animals				
10	There is increase in disease/pest infestation due to climate change				
11	There is reduction in the amount of forage crop yield due to climate				
12	There is change in feeding behaviour of dairy animals due to climate change				
13	Climate change affects the reproduction/conception of dairy animals				

Note: SA = strongly agree A = Agree D = Disagree SD = strongly disagree

SECTION C: ADAPTATION PRACTICES ADOPTED BY FARMERS

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S/N	Adaptation practices	Before RDDP	During RDDP
I	**Breeding**		
1.	Suitable breeds under vulnerable climatic condition	a) Exotic breeds ☐ b) Crossbreds(Jersey/HF) ☐ c) Indigenous ☐	a) Exotic breeds ☐ b) Crossbreds(Jersey/HF) ☐ c) Indigenous ☐
2.	Type of breeding practiced under condition of dry season (heat stress)	a) Natural ☐ b) Artificial ☐ Insemination c) Both ☐	a) Natural ☐ b) Artificial ☐ Insemination c) Both ☐
3	Type of breeding practiced under condition of cold	a) Natural ☐ b) Artificial ☐ Insemination c) Both ☐	a) Natural ☐ b) Artificial ☐ Insemination c) Both ☐
II.	Feeding		
4	Which type of fodder do you provide to dairy animals during heat stress	a) Feeding more forage and low concentrate ☐ b) Feeding less forage and high concentrate ☐ c) Feeding whatever is available ☐ d) Any other_____	a) Feeding more forage and low concentrate ☐ b) Feeding less forage and high concentrate ☐ c) Feeding whatever is available ☐ d) Any other_____
5	Which type of fodder do you provide to dairy animals during wet season	a) Feeding more forage and low concentrate ☐ b) Feeding less forage and high concentrate ☐ c) Feeding whatever is available ☐ d) Any other_____	a) Feeding more forage and low concentrate ☐ b) Feeding less forage and high concentrate ☐ c) Feeding whatever is available ☐ d) Any other_____
6	Feeding schedule followed during extreme heat and cold periods	a) Early hours (plenty of water + dry fodder) + Late Hours (plenty of water + leftover greenery + little concentrates) ☐ b) Feeding anytime ☐	a) Early hours (plenty of water + dry fodder) + Late Hours (plenty of water + leftover greenery + little concentrates) ☐ b) Feeding anytime ☐
7	Feed additives used to cope up extreme hot/cold weather	a) Mineral mixture ☐ b) No knowledge ☐ c) Any others _____)	a) Mineral mixture ☐ b) No knowledge ☐ c) Any others _____)
8	Fodders used during drought situation	a) Use of crop residues ☐ b) Use of tree leaves/vegetable waste ☐ c) Grazing the animals along roads/ canals/open fields ☐ d) migration to other places ☐ e) Any others _____	a) Use of crop residues ☐ b) Use of tree leaves/vegetable waste ☐ c) Grazing the animals along roads/ canals/open fields ☐ d) migration to other places ☐ e) Any others _____
9	Feeding practices followed during extremes of weather	a) Feeding practices for maintenance of animal to ensure its survival ☐ b) Feeding practices to maintain minimum level of production and growth ☐ c) Any others _____	a) Feeding practices for maintenance of animal to ensure its survival ☐ b) Feeding practices to maintain minimum level of production and growth ☐ c) Any others _____
III	Water		
10	Source of water during drought/dry season	a) Providing water from reservoirs ☐ b) Well ☐ c) Pond ☐ d) Others_____	a) Providing water from reservoirs ☐ b) Well ☐ c) Pond ☐ d) Others_____
11	Source of water during wet season	a) Providing water from reservoirs ☐ b) Well ☐	a) Providing water from reservoirs ☐ b) Well ☐

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		c) Pond ☐ d) Others_____	c) Pond ☐ d) Others_____
12	Frequency provision of drinking water during dry session	a) Twice in a day ☐ b) Thrice a day ☐ c) *Ad lib* water ☐ d) Any others _____	a) Twice in a day ☐ b) Thrice a day ☐ c) *Ad lib* water ☐ d) Any others _____
13	Frequency provision of drinking water during wet season	a) Twice in a day ☐ b) Thrice a day ☐ c) *Ad lib* water ☐ d) Any others _____	a) Twice in a day ☐ b) Thrice a day ☐ c) *Ad lib* water ☐ d) Any others _____
IV.	Healthcare		
14	Health management under adverse climatic conditions	a) Preventive measures like vaccination is adopted ☐ b) Ethno-veterinary practices followed ☐ c) Regular health check-up ☐ d) No practice followed ☐ e) Any others _____	a) Preventive measures like vaccination is adopted ☐ b) Ethno-veterinary practices followed ☐ c) Regular health check-up ☐ d) No practice followed ☐ e) Any others _____
V.	Housing/Shelter Management		
15	Is there any modifications done /followed in housing system during change in climatic conditions	a) Yes ☐ b) No ☐	a) Yes ☐ b) No ☐
16	Practices adopted to cope with extremes of weather	a) Use of sprinklers/mist in summer ☐ b) Use of bedding in winter ☐ c) Coverage of windows in winter ☐ d) Bathing during summers ☐ e) Wallowing is done ☐ f) Use of proper ventilation ☐ h) Tying under shady trees during summer/hot times ☐ i) Keeping inside during day time and Tying outside during night ☐ j) Any others _____	a) Use of sprinklers/mist in summer ☐ b) Use of bedding in winter ☐ c) Coverage of windows in winter ☐ d) Bathing during summers ☐ e) Wallowing is done ☐ f) Use of proper ventilation ☐ h) Tying under shady trees during summer/hot times ☐ i) Keeping inside during day time and tying outside during night ☐ j) Any others _____
V	Others Dairy Farming Activities		
17	Is there any modifications in milking process during change in climatic conditions	a) Yes ☐ b) No ☐	a) Yes ☐ b) No ☐
18	Is there any modifications in transporting process during change in climatic conditions	a) Yes ☐ b) No ☐	a) Yes ☐ b) No ☐
19	Is there any modifications in milk processing process during change in climatic conditions	a) Yes ☐ b) No ☐	a) Yes ☐ b) No ☐

SECTION D: INFORMATION ON PRODUCTIVE PERFORMANCE

1. Number of dairy cattle _____

2 Type of Cattle	**3 Type of breed**	**4 Sources**
Heifer ☐	local ☐	Local purchase ☐
Bull ☐	cross breed ☐	Inherited ☐
Bull calf ☐	Exotic breed ☐	Government programme ☐
Heifer Calf ☐		Others _____
Others _____		

S/N	**QUESTIONS/ STATEMENTS**	**BEFORE RDDP Intervention**	**DURING RDDP Intervention**

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5	How many times per day do you milk your cow(s)?	Once ☐ Twice ☐ Three time ☐ Others ☐	Once ☐ Twice ☐ Three time ☐ Others ☐
6	How long do you milk your cow when it's lactating?	Once ☐ Twice ☐ Three time ☐ Others ☐	Once ☐ Twice ☐ Three time ☐ Others ☐
7	How long is the dry period for your cow?	_____days	_____days
8	Total Milk produced daily	_____litres	_____litres

9. Milk Production and Income Generation

Average Monthly Income		
	BEFORE RDDP Intervention (RwF)	**DURING RDDP Intervention (RWF)**
Sales of Milk		
Remittances		
Others Dairy farming activities		

SECTION E: CLIMATE CHANGE ADAPTATION CONSTRAINTS

S/N	Constraints	VS	S	NS	NA
1	Lack of awareness and knowledge about climate change adaptation practices				
2	There is limited knowledge on adaptation practices				
3	There is Lack of financial resources for adaptation practices				
4	There is high cost of forage crop production for climate change adaptation				
5	Inadequate veterinary extension services				
6	Less expertise among field extension personnel on climate change adaptation				
7	Lack of training on adaptation to climate change adaptation				
8	Lack of training on adaptation to climate change adaptation				
9	Lack of government policies for climate change adaptation				
10	Lack of access to improved forage crop varieties to cope up climate change				
11	Lack of water resources for growing forage crops and maintenance of animals				
12	Lack of institutional support for climate change adaptation				
13	Non availability of weather information				
14	Lack of feedback/reporting system on climate change adaptation (between extension, research and clients/end-users)				
15	Needed information about climate change is not received on time (contingency plans/ on credit/animal care management etc.)				

VS – Very severe S- severe NS- not severe NA – Not applicable

Figure 2 Data collection at the farm of dairy farmer

Figure 3 Focus Group Discussion with Airy Farmers

Figure 4 Data Collection at the house of a female dairy farmer

Figure 5 at the Milk Collection Centre in Mukingo Sector

Figure 6 Focus Group Discussion with RDDP/MINAGRI Climate Change Specialist

Figure 7 on going focus group discussion aided by a local interpreter