Effectiveness of Innovation Platforms in Enhancing Technology Adoption, Productivity and Viability: The Case of Smallholder Dairying in Rusitu and Gokwe, Zimbabwe

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DEDICATION

This thesis is dedicated to my parents, Adam and Betty Hanyani-Mlambo, who have provided life-long inspiration to me, and to my children whose inspiration I also hope to enhance through this thesis.

DECLARATION 1: PLAGIARISM

I, **Benjamine Hanyani-Mlambo,** declare that:

1. The research reported in this thesis, except where otherwise indicated, is my original research.
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Benjamine Hanyani-Mlambo

As the candidate's supervisors, we agree to the submission of this thesis:

Signed ____ ________   Date__15.4.2018____________

Dr M. Mudhara (Supervisor)

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Professor K. Nyikahadzoi (Co-supervisor)

Signed ______________________   Date________________________

Professor P. Mafongoya (Co-supervisor)

DECLARATION 2: PUBLICATIONS

The following manuscripts (accepted or under review) form part of the research presented in this thesis.

Manuscript 1 – Chapter 5

Hanyani-Mlambo, B.T., Mudhara, M., Nyikahadzoi, K. & Mafongoya, P. 2017. Socio-economic differences between innovation platform participants and non-participants: The case of smallholder dairying in Zimbabwe. *Livestock Research for Rural Development. Volume 29, Article #159.*http://www.lrrd.org/lrrd29/8/bmla29159.html (*Published*).

Manuscript 2 – Chapter 4

Hanyani-Mlambo, B.T., Mudhara, M., Nyikahadzoi, K. & Mafongoya, P. Innovation domains for enhancing technology adoption and socio-economic development: The case of smallholder dairying in Zimbabwe (*under review: African Journal of Science, Technology, Innovation and Development*).

Manuscript 3 – Chapter 6

Hanyani-Mlambo, B.T., Mudhara, M., Nyikahadzoi, K. & Mafongoya, P. The effectiveness of innovation platforms in enhancing productivity and viability: The case of smallholder dairying in Rusitu and Gokwe, Zimbabwe. (*under review: Journal of Agricultural Education and Extension*).

Manuscript 4 – Chapter 7

Hanyani-Mlambo, B.T., Mudhara, M., Nyikahadzoi, K. & Mafongoya, P. The potential of innovation platforms and ICTs in enhancing adoption of CSA innovations in smallholder dairying: Evidence from Zimbabwe. (*under review: Climate and Development*).

Author contributions

All the papers were conceived by B. Hanyani-Mlambo. Data collection, analysis and writing up of the papers were also done by B. Hanyani-Mlambo, while M. Mudhara, K. Nyikahadzoi and P. Mafongoya contributed valuable supervision, guidance, insights and comments on every stage of producing the papers.

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ABSTRACT

Despite numerous interventions, low adoption of dairy technologies, low productivity and viability challenges characterize smallholder dairy farming in large parts of the tropics. The problem lies in the unavailability, low adoption rates and disadoption of available improved smallholder dairying technologies. Using Rusitu and Gokwe smallholder dairy projects in Zimbabwe as a case study and a cross-sectional survey of 227 households, this research set out to: (i) explore the innovation domains and their influence on technology adoption patterns, (ii) determine the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms, (iii) assess the effectiveness of innovation platforms in enhancing productivity and viability, and (iv) determine the potential of innovation platforms in enhancing the adoption of Climate Smart Agriculture (CSA) innovations in smallholder dairying.

Principal Component Analysis and Cluster Analysis identified five distinct innovation domains *viz:* smallholder dairy producers (61.6%), smallholder dairy heirs (15.9%), new and emergent producers (4.6%), smallholder dairy pioneers (2.0%), and market-oriented producers (15.9%). Innovation domains influence the level of dairy technology adoption, notably those with higher levels of participation in innovation platforms. Further comparisons indicated statistically significant differences between innovation platform participants and non-participants regarding dairy herd size, experience in commercial dairying, training received, dairy management systems, and overall Knowledge, Attitudes and Practices (KAP) ($p < 0.01$).

Propensity Score Matching (PSM) techniques were used to estimate the Average Treatment effect on the Treated (ATT) in determining the impact of innovation platforms on productivity and viability. Results show an ATT value of 0.135 ($p < 0.1$), while participation in innovation platforms had a positive significant impact on average milk productivity and gross income ($p < 0.01$). Multinomial Logit (MNL) regression analysis identified participation in innovation platforms to be significant in determining the adoption of CSA innovations such as artificial insemination and fodder production ($p < 0.01$), and hence the potential of innovation platforms in enhancing the adoption of CSA innovations in smallholder dairying.

Innovation platforms have great potential for enhancing technology adoption, productivity and viability in smallholder dairying. This study recommends the promotion, adoption and sustainable funding of innovation platforms as practical tools for developing smallholder dairying.

LIST OF ACRONYMS

AGRITEX	Department of Agricultural, Technical and Extension Services
ANOVA	Analysis of Variance
ARDA	Agricultural and Rural Development Authority
ATT	Average Treatment Effect on the Treated
CA	Cluster Analysis
CA	Conservation Agriculture
CGIAR	Consultative Group on International Agricultural Research
CSA	Climate Smart Agriculture
DA	District Administrator
DANIDA	Danish International Development Agency
DDP	Dairy Development Programme
DMB	Dairy Marketing Board
DR&SS	Department of Research and Specialist Services
DVS	Department of Veterinary Services
DZL	Dairiboard Zimbabwe Limited
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCS	Food Consumption Score
FGDs	Focus Group Discussions
FMD	Foot and Mouth Disease
FSR	Farming Systems Research
FTLRP	Fast Track Land Reform Programme
GDP	Gross Domestic Product
GNU	Government of National Unity
HDDS	Household Dietary Diversity Score
HH	Household
ICFU	Indigenous Commercial Farmers Union
ID	Innovation Domain
IDEAA	Initiative for the Development and Equity in African Agriculture
IFAD	International Fund for Agricultural Development
IMF	International Monetary Fund

IPs	Innovation Platforms
KAP	Knowledge, Attitudes and Practices
KIIs	Key Informant Interviews
KMO	Kaiser – Meyer – Olkin
LDC	Less Developed Country
LOL	Land O' Lakes
LPD	Department of Livestock Production and Development
LSD	Lumpy Skin Disease
MAHFP	Months of Adequate Household Food Provisioning
MAMID	Ministry of Agriculture, Mechanization and Irrigation Development
MCC	Milk Collection Centre
MICS	Multiple Indicator Cluster Survey
MNL	Multinomial Logit
MOHCW	Ministry of Health and Child Welfare
MPA	Milk Producers Association
NADF	National Association of Dairy Farmers
NNM	Nearest Neighbour Matching
PA	Provincial Administrator
PCA	Principal Component Analysis
PICES	Poverty, Income, Consumption and Expenditure Survey
PSM	Propensity Score Matching
QE	Quarter Evil
RDCSs	Rural District Councils
TOT	Transfer of Technology
SADC	Southern Africa Development Community
SCC	Swedish Cooperative Centre (now known as We Effect)
SNV	Netherlands Development Organization
SPSS	Statistical Package for Social Sciences
STABEX	EU's Stabilisation of LDCs' Export Earnings
STATA	Data Analysis and Statistical Software
UHT	Ultra High Temperature
UKZN	University of KwaZulu Natal
USA	United States of America
USAID	United States Agency for International Development

UZ	University of Zimbabwe
ZADF	Zimbabwe Association of Dairy Farmers
ZCFU	Zimbabwe Commercial Farmers Union
ZFU	Zimbabwe Farmers Union
ZimASSET	Zimbabwe Agenda for Sustainable Socio-Economic Transformation
ZimStat	Zimbabwe Statistics Agency
ZIMVAC	Zimbabwe Vulnerability Assessment Committee

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CHAPTER 1: INTRODUCTION

1.1 Background to the problem

Sub-Saharan African countries have for decades been faced with a formidable crisis of food insecurity, unsustainable agricultural production, malnutrition and persistent rural poverty (FAO, 2015). In response to this crisis, many governments and various development partners have undertaken major initiatives to help farm households improve their productive capacity, food security and living standards. One area of intervention has been the establishment of a smallholder targeted Dairy Development Programme which is important at both the household and national levels. Despite these interventions, smallholder dairy enterprises are still characterized by low productivity, restricted market participation, viability challenges, and insignificant reinvestments in dairying (Hanyani-Mlambo et al., 1998; Hanyani-Mlambo, 2000; Zvomuya, 2007; Chinogaramombe et al., 2008; Kagoro and Chatiza, 2012). The problem lies in the unavailability, lack of access to, and the low adoption rates of available improved smallholder dairy technologies. Past studies and literature ascertain that the unavailability and low adoption levels result from, *inter alia*, policy gaps, weak research-extension-farmer linkages, fragmented and inappropriately focused research, top-down and supply-driven extension, poor segmentation of target domains, and technologies that are elitist and out of touch with rural realities (Shumba et al., 1990; Mutimba, 1997; Hanyani-Mlambo, 2003; Mudhara and Hildebrand, 2005; Hebinck and Cousins, 2013). This gave rise to new paradigms and cutting edge intervention models such as innovation platforms (Klerkx et al., 2009; Nederlof et al., 2011; van Royen and Homann, 2012). It then becomes explicit that a study designed to analyze and improve the effectiveness of innovation platforms, through an understanding of the dynamics involved, is critical for advancing the theory and practice of innovations, and for the development of the smallholder agricultural sector.

1.2 Development of smallholder dairying in Zimbabwe

Before independence in 1980, market-oriented dairying was the sole prerogative of white farmers in the large-scale commercial sector. Chavunduka (1982) noted that smallholder milk production before independence was basically for subsistence purposes and there were no exotic breeds kept by the smallholder farmers. An acute need to expand the dairy industry arose from shortages of fresh milk and other milk products which occurred in the country just after independence. As a long-term policy, the government decided to stimulate milk production from the smallholder sector. This then resulted in the formation of the Peasant Sector Development Programme in 1982. The responsibility of running this programme was assigned to the Dairy Marketing Board (DMB) and later the Agricultural and Rural Development Authority (ARDA). The programme became known as the Dairy Development Programme (DDP). The main objective of the programme was to use smallholder dairying, through enhanced milk production and marketing, as a tool for rural development. By 1995 the DDP had 10 Milk Collection Centres (MCCs), and today the programme has 21 MCCs and 7 sub-collection centres in five of the country's eight rural provinces and 13 of the country's 57 rural districts (Kagoro and Chatiza, 2012).

1.3 Intervention and technology adoption

Interventions in the smallholder dairy subsector have traditionally followed a linear top-down approach, characteristically referred to as the Transfer of Technology (TOT) model. In this conventional model and in practice, technology development emphasis lies on the transfer of technology from one set of actors (researchers), through another (extension agents), to the so-called users (farmers). The TOT model was motivated by the Green Revolution model of technology development and transfer which tripled rice and wheat yields in Asia leading to widespread adoption but failed to reproduce the same success in Africa (Hall et al., 2003; Sumberg, 2005). The TOT model ignored the important function of information feedback in the system resulting in limited actor participation, inappropriate recommendations and low adoption levels by farmers. According to Sumberg (2005), numerous subsequent attempts to reform, down-size, merge and in some cases, dismantle public funded research institutions in Africa have yielded insignificant results. Intervention reforms have included the use of more holistic approaches such as Farming Systems Research (FSR), on-farm trials and participatory research. The missing link has been lack of a practical and inclusive approach enshrined throughout the entire agricultural value chain.

1.4 Problem statement

Despite the importance of smallholder dairying and numerous interventions, the smallholder dairy sector is still characterized by low adoption of dairy technologies, low productivity and viability challenges (Hanyani-Mlambo et al., 1998; Chinogaramombe et al., 2008; Kagoro and Chatiza, 2012). The key question is: are new intervention models such as innovation platforms effective mechanisms for improving intervention, farmer segmentation, technology adoption, productivity and viability?

1.5 Rationale of the study

Livestock contributes about 40% of global agricultural Gross Domestic Product (GDP) and 30% of agricultural GDP in developing countries (Gebremedhin and Hoekstra, 2010). In Zimbabwe, livestock production systems contribute directly to food security, income growth and poverty reduction at both micro- and macro-economy levels. Specifically, the dairy sub-component has proved to be practically vital, especially in the smallholder farming sector where milk is an important source of protein to young children and supplementary income to often economically disadvantaged farm households. The current estimated demand for milk and milk products is 180 million litres, which presents a supply gap of 129 million litres, thereby creating vast opportunities for import substitution (Kagoro and Chatiza, 2012). Due to the large numbers involved, the smallholder dairy subsector has the greatest potential and thus provides the best basis for increasing national dairy production and ensuring milk self-sufficiency. Smallholder dairying in Zimbabwe also presents the greatest opportunities for unlocking value, generating the highest and quickest returns to investment due to the diversity of dairy products and the higher margins that can be gained from niche markets.

Despite this apparent importance, government investment, research and extension programmes have portrayed biases by favouring crops over livestock systems, and biological over socio-economic issues. In addition, there has been no detailed or systematic study on institutional factor impediment in smallholder dairying and related production systems (topically and geographically). Current literature is also saturated with analysis of simulated and transitory innovation platforms, the bulk of which are initiated and propped by the Consultative Group on International Agricultural Research (CGIAR), whose sustainability remains questionable. In contrast, this study seeks to analyze existing and organically developed innovation platforms. Information generated by the study was anticipated to provide insights on issues critical for the academic advancement of innovation theory, formulation of realistic dairy development policies, as well as feedback to technology development and dissemination processes. The outcomes of this study are anticipated to assist input suppliers, smallholder dairy producers, processors, traders, retailers, potential investors, other actors, and the synergies along the dairy value chain in enhancing the effectiveness of innovation platforms.

At the micro-level, smallholder dairying has great potential in contributing to the transformation of the meso-economy within different contexts, and ultimately a revival of Zimbabwe's ailing macro-economy. This study is also critical in identifying bottlenecks and opportunities within the local smallholder dairy sector. An understanding of the dynamics, constraints and prospects can provide the impetus for the uplifting of the benefits, margins and livelihoods of smallholder dairy value chain players, notably the already economically disadvantaged smallholder dairy farmers.

1.6 Research objectives and hypotheses

Purpose

The purpose of this research study was to determine the effectiveness of innovation platforms within the context of smallholder dairying in Zimbabwe.

Objectives

The specific objectives were to:-

(i) Explore the innovation domains and their influence on technology adoption patterns,

(ii) Determine the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms,

(iii) Assess the effectiveness of innovation platforms in enhancing smallholder dairy productivity and viability, and

(iv) Determine the potential of innovation platforms and Information and Communication Technologies (ICTs) in enhancing the adoption of Climate Smart Agriculture (CSA) innovations in smallholder dairying.

Hypotheses

Based on the specific research objectives, the thesis will test the following hypotheses:-

H_{01} Innovation domains have a positive influence on technology adoption patterns.

H_{02} Significant socio-economic differences exist between participants and non-participants in smallholder dairy innovation platforms.

H_{03} Innovation platforms are effective in enhancing smallholder dairy productivity and viability.

H_{04} Innovation platforms and ICTs enhance the adoption of CSA innovations in smallholder dairying.

1.7 Overview of research methods

The study was based on a cross-sectional survey of 227 households in Rusitu and Gokwe dairy project sites in Zimbabwe. Other data collection methods included desk research, Key Informant Interviews (KIIs), and Focus Group Discussions (FGDs). Collected quantitative data were analyzed using Principal Component Analysis (PCA), Cluster Analysis (CA), descriptive statistics, cross tabulations, Propensity Score Matching (PSM), the Nearest Neighbour Matching (NNM) method, and Multinomial Logit (MNL) regression. On the other hand, qualitative data analysis relied on interpreting verbal responses, descriptions, ideas, perspectives and opinions, as well as establishing common patterns in available data.

1.8 Organization of the thesis

This thesis comprises eight chapters. The introductory chapter has already provided the background, study rationale, nature of the research problem and the study purpose and objectives. Chapter two gives the background to the study context and the Zimbabwean dairy value chain, while Chapter three reviews the theoretical and conceptual frameworks, as well as literature on smallholder dairy technology adoption, productivity and viability. The next chapter explores the influence of innovation domains on technology adoption patterns, while Chapter five outlines the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms. Chapter six presents an analysis of the effectiveness of innovation platforms in enhancing smallholder dairy productivity and viability. Chapter seven looks at the potential of innovation platforms and ICTs in facilitating the adoption of CSA innovations. The thesis concludes by drawing up key conclusions, policy implications and proffering recommendations.

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CHAPTER 2 : BACKGROUND AND CONTEXT

2.1 Preamble

This chapter gives a background to the study context; detailing the agro-ecological, socio-economic, poverty, and food and nutrition security issues, as well as livestock production practices. It also provides a background to the Zimbabwean dairy value chain, the actors and stakeholders involved, their interactions and production models prescribed to.

2.2 Background and general context

2.2.1 Geophysical and agro-ecological context

Zimbabwe's agro-ecological regions I – V, also commonly referred to as natural regions, present dimensional differences in the geophysical, natural and the agricultural potential of the different agro-ecological regions. Observed and perceived differences emerge from the agro-ecological regions' geographical location in different parts of the country as well as differences in the geophysical and natural environments. These dissimilarities give rise to patent variations in rainfall regimes (as determined by the amount and distribution of precipitation), soil quality and vegetation. According to Moyo (2000), the quality of land resource declines from Natural Region I through to region V. Likewise, crop production potential is highest in Natural Region I, which is relatively wet and has good quality soils, and lowest in Natural Region V, which is drier and more marginal (Rukuni et al., 2006). See Figure 2.1 for the illustration and below for the detailed descriptions.

Natural Region I lies in the east of the country. This region is characterized by evenly distributed rainfall that exceeds 1,000mm per year, low temperatures, high altitude and well drained soils. It is ideally suitable for intensive diversified agriculture, mainly the production of plantation and other high value crops, and dairy farming. Natural Region II if found in the middle of the north of the country, with fairly reliable uni-modal rainfall of 750 – 1,000mm per year. Attributes that includes reliable rainfall and generally good soils make NR II suitable for intensive cropping and livestock production. Natural Region III is located largely in the mid-altitude areas of the country. This region has a disposition of rainfall of between 500 – 750mm per year and mid-season dry spells, making it marginally suitable for dairying.

On the other hand, Natural Region IV lies in the low-lying areas in the north and south of the country. Annual rainfall in this agro-ecological zone ranges from 450 – 650mm per year with severe dry spells during rainy season and frequent seasonal droughts. Similarly, Natural Region V is found within the lowland areas below 900m above sea level in both the north and south of the country, with highly erratic average annual rainfall of less than 650 mm per year. Unreliable rainfall, uneven topography and poor soils make these agro-ecological zones unsuitable for crop production, but ideal for extensive livestock and wildlife production.

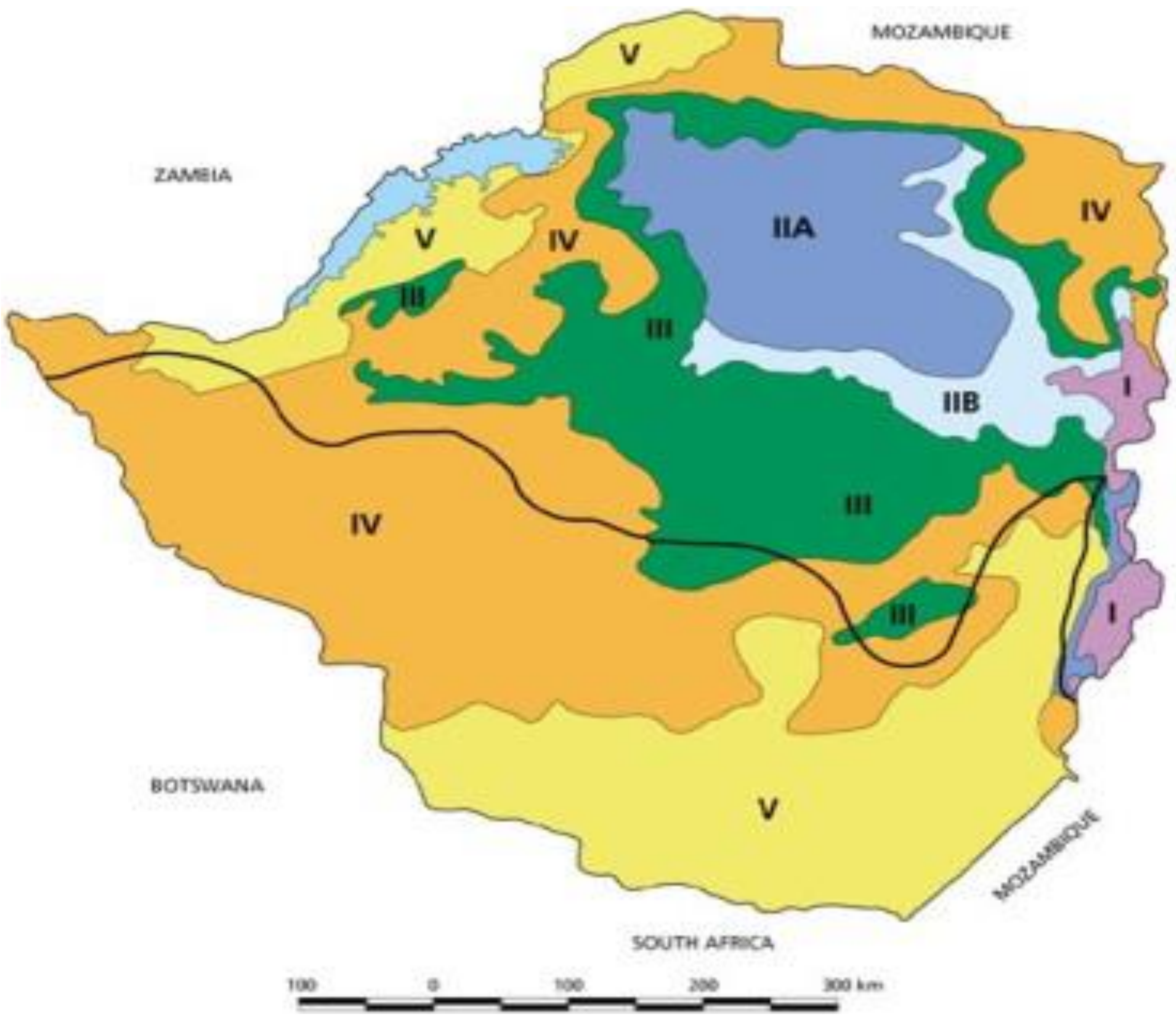

Figure 2.1 : *Map depicting agro-ecological regions in Zimbabwe.*

Source: http://www.fao.org/docrep/009/a0395e/a0395e06.htm

2.2.2 Socio-economic context

Zimbabwe has traditionally had an agro-based economy, whose success rode on the back of a well-developed and diversified agricultural sector, as well as forward and backward linkages between the agricultural, manufacturing and service sectors. The country was the breadbasket for Southern Africa, the largest beef exporter in Africa, and a net exporter of milk and other dairy products. In 1999, the agricultural sector directly employed about 70 percent of the total labour force, represented 51 percent of total export earnings, and contributed about 28 percent to the country's GDP. The implementation of the Fast Track Land Reform Programme (FTLRP) in 2000 triggered a series of economic, political, and social shocks whose ripple effects has far reaching impacts. The macro-economic challenges that typified Zimbabwe during the 2000 – 2008 period, were characterized by hyperinflation, a period of economic decline, a slump in agricultural output, and a deterioration in private sector activities that resulted in the shrinkage of the country's real GDP. It is estimated that agricultural production declined by 79 percent between 2002 and 2008, total export earnings fell to 29 percent by 2008, while GDP plunged by more than 50 percent between 2000 and 2008 (DANIDA, 2010; USAID, 2014).

The Zimbabwean economy has, however, been rebounding since February 2009 following political reforms, with the formation of a Government of National Unity (GNU), the embracing of short-term economic stabilization programmes such as the liberalization of selected agricultural markets, and the adoption of a multi-currency regime. This has turned around and largely stabilized the economy, controlled inflation, and generated economic growth rates, with GDP growth ranging from 10 – 12 percent in the early recovery years to 3 percent or less in 2013 (IMF, 2014). Although production levels in most agricultural value chains remain far below levels achieved in prior to 2000, the sector has recorded strong growth ranging between 15 – 17 percent during the recovery period. Presently, agriculture contributes between 16 – 20 percent of GDP, 40 percent of national export earnings, and with over 70 percent of the population depending directly and/or indirectly on the sector.

2.2.3 Poverty, food and nutrition security

Poverty, food and nutrition insecurity remain key concerns in Zimbabwe, a far outcry from the pre-2000 era when the country boasted of being food secure, and served as the bread basket of the region. According to ZimStat (2012), Zimbabwe is amongst the highest poverty rates in Africa. Results of the Poverty, Income, Consumption and Expenditure Survey (PICES) conducted in 2011/12 show that 82 percent of communal farming households are poor (living on less than $2.52 per person per day), whilst 26 percent are classified as being extremely poor (living on less than $1.07 per person per day). Malnutrition, as manifested in stunting in children less than five years of age, also remains a challenge in Zimbabwe. Malnutrition is largely due to poor dietary diversity. According to the Multiple Indicator Cluster Survey (MICS) in 2014, more than one-quarter of all children (28%) are stunted, with stunting rates exceeding 40 percent in some districts (ZimStat, 2014). The most recent available statistics indicate that up to 11 percent of children under five are underweight (ibid.), while 16 percent of school children suffer from iodine deficiency (MOHCW, 2009).

Reducing poverty and achieving food, nutrition and income security at household, community and national levels remains a long-standing goal of the Government of Zimbabwe. Major drawbacks have included, *inter alia*, declining agricultural productivity, poor technical skills, and lack of access to irrigation facilities. Subsequent consequences have been a loss of livelihoods, increasing levels of poverty and reduced food security situation. Recovery in the Zimbabwean agricultural sector has also been hampered by poor entrepreneurship, the lack of agricultural competitiveness, viability challenges, lack of liquidity, high interest rates, limited access to finance, and an unconducive policy environment. In addition, recurrent droughts continue to pose a major threat to food security. On the other hand, drivers of poor nutrition are three-pronged *viz:* (i) the quantity of available food, (ii) quality of the available food, and (iii) water, sanitation and hygiene circumstances.

2.2.4 Livestock production

Livestock contributes about 40 percent of the agricultural GDP. Having said this, it has to be noted, however, that the sub-sector contribution to national agricultural sector performance has remained relatively low compared to that of the crop production sub-sector. About 80 percent of cattle, sheep, goats and donkeys are owned by smallholder farmers. According to

MAMID (2012), approximately 68 percent of all cattle are owned by smallholder farmers in communal areas, with 58 percent of those cattle in drier areas such as Natural Regions III to V. On the other hand, Natural Regions I and II feature strongly on the dairy component.

There are observed significant differences in grazing and foraging techniques between traditional subsistence and commercialized livestock production systems. Subsistence livestock production systems are characterized by randomised grazing systems with communal grazing, non-use of fencing or paddock systems. There is no or limited supplementary feeding for the majority of livestock owning households. On the other hand, grazing and foraging techniques in semi-commercialized and business-related livestock production enterprises are characterized by capital intensive investments in fodder supply systems. As an illustrational example, smallholder dairy farmers producing as a part of milk hubs or supplying MCCs rely on zero grazing for lactating cows and paddock grazing for follower stock (LOL, 2013). Disease is the largest cause of livestock mortality in the smallholder sector. Disease is also the largest extractor of livestock at household level. The most common diseases include Foot and Mouth Disease (FMD), Quarter Evil (QE), Lumpy Skin Disease (LSD), tick borne diseases, and internal parasites including measles. Disease control efforts include vaccinations, dosing against parasites, and dipping (once fortnightly during the dry season and weekly during the rainy season). A large number of smallholder farmers also rely on ethno-veterinary medicines for treatment, with *aloe vera*, tubers and tree buck being the major remedies.

Identified limitations in livestock production and animal health, based on available statistics, indicate challenges but also great potential given that the flipside of any challenge is an opportunity. As examples, the average calving rate is 45 percent compared to 60 percent on large commercial farms, mortality rates for beef cattle is about 4.4 percent compared to the desired rate of 2 – 3 percent per annum, and cattle off take rates average 5.3 percent compared to 20 percent on commercial farms (Hanyani-Mlambo and Manyonga-Matingo, 2014).

2.3 The Zimbabwean dairy value chain

2.3.1 Overview of the dairy industry in Zimbabwe

For years, Zimbabwe has had a dualized agricultural structure, whose partitioning cascaded down to most sub-sectors and still remains as one of the country's colonial legacies, although the disaggregation is less obvious today than before. The Zimbabwean dairy value chain is thus characterized by production sub-groups classified under a large scale commercial dairy subsector and a smallholder dairy subsector (See Figure 2.2).

Prior to 2000, the large scale commercial dairy subsector comprised commercial dairy farms that were well developed and compared very favourably with dairy farms in Europe and North America. The farms, located in high potential and intensive farming regions (Natural Regions I, II and III), had high producing pure exotic cows and their crosses. The predominant dairy cattle breeds were the Holstein-Friesian breeds, followed by Jersey, Ayrshire, Guernsey, Redpoll, Simmental and Red Dane. This thrust Zimbabwe as a major milk producer and exporter of milk throughout the Southern Africa Development Community (SADC) region, peaking at approximately 262 million litres in 1990 (NADF, 2012). As discussed earlier, Zimbabwe then faced a decline in agricultural production, for nearly a decade between 2000 and 2008 due to a complex combination of socio-economic, political and environmental factors. This negatively affected the ability of many dairy farmers to remain in viable milk business, with total annual milk volumes declining to less than 35 million litres by 2008 (NADF, 2012). A number of milk processing plants in the country also subsequently shut down, with the country running at less than 30% of installed capacity. Similarly, the number of registered large scale commercial dairy farmers has dropped from 559 in 1987 to less than 120 in 2012 (NADF, 2012), while the national dairy herd has declined from 115,790 in 1987 to 22,738 in 2011 (Kagoro and Chatiza, 2012).

Politico-economic reforms, including the adoption of an inclusive government and the dollarization of the economy in February 2009, and the subsequent recovery in many sectors of the economy witnessed a resurgence in national milk production to 51 million litres in 2011, which picked up further to 56 million litres in 2012 (Dube and Hanyani-Mlambo, 2012; Carr and Hanyani-Mlambo, 2013). The estimated demand for milk and milk products in Zimbabwe is 180 million litres, which presents a supply gap of 129 million litres. The country is also currently importing more than 60 million litres of milk annually, which presents an opportunity for import substitution. This is a gap that can be filled in through improved productivity from local smallholder dairy farmers.

2.3.2 Smallholder dairy production

Despite the great potential and support from the government and international development partners, the contribution of the smallholder dairy subsector to total national milk output has remained insignificant. See Figure 2.2.

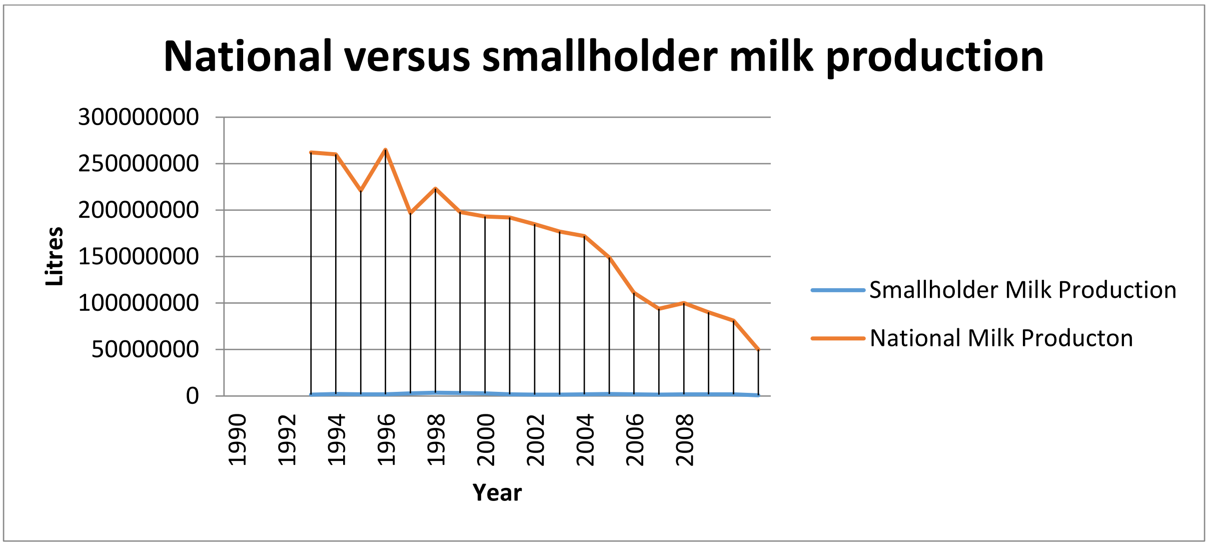

Figure 2.2: *National versus smallholder milk production volumes.*

Source: NADF (2012).

Milk production within the smallholder dairy sector fluctuated from 2.7 million litres in 1990 to 1.5 million litres in 1998 and 1.13 million litres in 2011, while recent reviews of the smallholder dairy subsector reveal some signs of subsector recovery since 2009 (Dube and Hanyani-Mlambo, 2012; Carr and Hanyani-Mlambo, 2013). See Figure 2.3.

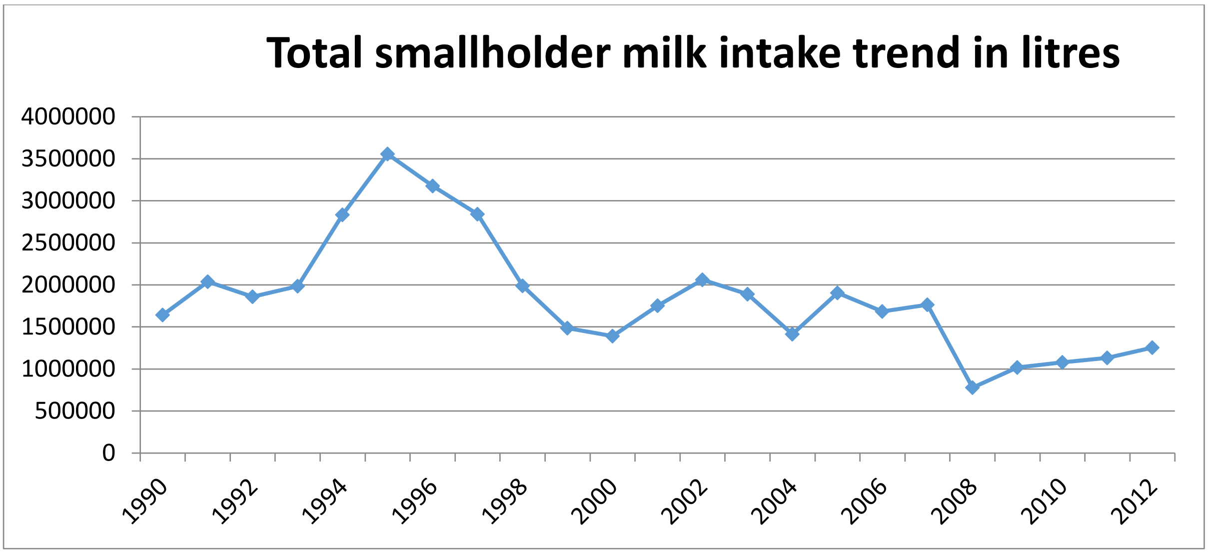

Figure 2.3: *Smallholder milk intake trends by year.*

Source: DDP (2012).

Identified major constraining factors hindering growth within the Zimbabwean smallholder dairy sector are poor commercialisation, weak organisation, poor governance, and low productivity. In a dairy value chain study, Kagoro and Chatiza (2012), established that smallholder dairy farmers had little or no access to dairy stock, dairy cattle loans, markets, improved breeding technology and animal health services. The review also indicates that the subsector remains strained by a reduced producer base, lack of capital, low herd sizes, poor animal breeds, low farm-level productivity, lack of viability and sustainability, and weak institutional support. It is also reported that most smallholder dairy projects, initiated by the Government and supported by development partners, and smallholder milk production suffered a slump during the period 2006 to 2008 with some closing as a result of the prevailing hyperinflationary environment. However, the sub-sector has infrastructure in place, vast knowledge has been disseminated to the sector since inception in 1983, and vast opportunities prevail in the current demand – supply deficit (Kagoro and Chatiza, 2012).

2.3.3 Status of smallholder dairy MCCs

According to Dube and Hanyani-Mlambo (2012), in an SNV Evaluation of the Smallholder Dairy Sector in Zimbabwe, the bulk of dairy cattle within the smallholder dairy subsector succumbed to diseases while macro-economic challenges eroded any opportunities for farmers to raise capital and rebuilt their dairy herds. Subsequently, there have been no adequate dairy animals to sustain milk production, deliveries to the MCCs, and MCC operations leading to the collapse of a number of smallholder dairy schemes. Consultations with key stakeholders revealed that out of the 19 established Smallholder Milk Collection Centres (MCCs), 16 remain active, while three (3) had ceased operations by the time of the 2012 study. Another five were reported to be at different stages of establishment. Out of the total of 1,444 registered smallholder dairy producers only 436 (30.2%) were active and delivering milk to local MCCs, while only 7.5 – 50.0 percent of the existing milk storage capacity was being utilized due to a myriad of challenges that included low productivity as a result of poor breeding, animal health management and feed management practices. The study also established a mean dairy herd of 5.76 animals, while the average daily milk yield per cow stood at 6.77 litres (std. dev. of 7.55). A number of technologies had been successfully adopted by smallholder dairy farmers including breed improvement that had been taken up by 74 percent of the interviewed households, supplementary feeding (76%) and use of home-made rations (55%).

2.3.4 Milk products and milk marketing

Using locally produced raw milk and imported Ultra High Temperature (UHT) and/or powdered milk, the local dairy value chain produces a wide diversity of milk and dairy products. Nyoka and Saidi (2014) categorized milk products in Zimbabwe into subgroups that encompass liquid milk, foods and beverages. In the liquid milk category there is short and long life liquid milk, cultured milk and fresh cream. On the other hand, the food category comprises yoghurts, ice cream, powdered milk, cheese and butter, while the beverages group is made up of juices. As discussed in more detail below, milk marketing follows several model options. However, processors largely dominate the dairy industry and shape the marketing structure.

The marketing of dairy products in the country is largely through formal channels, while dairy products marketed through informal channels remain insignificant. According to Kagoro and Chatiza (2012), this is largely due to the long traditions of highly regulated food processing and marketing activities in the country. The formal market deals mostly with milk coming from commercial producers who have supply contracts with processors. Conversely, the informal market mobilizes milk predominantly from smallholder dairy farmers as well as from a few large scale commercial dairy farmers through farm-gate stores. Marecha (2009) also established that smallholder farmers sell up to 68 percent of their milk through the informal channel. Milk producer prices are a result of negotiations between the Dairy Processors Association and the Farmers' Associations. The base producer prices, paid by all processors, are determined on the basis of input costs plus a profit margin for the producer. An additional premium is also paid based on the quality of delivered/collected milk. On the other hand, wholesale prices are a function of the production costs and the recommended retail price based on a 10 percent mark-up.

2.3.5 Potential for dairy value chain development

Despite the existence of structural and inherent limitations, the potential of dairy value chain development in all the five agro-ecological regions is quite high. This is due to a number of reasons. Zimbabwe has a large market for dairy products given that the country is currently importing 60 percent of its dairy product requirements, thus there are great opportunities for import substitution and potential for growing the smallholder dairy sector. Great potential exists for addressing challenges within the smallholder dairy sector e.g. problems with quality of the animal (breed), lack of availability and access to fodder and feeds, and the low capacity of MCCs, as manifested in MCCs' failure to observe basic hygienic practices, failure to maintain the cold chain, and poor quality of milk products and by-products. There are also opportunities for increasing milk production through growing the national dairy herd, increasing dairy animal ownership by smallholder farmers, and by improving farmers' access to loan and credit facilities. On the other hand, there are opportunities for improving milk volumes and quality by improving the breeds (e.g. through artificial insemination), improving access to fodder and feeds through innovation platforms and innovative strategies such as the promotion of fodder entrepreneurs, training of farmers and MCC staff, and facilitated access to improved materials, utensils and equipment.

2.4 Dairy value chain actors, stakeholders and interactions

2.4.1 Actor analysis

The dairy value chain encompasses input suppliers, producers (registered large scale commercial dairy farmers, company dairy farms, small scale dairy producers and smallholder dairy farmers), bulking facilities, processors (including Dairiboard Zimbabwe Limited, Dendairy, Kefalos, Nestle, Kershelmar, Alpha Omega and Dorkins), distributors, wholesalers, retailers, consumers and a variety of service providers along the value chain. An illustrational depiction of the dairy value chain map is presented in Figure 2.4.

2.4.2 Stakeholder matrix

Further to the actor Analysis, this section presents a Stakeholder Matrix, that identifies, categorizes, and plots stakeholders based on their power and interest. This is key in guiding interventions and in prioritizing the level of engagement with each of the identified stakeholders. For the purposes of this thesis, a stakeholder is defined as any individual, groups of people, institutions or organizations that may have a significant interest in the success or failure of an intervention or development initiative. Interest is hereby also conceptualized as the stakeholder's level of interest in the issue, while power refers to their ability to facilitate or prevent change from happening. Table 2.1 presents a detailed stakeholder matrix.

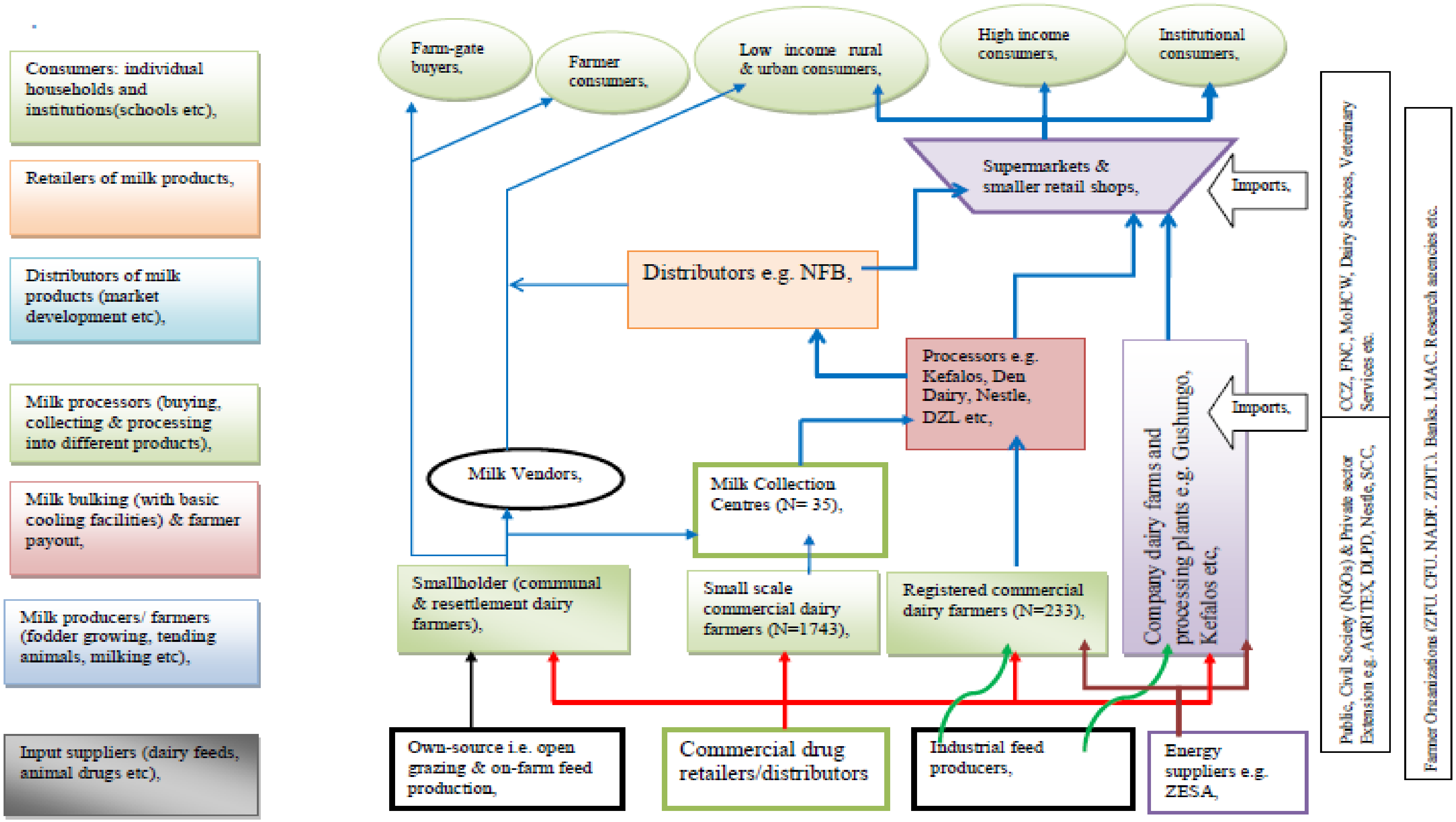

Figure 2.4: *Zimbabwean dairy value chain map (Kagoro and Chatiza, 2012).*

Table 2.1: *Dairy stakeholder matrix.*

STAKEHOLDER Name & brief description.	**STAKE IN THE ISSUE** What is of interest to them, what do they want to see happen, how are they affected, how motivated are they etc.?	**HOW CAN THEY HELP THE INTERVENTION TO BE SUCCESSFUL** What skills, attributes do they have to bring to the intervention?	**HOW SHOULD THEY BE ENGAGED** What level of engagement do you need to consider, and what processes of engagement would suit? Are there conflicts amongst some stakeholders?
Farmers (Primary drivers of the project. Stakeholder group includes men, women, the elderly, the youth, resource endowed & resource-poor)	• Interest – deriving livelihoods & income • Expectation – successful project implementation. • Impacts – loss of livelihoods/poverty. • Motivation – highly motivated.	• Skills – possess production, marketing, resource allocation & management skills. • Attributes – traditionally been dairy farmers (subsistence),	• Primary stakeholders. • Level of engagement – Manage Closely (High Interest, High Power). • Capacity development on production, marketing, and business skills e.g. leadership and management (with use of participatory methods)
Public Extensionists (DDP, LPD, DVS, AGRITEX)	• Interest – part of their mandate. • Expectation – growth in the dairy industry (ZimASSET) • Impacts – no direct impact (work not output related). • Motivation – poorly motivated (low salaries, lack of operational budget, equipment, mobility, etc).	• Skills – most of the frontline staff (foot soldiers) have basic knowledge and skills. • Attributes – well respected and falls within farmers' circles of confidence.	• Level of engagement – Manage Closely (High Interest, High Power). • This is key in guaranteeing project success and sustainability. • Conflicts – fight for limited resources. • Conflict management tool – create an Innovation Platform that bring together all stakeholders.

Input Suppliers, Private Researchers & Extension Agents (Private Input Suppliers – feed manufacturers, veterinary chemicals companies, etc).	• Interest – profit maximization based on product sales. • Expectation – growth of the sector. • Impacts – decline in production and productivity. • Motivation – very high.	• Skills – high level of expertise. • Attributes – business approach facilitates sector growth.	• Level of engagement – Manage Closely (High Interest, High Power). • Conflicts – different players have different interests and products.
Development Programmes (Donor funded programmes - LOL, SNV, ZADF)	• Interest – mandate is developmental. • Expectation – graduation of target groups from one socio-economic group to another. • Impacts – slow down rate of sector growth. • Motivation – high.	• Skills – Mixed. • Attributes – Mixed. • Some are highly skilled and goal oriented. Others are not output oriented. Greater focus on activities rather than outcomes and impact. • There is need to strengthen development skills.	• Level of engagement – Manage Closely (High Interest, High Power). • Conflicts – clash between developmental and humanitarian approaches.
Public Researchers (Public – Academia and DR&SS)	• Interest – institutional mandate and individual career growth (promotions based on publications). • Expectation – uptake/adoption of technology. • Impacts – slow generation of technologies. • Motivation – high.	• Skills – high technical aptitude but also diverse skills. • Attributes – vast experience in technical skills but majority still lagging in soft skills development (e.g. communication and engaging communities).	• Level of engagement – Keep Informed (Low Power, Medium Interest). • Conflicts – impact versus scientific research acceptable by high impact journals.

Processors (DZL, Dendairy, Kefalos, Alpha & Omega, Kershelmar)	• Interest – increased production and delivery of raw products (profits). • Expectation – growth of the sector. • Impacts – growth or total collapse. Drivers of the sector. • Motivation – high.	• Skills – high technical skills e.g. processing skills. • Attributes – developmental skills questionable e.g. support for sector growth.	• Drivers of the sector. • Level of engagement – Manage Closely (High Interest, High Power). • Conflicts – tradeoffs between competition and coordination.
Government (MAMID, Politicians)	• Interest – policy driven interest. • Expectation – sectoral growth. • Impacts – determines direction and rate of growth through either a supportive or unconducive policy environment. • Motivation – high.	• Skills – mixed. Affected by high staff turnover and poor incentives. • Attributes – know direction in which policy and sector should be tagged.	• Level of engagement – Manage Closely (High Interest, High Power). • Conflicts – political versus developmental goals e.g. lack of political will in resource mobilisation.
Farmer Associations (ZFU, ZCFU, ICFU)	• Interest – membership driven, but of late it has been more of political survival. • Expectation – sectoral growth. • Impacts – poor sectoral performance results in low membership. • Motivation – high.	• Skills – poor and varied. • Attributes – important interface between producers and the government.	• Level of engagement – Keep Satisfied (High Interest, Medium Power). • Conflicts – fight for members and power.

Consumers (varied group)	• Interest – availability and access to safe, affordable and good quality products. • Expectation – increased volumes, diversity in products & competition. • Impacts – affected by non-availability of commodities. • Motivation – medium.	• Skills – N/A. • Attributes – diversified group.	• Most important stakeholder. • Level of engagement – Keep Satisfied (High Power, Low Interest). • Conflicts – none.

Source: Key Informant Interviews (October, 2014).

2.4.3 Interventions and innovation platforms

The Zimbabwean Government, in alliance with international development partners, have over the years initiated numerous interventions within the dairy sector. Such interventions have created prospects for not just improving technology adoption, productivity and viability, but also possibilities for wider interactions, learning, the identification of bottlenecks, finding solutions for the identified bottlenecks, and taking advantages of opportunities along the value chain (in short – innovation platforms).

Insights from Dube and Hanyani-Mlambo (2012) based on an SNV dairy sector study, highlight several interventions and opportunities for win-win innovation platforms which include:-

- Bulk Milk Counterpart Fund - Norway/Government of Zimbabwe.
- Direct funding to the Dairy Development Programme (DDP) by the governments of Zimbabwe and Norway (1990-1994).
- Training - Regional Dairy Development Training by the Food and Agriculture Organization of the United Nations (FAO RDDTT, Kenya).
- Africa Now infrastructure and operational support.
- Provision of heifers - Heifer Project International (USA).
- Provision of heifers and bulls by the Agriculture and Rural Development Authority (ARDA).
- Initiative for the Development and Equity in African Agriculture (IDEAA) – KELLOG Foundation institutional development, production, heifer/breeding and marketing support for Wedza MCC.
- Livestock and marketing support by the Swedish Cooperative Centre (SCC).
- Food and Agriculture Organisation of the United Nations (FAO) support to breeding and fodder production for Wedza MCC.
- EU STABEX 95 support through NADF to selected smallholder dairy projects (2000 – 2005 and 2009 - present).
- Land O Lakes support through NADF to selected smallholder dairy projects (2010 – 2013).
- Plan International equipment support for Marange MCC.

- SADC smallholder dairy development initiative, including training through an MSc in Dairy Technology (2008 – present).
- DANIDA/SNV development of smallholder dairying through interventions on breeding, fodder production and MCC business development (2013 – present).

2.5 Production models

2.5.1 Commercial dairying model

The commercial dairying model is a remnant of the large-scale commercial dairying subsector. Current benefactors of this model include emergent black commercial dairy producers and a group of the remaining white large scale commercial farmers. The model is built upon forward supply contracts with established processors and/or integration with individualized processing units within production zones, entities such as Dendairy and Kefalos. This model has all the attributes of contract farming arrangements that include a guaranteed market for the producer's milk, a pre-agreed upon producer price, guaranteed raw materials for processing units, reduced risk and a win-win situation for both parties. The model also has an advantage of economies of scale, and better opportunities for viability, growth and sustainability.

2.5.2 MCC bulking and supplying to processors model

Under this model MCCs take deliveries of smallholder farmers' milk, bulk the product and supply the milk to an established processor for development into various milk and dairy products. As with the predecessor mould, the model ensures a guaranteed market; removing marketing hassles for producers. By bulking and supplying to processors, the model reduces risk for MCCs and Milk Producer Association (MPA) members. The model also ensures guaranteed transport and zero financial marketing costs. However, MCCs become price takers under this model given that this normally is a buyers' market. An assessment of average producer prices under this model have hovered around US$0.45 – 0.65 per litre.

2.5.3 MCC bulking and processing model

Both large scale commercial and smallholder dairying offer opportunities for vertical integration and an improvement of margins by appending value addition to conventional production activities. This, however, depend greatly on the management, efficiency and the level of professionalism of the production and processing units. Experiences on the ground have shown that the average producer price is dependent on overhead costs. Average producer prices are usually higher than prices obtainable when MCCs supply processors. Prices are, This, however, but is highly prone to shocks. Where large markets exist e.g. Gokwe, this model presents better opportunities for adaptation of the inclusive business model.

2.5.4 Dairy Zone (MilkZim) model

The Dairy Zone or MilkZim Model, dubbed the "dairy cow hotel", hinges on economies of scale emanating from a cluster of producers who bring in animals to a central production environment for common, organized and centralized production and management of a nuclei dairy herd. The model allows for intimate knowledge of each animal within the herd and a breeding strategy easier to plan, implement and manage leading to improved calving intervals. Disease control is easier and leading to reduced mortalities. The model thus guarantees a farmer a return on investment and frees the farmer's labour to concentrate on other chores. Farmers subscribing to the model are paid a monthly dividend of 20 percent. To ensure effective and efficient management systems, various sub-committees are put in place. Examples include management committees for breeding, fodder production, marketing, and finance.

The model allows for an exit strategy over 5 years with first two years for business building. The model offers subscribers to the model security and investor confidence through shareholding, with risk and potential shocks spread across the entire membership. Key stakeholder interviews, however, revealed that convincing potential subscribers to buy into the model and confidence building takes time. In a lot of the cases, practically implemented models have also shown that there is usually limited space for adequate fodder production, while bought-in feeds or concentrates are expensive. In addition, it is common for subscriber farmers to seed substandard animals, while group dynamics has tended to water down group cohesiveness, effectiveness and tangible benefits for individual subscribers. This model can be an alternative model for future dairy farming with a difference. There is, however, need for further analysis to determine the model's feasibility, opportunities for adaptation, scaling-up and the economic viability and the sustainability of the model.

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CHAPTER 3 : LITERATURE REVIEW

3.1 Conceptual framework

3.1.1 Preamble

The literature review chapter hinges on an appraisal of related literature including academic books, conference papers, journal articles, web-based documents, as well as both published and grey literature. This chapter forms the basis and the blocks upon which the concepts, theoretical framework, the thesis paradigm, and the issues under investigation (technology adoption, productivity, viability, and the effectiveness of innovation platforms) are built.

3.1.2 Smallholder farming and smallholder dairying

Smallholder farming, the world over, is characterized by a marginal and fragile production base, limited production resources (including land, labour and capital), and the marginalization and an alienation from both input and output markets (Ruthernberg, 1980; Ellis, 1988). In Zimbabwe, the smallholder farming system comprises small-scale farming units (ranging in size from 15 – 80ha), old resettlement areas (comprising 6ha plots for farmers resettled prior to 2000) and communal farming areas (with an average arable land size of 2ha), and is home to largely disadvantaged smallholder farmers who constitute the bulk of farming households in the country (Moyo, 2000; Moyo and Yeros, 2005; Siziba, 2008). On the other hand, smallholder dairying forms a sub-sector within both the smallholder farming system and the national dairy sector. However, in global literature, smallholder dairy is inter-changeably used with small scale dairying.

3.1.3 Definition and characteristics of innovation

An innovation is a new technology but also includes any thought, behaviour or design that is new because it is qualitatively different from existing forms (Jones, 1967). Innovation is also defined as the process of application of new or existing knowledge in new ways and contexts to do something better (Makini et al., 2013). In its broader sense, innovation also includes changes in organizational elements, institutional arrangements and policies. According to Rosenberg (1976), Dosi et al. (1988), Nelson (1996) and the World Bank (2006), distinguishing characteristics of innovations and the innovation process include:-

(i) Innovations are new creations of social and economic significance. They may be brand new, but they are more often new combinations of existing elements.

(ii) Innovation can comprise radical improvements but usually consists of many small improvements and a continuous process of upgrading.

(iii) These improvements may be of a technical, managerial, institutional (i.e. the way things are routinely done), or policy nature.

(iv) Very often innovations involve a combination of technical, institutional, and other sorts of changes.

(v) Innovation can be triggered in many ways, e.g. bottlenecks in production within a firm, changes in available technology, competitive conditions, domestic regulations and international trade rules.

(vi) For products, processes and services, innovation cal also entail value addition to improve the type and quality of the product, process and/or service.

Within the context of smallholder dairying, typical innovations include new fodder crop varieties, improved animal breeds, methods of planting or silage making, new equipment or a suit of new production practices, such as the use of Artificial Insemination (AI), embryo transfers, the Henderson Calf Rearing system and the Milk Zim Dairy Zone Model (Hanyani-Mlambo et al., 1998; Kagoro and Chatiza, 2012).

3.1.4 Technology development, innovation, adaptation and adoption processes

Technology development entails all activities and processes associated with the generation of new technology. Innovation processes are broader and include technology development processes. According to Boogaard et al. (2013), innovation processes encompasses activities and processes associated with the generation, dissemination, adaptation and use of new technical, institutional and organizational knowledge, skills, and resources to the benefit of all stakeholders. The perception of innovation processes has also changed from a simplistic and linear process. Leeuwis and van den Ban (2004) and Makini et al. (2013) argue that innovation processes are continuous and iterative processes, and are characterized by joint learning based on both successes and failures, reflection, experimentation and adaptation.

Related to the issues of technology development and innovation, are the concepts of adaptation and adoption. Adaptations are based on modifications of existing technologies, current techniques, traditional approaches or through the taking of new approaches depending upon the challenge being addressed or opportunity being taken advantage of. Conversely, adoption describes the decision by an economic unit to use or not use a particular innovation. Oladele (2005) defines adoption of an innovation as a decision to apply an innovation and to continue using it. Abera (2008) describes adoption as a decision to use a new technology or practice by economic units on a regular basis. Both definitions characterize adoption as a process and not an event, and highlight the essence of knowledge and information on the innovation. It is also, however, worth noting the differences between sustained adoption, as described above, and temporal adoption, hinged on short-term incentives and benefits.

3.1.5 Innovation platforms

Innovation platforms are defined as physical, virtual, or physico-virtual network of stakeholders which have been set up around a commodity or system of mutual interest to foster collaboration, partnership and mutual focus to generate innovation on the commodity or system (Adekunle and Fatunbi, 2012). Also according to Makini et al. (2013), innovation platforms form fora that consist of a broad range of stakeholders who share a common interest and come together to solve problems and develop mutually beneficial solutions. Stakeholders who may be part of an agricultural innovation platform can include farmers, researchers, extension agents, traders, processors, wholesalers, retailers, transporters, other private sector placers such as finance institutions, NGOs and policy makers at local, regional and national levels.

3.1.6 Productivity

Productivity is a measure of the effectiveness and efficiency of productive effort by an individual, a group or a system in producing a good or service. More specifically, productivity is the measure of how specified resources are managed to accomplish timely objectives as stated in terms of quantity and quality[1]. Productivity may also be defined as an index that measures output (goods and services) relative to the input (labor, materials, energy, etc., used to produce the output)[2]. Within the context of this thesis, productivity will be analyzed largely on the basis of milk yields. While milk quality is of equal importance, the issue goes beyond the scope of this thesis.

The link between technology development, innovation and innovation platforms, and productivity hinges on the fact that productivity depends to a great extent on how successfully knowledge is generated and applied. Productivity also maintains an element of the effective use of innovation and resources to increase value-addition in the production process.

3.1.7 Viability

Viability relates to a practicable capacity for success or continuing effectiveness. In a business sense, viability refers to the ability of a business, product, or service to compete at a commercial level, while statistically viability describes the quality or probability of occurrence of a phenomena or having a reasonable chance of success. In agricultural and applied economics, viability is measured on the basis of a gross margin analysis which determines an enterprise or system's gross margin. In turn, a gross margin is defined as return to fixed factors of production which gives a good indication of profitability and is calculated as the difference between the total value of the harvested product and the total variable costs incurred during the production process (Cavatassi et al., 2009).

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[1] http://www.referenceforbusiness.com/management/Pr-Sa/Productivity-Concepts-and-Measures.html#ixzz3PG5gbWme

[2] Ibid.

3.1.8 Effectiveness

Effectiveness is the extent to which a development outcome is achieved through interventions, or the extent to which a programme or project achieves its planned results (goals, purposes and outputs) and contributes to outcomes (UNDP, 2002). Implicit within the effectiveness criterion is output and quality. Effectiveness should indicate the real difference made in practice by the activities implemented, the quality of the output; how far means were used to their maximum effect, and how far the intended beneficiaries really benefited from the products or services it made available.

Effectiveness, *inter alia*, addresses the following issues:-

(i) Extent to which implementation has been achieved against planned targets.
(ii) The quality of outputs and project delivery.
(iii) How well the partnerships worked.

And the following questions:-

(i) Are beneficiaries performing as anticipated?
(ii) Are beneficiaries performing better than those outside the programme or IP?
(iii) Is there evidence of programme/intervention impact?
(iv) What factors contributed to this?

3.2 Theoretical framework for assessing innovation platforms

3.2.1 Overture

For many years modernist, neo-marxist and structuralist theories viewed farmers mostly as victims or objects in developmental processes. Scholars focused on what was done to farmers and what could be done for them. Similarly, analytical approaches to agrarian development and intervention produced a generalized view of farmers as a society or social group within a context. The reaction motivated by systems thinking and actor-oriented advocates produced the

Agricultural Knowledge and Information Systems Framework (Röling, 1988), Knowledge and Information Networks (Box, 1990), the Actor-Oriented Approach (Long, 1992), and the Collective Agency Perspective (Gubbels, 1992). These form the pillars of the Innovation Systems Perspective and the Innovation Platforms Paradigm.

3.2.2 Innovation systems perspective

The Innovation Systems Perspective provides a major turning point and departure from earlier approaches and has, thus, been widely adopted for purposes of addressing some of the shortcomings of the previous approaches. The perspective is hinged on the concept of "innovation" which refers to the search for, development, adaptation, imitation and adoption of technologies that are new to a specific context. In this realm, innovation goes beyond research and technology, to include design and institutional innovation (Sumberg, 2005). Leeuwis and Van den Ban (2004) also stresses the shift in emphasis from "technology" to "innovation", and the distinction between technology (which includes "hardware" such as dairy animals, equipment, animal disease management techniques, etc.) and innovation (which includes technology but also organisational and institutional elements). Also according to the World Bank (2006), the scope of innovation includes not only technology and production but organizations (attitudes, practices, and new ways of working), management, and marketing changes, which calls for new types of knowledge and new ways of using this knowledge. Dantas (2005) describes innovation systems as networks of organizations within an economic system that are directly involved in the creation, diffusion, adaption, and use of scientific and technological knowledge, as well as the organizations responsible for the coordination and support of these processes[3]. See Figure 3.1.

[3]E.g. Organizations that shape agendas, design and implement policy.

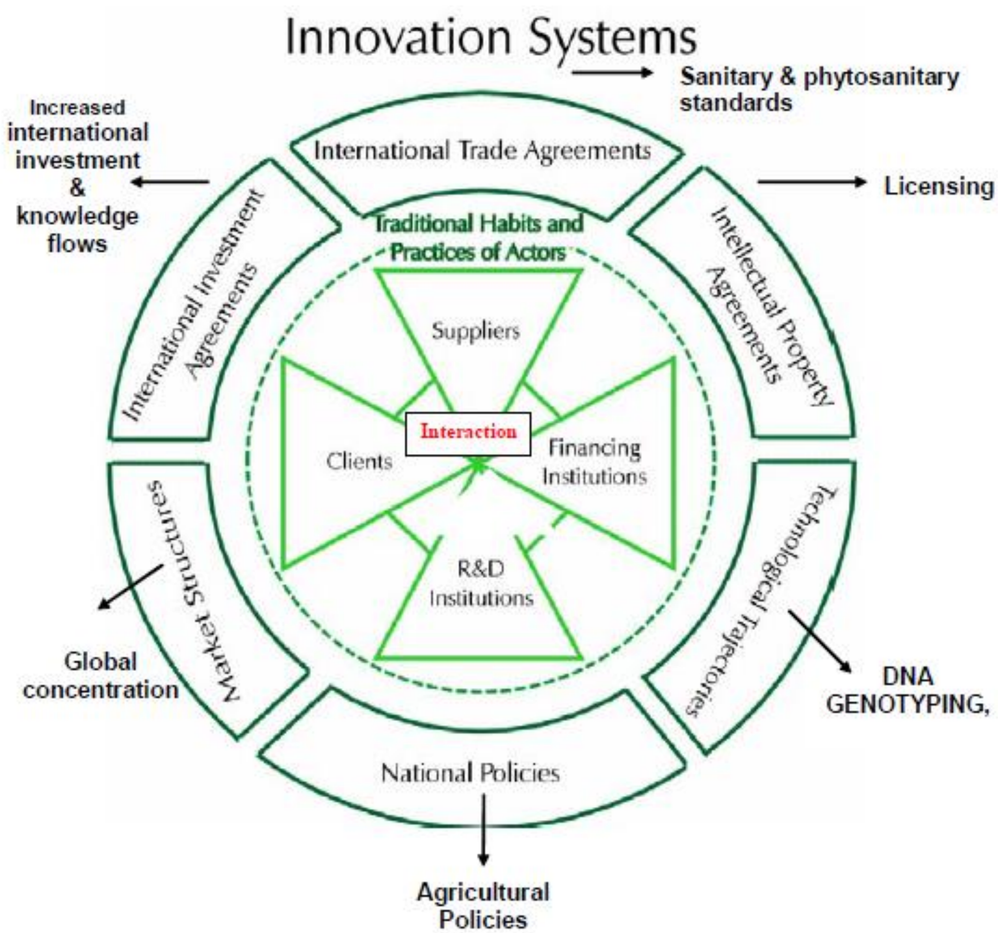

Figure 3.1: *Innovation Systems Illustration. Adapted from Mytelka (2000)*

The innovation systems concept provides not just a holistic explanation of how knowledge is generated, diffused and utilized, but also emphasizes the actors and processes involved. This is because the perspective is driven by the desire to understand the complexities of the innovation process[4], the continuous feedback loops between different stages of the innovation process, as well as the interactions, linkages, interdependencies and coordination between multiple actors (Hall et al., 2003; Leeuwis and Van den Ban, 2004; Dantas, 2005; Clark, 2006). As such, the Innovation Systems Perspective provides a coherent analytical tool for studying innovations, context-specific factors affecting innovation, and how these affect productivity, competitiveness, and economic and social development. The perspective can also be used as a prescriptive tool for policymaking in developing countries. However, other scholars have criticized the innovation

[4]As opposed to the linear TOT models.

systems perspective as “old wine in a new bottle” noting that what is being proposed has in fact been done for some time, though not with the same label, and perhaps with a reduced scope (Dalrymple, 2005).

3.2.3 Innovation platforms paradigm

Ideas on Innovation Platforms are firmly rooted in theories of innovation systems. Innovation Platforms are, however, conceptualized as multi-sectoral and multi-institutional coalition of actors in specific value chain systems, which act as mechanisms for encouraging, developing, and/or disseminating innovations to users. A key element of innovation platforms is in identifying bottlenecks and opportunities in production, marketing and the policy environment, and to leverage innovation to address the identified constraints and take advantage of opportunities across the entire impact pathway – in this case the dairy value chain – (FARA, 2007; Nederlof et al., 2011; van Rooyen and Homann, 2012; BMGF, 2013). See innovation platform illustration in Figure 3.2.

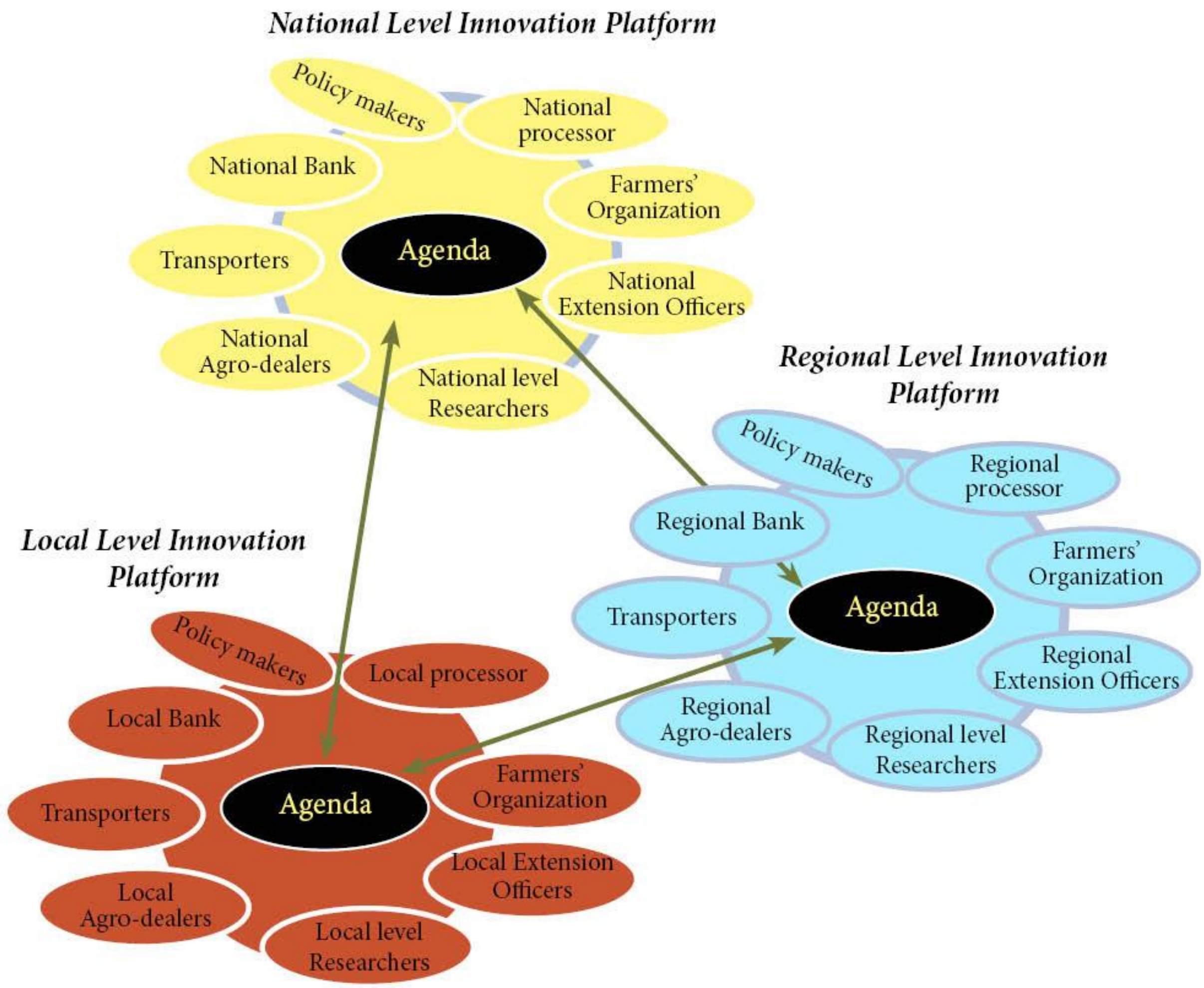

Figure 3.2: *Local, Regional and National Level Innovation Platforms. Adapted from Makini et al. (2013)*

The innovation platform facilitates dialogue between the main local players in the value chain: farmers, input suppliers, traders, transporters, processors, wholesalers, retailers, regulators, and the research and development fraternity. This makes innovation platforms participatory approaches for problem solving and knowledge creation. The effectiveness of innovation platforms is determined by the strength of the established partnerships, the intensity of knowledge and information sharing, and their leverage in scaling out innovations, improving the rates of technology adoption, productivity, the level of market participation and viability at the enterprise, household, and value chain levels. The use of such a comprehensive analytical and prescriptive tool is critical in moving innovations forward e.g. many of the bottlenecks related to the dissemination and adoption of technology have long been known but with little progress having been made to overcome those bottlenecks.

3.2.4 Farmer segmentation

Farmer segmentation is critical for purposes of understanding, modelling and predicting farmers' attitudes towards interventions, behaviour in response to government policy measures, and uptake of agricultural advice. Farmer segmentation and the generation of farmer typologies is also key in informing agricultural policy, developing agricultural extension approaches/strategies, and for better targeting of technology development, dissemination and communication. It is, therefore, critical to have meaningful ways to group farmers into sub-groups or segments based on similar characteristics, personal attributes, knowledge, attitudes, practices and likely response to interventions, for example, when exposed to new innovations.

Several attempts at farmer segmentation has been modelled, with varying degrees of success, accuracy and applicability. Defra's Segmentation Framework, developed five segmentation groups, each with key descriptors and characteristics designed to differentiate distinct groups (Defra, 2008). However, the boundaries of the five segmentation groups were not as neatly defined, with many farmers sitting across more than one group. Later initiatives focused on attempting to embed Defra's segmentation framework within the Farm Business Survey (FBS) approach (Wilson et al., 2010). The determination of segments pre-data collection has presented challenges. Emtage et al. (2006) sought to classify landholders on the basis of various combinations of attitudes, structural-demographic characteristics and farming practices of interest to the researcher. However, according to Waters et al. (2010), whilst this segmentation approach can provide insights into the likelihood of specific typology-biased behaviours, its ability to explain or predict other behaviours is limited. This ushers in the Derived Attitudinal Farmer Segments (DAFS), as developed by Waters et al. (2010), as a model of choice for both review and application in this current task.

The DAFS framework has a distinguish benefit given the methodology's ability to accounting for both individual and situational characteristics of farms and farmers. The framework also uses a derived, as opposed to an assumed or imposed approach to identifying segments, by determining farmer segments through statistical analysis. According to Waters et al. (2010), farmer segments can be identified through K-means clustering from an attitudinal survey and described by highlighting the significant differences between segments across a range of attitudinal, demographic and behavioural characteristics, such as actual and planned practice change. The underlying theory is that groups of farmers can be segmented on the basis of their perceptions and preferences on a wide range of situational and individual characteristics (drivers), which include social, cultural, economic and physical factors. Farmers will therefore react in different ways to external drivers of change and will respond differently to encouragement, incentives and legislation aimed at influencing their farming practice (Thomson, 2008). Farmer segments will then be groups of farmers who have a similar pattern of responses to social, cultural, political, economic, historical and farm management 'forces'.

An alternative is Rogers (2003)'s categorization of innovation categories viz: innovators, early adopters, early majority, late majority and laggards categories. Rogers' use of general theoretical constructs enables the categorization or farmer segmentation to be applied across industries, regions and times.

3.2.5 Participation

Participation, and notably farmer participation, is a concept borrowed from the field of psychology, which has been widely used in the study of management science. The concept of participation entails different meanings to different individuals, programme stakeholders and contexts. Grether (2008) defines participation as the readiness and degree of subjectivity actors are playing. Participatory approaches to development ushered in the 70s and 80s have failed to ensure active stakeholder participation due to built-in weaknesses within most of the models. Biggs (1989) identifies four modes of farmer participation, each characterized by the intensity of farmer involvement. The first is the contract mode in which farmers' resources such as land and services are hired or borrowed. The second mode is consultative which resembles a doctor-patient relationship, in which researchers consult farmers, diagnose their problems, and try to find solutions for the farmers. The third is the collaborative mode in which intervention parties and farmers are partners in technology development, dissemination and utilization processes. The fourth is the collegial mode where there is active promotion of integrated research and development systems. Pretty et al. (1995) also identified seven levels of participation including passive participation; participation in information giving; participation by consultation; participation for material incentives; functional participation; interactive participation; and self-mobilization. For the purposes of this study, participation analysis will be based on interactive participation.

3.2.6 Interactions

According to the World Bank (2006), interaction patterns between different knowledge and information sources form a central component of an organization's or sector's capacity to innovate. Interactions among IP stakeholders will be analyzed on the basis of the linkage mechanisms between various actors within the innovation platform, based on the technology triangle put forward by Kaimowitz et al. (1990). In their conceptual framework, linkage mechanisms were conceptualized as specific organisational procedures used to maintain interactive links among actors and stakeholders within an intervention context. It is worth noting that, since *intervention* and *innovation* have both functional and institutional meanings, linkage mechanisms have a two-way conceptualisation; as functional links, which relate to intervention and innovation activities; or as institutional links, which relate to the institutions and personnel that carry out these activities. In the former case, focus is on activities which aim to form a bridge between the various actors (such as joint planning, implementation and evaluation of initiatives). In the latter, focus falls on the exchange of resources (for example, information, finance, personnel and materials).

According to Kaimowitz et al. (1990) linkage mechanisms are influenced by internal and external contextual factors, namely: political, technical and organisational factors. Political factors refer to institutional politics and the interest groups which play a role in them (e.g.

pressure from policy makers, foreign agencies and farmer organisations and subsequent effects on created values, rewards and sanctions which inhibit or facilitate collaboration between different actors). The technical factors are the activities and methods which are associated specifically with the development and dissemination of agricultural technology to different environments and target groups. Lastly, organisational factors include the division of tasks, resources and authority between different organisations and individuals, and the internal management and informal dynamics of each organisation and its components.

3.2.7 Effectiveness

Two theories espouse the discussion on effectiveness. These are the Framework for Organizational Effectiveness by Pennings and Goodman (1977) and Network Enterprise by Castells (1996). The Framework for Organizational Effectiveness views organizations as comprising of constituencies, with effectiveness based on how well the various subunits are coordinated. This entails that interdependency between the various subunits is of paramount importance. There is an assumption that organizations exist in an environment of external constituencies with whom they have exchange relationships, with dominant coalitions of constituencies setting the agenda within the organization.

Conversely, for the Network Enterprise, Castells (1996) identifies two distinct analytical descriptions of organizations *viz*: (i) organizations for which the reproduction of their system of means becomes their main organizational goal; and (ii) organizations in which goals, and the change of goals, shape and endlessly reshape the structure of means. The first analytical description symbolizes bureaucracy; while the second embodies the enterprise. Castells then defines the network enterprise as that specific form of enterprise where the system of means is constituted by the intersection of segments of autonomous systems of goals. This makes the components of the network both autonomous and dependent *vis-à-vis* the network, and may be a part of other networks, and, therefore, of other systems of means aimed at other goals. In this framework, the performance of a given network depends on two fundamental attributes of the network *viz:*

(i) Its connectedness – i.e. the structural ability to facilitate noise-free communications between its components; and

(ii) Its consistency – i.e. the extent to which there is sharing of interests between the network's goals and the goals of its components.

3.2.8 Necessary conditions (drivers)

According to Goertz and Starr (2002), necessary conditions form a core part of social science theory, although some scholars might argue that there are no significant necessary conditions for social phenomena, and that causation is probabilistic. Goertz and Starr (2002) list and discuss 150 necessary conditions. I pick only two that are compatible and consistent with the framework of innovation platforms *viz*:-

(i) The two key requisites for cooperation to thrive are that the cooperation be based on reciprocity, and that the shadow of the future is important enough to make this reciprocity stable (Axelrod 1984, pp. 173).

(ii) A group can only obtain high compliance of its members if they are dependent on it to achieve preferred goals. . . . The group's capacity to monitor the member's behaviour is a necessary condition of compliance. . . . More formally, dependence and the group's monitoring capacity are both necessary conditions for compliance but each is by itself insufficient (Hechter 1983, pp. 24, 26).

As discussed in greater detail elsewhere in this chapter, according to studies conducted in East Asia and Africa, identified necessary conditions (drivers) of innovation platforms include, *inter alia*, an existence of functional output markets, incentives, a critical mass of relevant actors, and the ability of the organizations to conduct critical functions, provide services and develop policy, coordinate, and afford mechanisms for reducing risk and transaction costs (Dantas, 2005; van Rooyen and Homann, 2012).

3.2.9 A Framework for assessing the effectiveness of innovation platforms

As already highlighted, the purpose of this research study is to assess the effectiveness of innovation platforms within the context of smallholder dairying in Zimbabwe. Specifically, the study examines the effectiveness of innovation platforms in enhancing technology adoption, productivity and viability. This section provides a conceptual framework for integrating the array of variables defined in the theoretical framework to explicate their influence on the effectiveness of innovation platforms, and ultimately on IPs' efficacy in boosting technology adoption processes, productivity and viability levels as depicted in Figure 3.3.

The framework consists of five major components *viz*: the necessary conditions (drivers) for effective innovation platforms, innovation platform process including farmer segmentation and stakeholder participation, innovation platforms, parameters measuring the effectiveness of innovation platforms, and strategic impacts (improved technology adoption, increased productivity and improved sector viability).

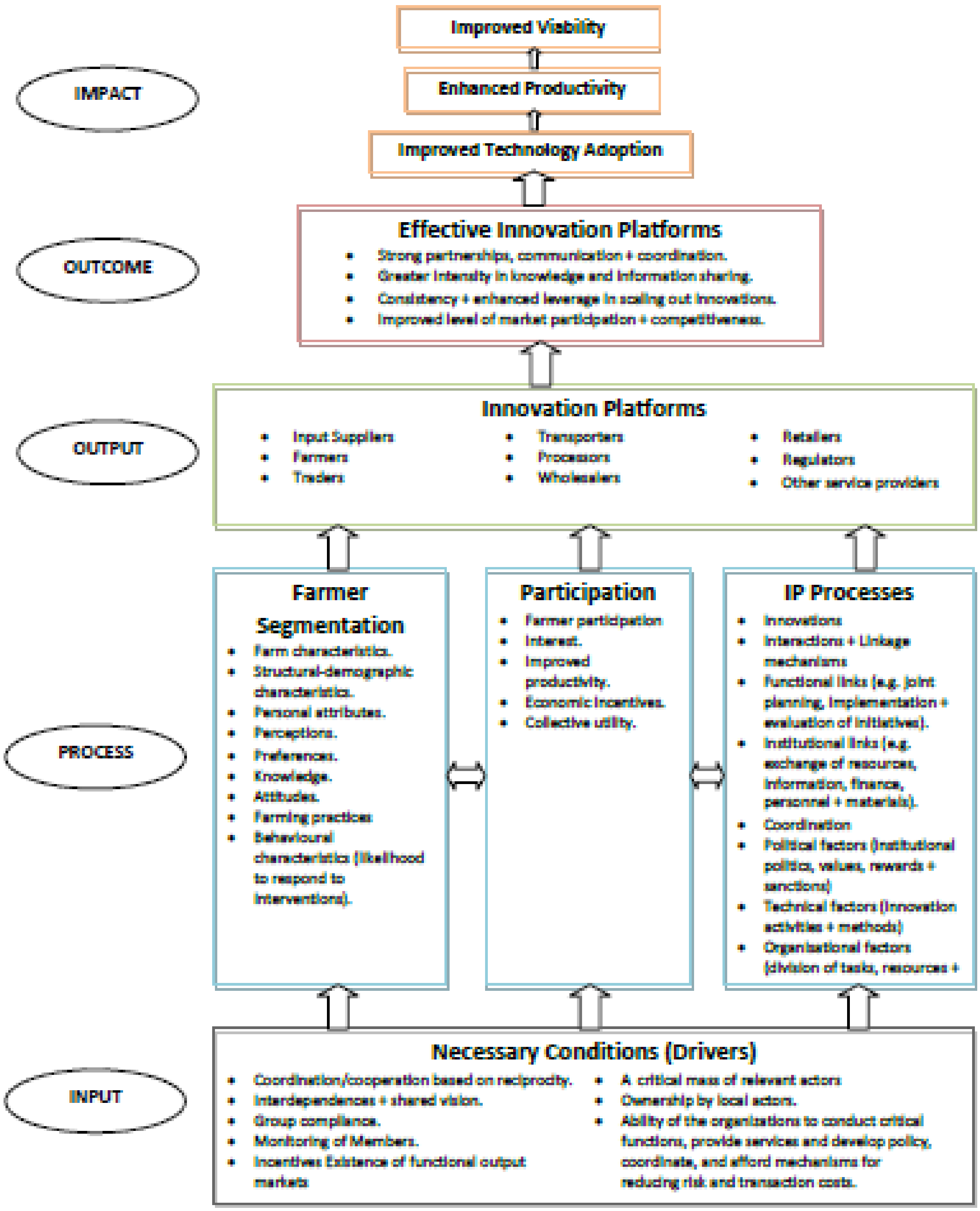

Figure 3.3: *Framework for assessing the effectiveness of IPs (Hanyani-Mlambo, 2015).*

3.3 Innovation platforms (IPs)

3.3.1 The rise of innovation platforms (IPs)

Agricultural research and extension have been characterized by a long history of linear, top down and supply driven technologies that have over the years produced “best bet” recommendations that were largely irrelevant and inappropriate *vis à vis* local needs and conditions. The transformation has witnessed a progression from an emphasis on expanding public sector research through investments in infrastructure, equipment and the capacitation of the human resource base in the early 1980s; the improvement of management of existing public sector research institutions in the late 1980s; the development of pluralistic agricultural knowledge and information systems and greater client participation in the mid- to late 1990s; and a change in focus to strengthening of the broad spectrum of organizations, enterprises and individuals involved in innovations at the turn of the millennium (World Bank, 2006). In all cases, the result has been little or no impact on local, national and regional agricultural systems.

The dynamic changes in Sub Saharan Africa, characterized by a degrading agricultural production base, declining agricultural productivity, worsening levels of poverty and food insecurity, increased per capita food demand as a result of increasing populations, and climate change demand innovative solutions to these emerging challenges. Hence, the emergency of Innovation Platforms (IPs), which facilitates interaction amongst IP actors, coordination, technological and institutional innovation, social learning and adoption of improved practices (World Bank, 2006; Makini et al., 2013; Boogaard et al., 2013) has once again ushered in hope, enthusiasm and prospects for improved relevance, tangible impact on the ground and agricultural development. The interest in IPs is being further propelled by the realization that barriers for agricultural development are not only technological but also institutional[5] (Flinterman et al., 2012). Again, the thesis is that IPs can facilitate institutional changes and support system innovations through increased interaction, negotiation and learning among stakeholders (Boogaard et al., 2013).

[5] Institutions include laws, regulations, attitudes, habits, practices, norms, values, culture, and incentives (Hermans *et al.,* 2012; Hounkonnou *et al.,* 2012).

3.3.2 Innovation platform (IP) values and principles

Innovation Platforms (IPs) are interactive processes that are based on sector-specific, multi-stakeholder and multi-level fora; that offer medium for communication, learning and joint auctioning; fostering innovation, meaningful change, and development. See also the IPs definition on page 31 (sub-Section 3.1.5). This entails that IPs are hinged on the joint identification of common problems and determination of solutions within a specific sector or sub-sector, context (social, political, policy, economic and institutional), by a group of interdependent stakeholders, and can exist at the local, regional and national levels. Makini et al. (2013); World Bank (2011), Adekunle et al. (2010); Nederlof et al. (2011) highlights seven key characteristics of IPs *viz:* embodiment, roles, partnership mix, nature of collaboration, boundaries, status, and the fluidity of membership.

(i) IPs are described as fora established to foster interaction among a group of relevant stakeholder around a shared interest.

(ii) The stakeholders perform different but complementary roles in the development, dissemination and adoption of innovations.

(iii) Partnerships along and beyond agricultural value chains can be nurtured to bring on board actors with different skills.

(iv) All stakeholders can make meaningful contribution to the platform and benefit, thus making it a win-win collaborative mechanism e.g. members can jointly identify problems, seek and apply solutions, learn and reflect, a situation which can be reiterated.

(v) An IP has boundaries based on thematic, geographic, sectoral or value chain demarcations.

(vi) IPs can be formal or informal but should be guided by clear ground rules that define how decisions are made, conflicts are settled, as well as the entry and/or exit of members.

(vii) Organizations and members may join and leave at will, while roles of actors and the platform focus may change over time.

While local IPs operate at the community level, by identifying problems, practical solutions and opportunities; higher level IPs engage policy makers to influence the operational environment for the mutual benefit of all stakeholders. Regional and national IPs thus have a strategic rather than an operational focus (Makini et al. 2013; Tucker et al. 2013). See Figure 3.2. According to Makini et al. (2013), IP formulation involves: (i) initiation and visioning (focusing on engagement with stakeholders and setting vision for the group); (ii) establishment (planning and stakeholder engagement); (iii) management (facilitation, learning, assessing); and (iv) sustainability (application of lessons from assessment in developing sustainability measures). Different stakeholders can take on different roles which can change at different phases depending on the initiative, thus maintaining fluidity in the format and roles of the different stakeholders (Swaans et al., 2013).

In addition, according to Nederlof et al. (2011); Adekunle and Fatunbi (2012); Lundyet al. (2013); innovation platforms can also support the operationalization of research and development, contribute to improving the relevance and impact of research, contribute to increasing returns on investment in agricultural research for development, stimulate and strengthen interaction between multiple stakeholders, link different stakeholders to achieve a common objective, contribute to jointly identifying and solving complex problems, provide an enabling environment for innovation, and contribute to overcoming institutional barriers and creating institutional change, and are suitable for situations where there are multiple stakeholders, who deal with complex issues which require coordinated action, where there are institutional barriers hampering development, where competition or conflict is likely to occur, and where there is space for experimentation (Boogaard et al., 2013).

3.3.3 Innovation platform processes

IP establishment encompasses processes that include site selection, determination of the agenda, scoping study designed to identify value chain challenges, stakeholder analysis, while later stages involve social learning, innovation, and IP management (Makini et al., 2013). Learning, like innovation, encompasses social learning and reflection. Social learning occurs when different stakeholders generate new knowledge, skills, confidence, resources, insights and perspectives on which action can be based (Leeuwis, 2000). Social learning, which can occur within or between different IPs, is a critical ingredient for IP processes since it facilitates an understanding of different perspectives amongst different stakeholders and is the basis for the establishment of a common vision and joint solutions. Where researchers and other organizations are involved this process can also enhance institutional learning (Hall et al., 2003). On the other hand, reflection and self-reflection amongst actors enables stakeholders to learn from failures (Boogaard et al., 2013). The diversity of actors involved and a long history of non-engagement amongst actors also entails the need for facilitation to ensure fruitful and effective interaction (Nederlof et al., 2011; Adekunle and Fatunbi, 2012; van Rooyen et al., 2013; Boogaard et al., 2013). IP management also inherently involves conflicts and negotiation processes (Boogaard et al., 2013). Innovation processes, the context, changes in the context, the nature of the actors involved, the policy and market factors that trigger innovation, as well as arising opportunities shape the innovation capacity of IPs and the emerging sector (World Bank, 2006). These in turn shape the innovation processes in different IPs. This gives rise to the issue of path dependency in innovation processes. A dynamic innovation system also enables dexterity in responding to changes, emerging challenges and opportunities. As such, other authors have described innovation processes as non-linear, dynamic, diverse, highly context-specific and characterized by coincidence, uncertainty and unpredictability (Sumberg, 2005; Hall, 2007; Klerkx et al., 2009).

3.3.4 Empirical Studies on Innovation Platforms

Literature reviews provide insights on a number of innovation platform issues. In practice, and as discussed below, innovation platforms have faired differently (Nederlof et al., 2011). The Cowpea and Soybean Platform in Nigeria strengthened platform members' convening power, improving their access to banks, policy makers and other stakeholders. The Oilseed Platform in Uganda addressed a number of conflicting issues in the sector, such as access to open-pollinated varieties and the use of hybrid seed, as well as building trust amongst stakeholders. In Tanzania, in a Research Into Use (RIU) Poultry Network programme, meetings amongst stakeholders did not bring the expected results, while the Promotion of Private Sector Development in Agriculture

Programme (PSDA), moulded around the mango value chain in Kenya, also resulted in innovation platform failure.

The World Bank (2006) reviews a mixed bag of innovation platform case studies which provide an equally colourful array of insights. In a vanilla value chain in India, farmer-to-farmer interactions promoted the dissemination of production and postharvest innovations largely due to farmers' experience with farmer associations, which enhanced organization and the facilitation of interactions. In Ghana, interactions in the pineapple value chain facilitated the development of win-win, pro-poor business models that were successful in terms of the profit perspective of the company as well as the income-earning perspective of the poor. However, in some case studies despite the existence of competitive pressures which provided incentives for companies to interact and innovate, interaction remained inadequate due to attitudes and inherent business cultures which restrict the range of issues on which companies will be willing to collaborate on. Where arrangements were put in place to foster collaboration between researchers and entrepreneurs, research tended to be more effective in promoting innovation, based on the recognition that the key role of research was to determine how to create or strengthen value chains and identify ways in which research could support innovation at different nodes of the value chain. Also, in IPs built around medicinal plants in India and cassava processing in Colombia, interactions of multiple actors were important in the development of the sector, which supports the notion that innovation requires a dense network of interactions. Lastly, key innovations across the different case studies included improvements in crop varieties, new drying and processing technologies, and institutional innovation based on initiatives to support marketing.

In a detailed assessment of multi-stakeholder potato innovation platforms in Ecuador, the study adopted the use of a standard OLS with multiple controls, propensity score matching, and an intermediate approach of weighted least squares. The results showed higher yields and returns for platform beneficiaries, with the group of beneficiaries on average obtaining statistically significantly higher yields of 8.4 MT per hectare against an average of 6.3 MT per hectare for counterfactual groups (Cavatassi et al., 2009). The highest gross margins for beneficiaries were USD259/ha compared to the lowest gross margins of USD18/ha for non-beneficiaries (ibid).

These remarkable results were achieved primarily through mechanisms put in place to improve production techniques, and by shortening and improving the efficiency of the potato value chain thereby reducing transaction costs and capturing a higher share of the final price for producers.

3.3.5 Factors affecting the effectiveness of innovation platforms

According to studies conducted in East Asia and Africa, the overall performance (effectiveness) of an innovation platform depends partly on the existence of functional output markets, incentives, a critical mass of relevant actors, and the ability of the organizations to conduct critical functions, provide services and develop policy, coordinate, and afford mechanisms for reducing risk and transaction costs (Dantas, 2005; van Rooyen and Homann, 2012). The effectiveness of IPs also hinge on the existence of a common objective and a shared vision (Nederlof et al., 2011; Makini et al., 2013).

On the other hand, conflicts can turn IPs into arenas of struggles due to the diversity of interests from different stakeholders, thereby reducing the effectiveness of innovation platforms (Leeuwis, 2000). Examples from the literature include cases where potential conflicts might emanate from opposing expectations from different parties about roles, the domination of platforms by the agendas of specific stakeholders, the failure by IP representatives to completely represent the interests of the diversity of stakeholders in their constituencies, power dynamics and asymmetries, emerging inequities, and researchers who might view platforms as dissemination mechanisms for their research findings and thus risking the collapse of IPs into instruments of linear technology transfer rather than as genuine equitable fora for innovation (Boogaard et al., 2013, Cullen et al., 2013). Resistance to change and adherence to established structures can often also stifle innovation and the effectiveness of IPs.

3.3.6 Challenges in achieving sustainable IPs.

According to Makini et al. (2013), a sustainable innovation platform is one that is able to continue to innovate, consolidate its gains, change its focus when necessary, renew its membership to address new issues and thereby continue to generate benefits for its members over time with relative stability. This calls for feedback loops, learning, continuous regeneration, self-innovation in IP processes and activities, good facilitation, a sense of ownership by all stakeholders notably smallholder dairy farmers who in this case will be the primary stakeholders, training and capacity building, and continuous technical backstopping from knowledgeable external stakeholders (Adekunle, 2013; Makini et al., 2013).

Conversely, challenges in achieving sustainable innovation platforms include:-

(i) Lack of a shared vision.
(ii) Failure to achieve convergence of an initial array of diverse interests and expectations.
(iii) Lack of resources.
(iv) Lack of transparency.
(v) Lack of participation and ownership by all actors.
(vi) Lack of tangible benefits for participating actors.
(vii) Competing IP agendas e.g. private input agro-dealer working on the same platform as NGOs distributing free inputs.
(viii) Lack of willingness and commitment by some key stakeholders e.g. government.
(ix) Conflicts among IP stakeholders.
(x) Spoiler factors such as a sudden change of agenda among actors or death of a key participant which can derail IP progress.
(xi) Failure to identify new constraints and opportunities, and acting upon these.
(xii) Lack of a functional communication strategy for maintaining awareness of IP functions, individual tasks and progress among stakeholders.

(World Bank, 2006; Makini et al., 2013; Boogaard et al., 2013)

3.4 Technology adoption

Technology adoption takes many facets. This section discusses the issues of technology adoption, technology disadoption, as well as the factors that influence both technology adoption and disadoption.

3.4.1 Intervention and technology adoption

The concept of intervention is usually taken for granted, where reference is made to the simple execution of already specified plans of action with expected outcomes (Hanyani-Mlambo, 1995; Hanyani-Mlambo and Hebinck, 1996). This emanates from, as elaborated below, linear thinking and the top-down intervention models. Röling and De Zeeuw (1983) define an intervention as a systematic effort to strategically apply resources to manipulate seemingly causal elements in an ongoing social process, so as to permanently reorient that process in directions deemed desirable by the intervening party. In this thesis, intervention is regarded as a process of complex interaction between actors with multiple objectives, where at various interfaces, goals and strategies are negotiated, reinterpreted and displaced. An example here is the conceptualization of smallholder dairying or the Dairy Development Programme (DDP) as an intervention. Included in this conceptualization are splinter policies and programmes within smallholder dairying or the DDP programme, such as animal health legislation and training, which are themselves conceptualised as interventions. As already highlighted, technology adoption describes a decision to apply an innovation and to continue using it, with distinctions between sustained and temporal adoption (Oladele, 2005; Abera, 2008).

3.4.2 Technology disadoption

Numerous interventions, agricultural development programmes and project initiatives have been at the forefront in promoting the adoption of innovations and new agricultural technologies. This has driven up participation and the subsequent adoption of innovations by multitudes of farmers, yet the same farmers have also been observed to revert back to their old practices at the end of the intervention, programme or project's lifecycle. This highlights the concept and issue of technology disadoption. According to Rogers (2003), technology disadoption or discontinuance can take two forms viz: (i) replacement discontinuance hinged on the rejection of an idea in order to adopt a better one that supersedes it, and (ii) disenchantment discontinuance which occurs when a decision to reject an idea is made as a result of dissatisfaction with its performance. Technology disadoption has not been analyzed in the literature widely and there is no theoretical model that analyzes technology disadoption.

3.4.3 Factors affecting adoption

Social scientists investigating farmers' adoption behaviour have accumulated considerable evidence showing that demographic variables, technology characteristics, information sources, knowledge, awareness, attitude, and group influence affect adoption behaviour (Oladele, 2005). Identified demographic factors include age, dependency ratios, literacy levels, years in formal schooling, livestock ownership, access to other production resources and the level of poverty (Mudhara and Hildebrand, 2005; Rukuni et al., 2006; Siziba, 2008; van Rooyen and Homann, 2012). Other factors include knowledge of a practice, farming experience, training received, socio-economic status, cropping intensity, aspiration, economic motivation, innovativeness, information source utilization, information source, agent credibility, and adoption (Rao and Rao, 1996). Farm and technology specific factors, institutional, policy variables, and environmental factors have also been identified as factors that explain the patterns and intensity of adoption (Abdelmagid and Hassan, 1996). The participation in innovation platforms and adoption of innovations can also be motivated by the mere desire to use improved production practices, driven by the ultimate goal of improved access to services, ensuring household food security, and profit making (Makini et al. 2013). Material inputs can also motivate stakeholders externally, but can also provoke opportunistic behaviour and dependency among target beneficiaries (Triomphe et al., 2012).

3.4.4 Factors affecting technology disadoption

A number of factors influence the sustainable adoption of innovations and new technologies. These include land tenure security, farm size, agronomic management factors such as the ability or failure to control pests and diseases, climate change and weather variability, enterprise viability, and the opportunity cost of land and labour (Neill and Lee, 2001; Boys et al., 2007). In an assessment of the propensity to discontinue adoption of agricultural technologies amongst farmers in South Western Nigeria Oladele (2005), established that factors that significantly affected technology disadoption embraced extension visits, which related to the lack of extension visits to farmers who have adopted the new technology or new innovation, the provision of feedback on the adopted technologies or new innovations, the availability of critical inputs, attitudes, and the marketability of the product and an ability to generate income from surplus production. Rahim et al. (2008), used a logit model to study the decision making behaviour of farmers in West Sudan and identified factors influencing the disadoption of gum production as farmer' wealth status, access to off-farm work, and the level of income that can be generated from alternative sources. Shah et al. (2014) also established that at times, the key reasons that farmers state for non-adoption are the same as those hypothesized for disadoption.

3.4.5 Intervention models

Intervention as both a concept and a practice has witnessed an evolution in thinking, paradigm shift and a change in the modus operandi on the ground (in practice). Early interventions, particularly between the 1950s – 1970s, were crafted around the linear Transfer of Technology (TOT) model. In the model, scientific research is perceived as the main driver of innovation and the scientists as the innovators. New knowledge and technology were transferred as "best practices" and/or "best bet options" designed to improve productivity of agricultural commodities for a diversity of farmer target domains, which were largely viewed as ignorant or "blank tabularizers". The TOT model, which has been dubbed the "single source of innovation" model (Röling, 1988), produced disappointing impact at the farm level.

Linear technology transfer approaches were followed by Farming Systems Research (FSR) perspectives in the 1980s and the Farmer Participatory Research (FPR) approaches in the 1990s. The FSR perspective emerged with the objective of understanding constraints at the farmer level through an interdisciplinary approach and on-farm research. However, farmers remained as passive givers of information through consultative processes, while researchers continued as the key sources of knowledge and innovation (Makini et al., 2013). FPR approaches, on the other hand, conceptualized scientists and farmers as co-creators of new knowledge and innovation. While the FPR approach recognized the importance of farmer engagement in knowledge and innovation generation, it failed to acknowledge institutional constraints, the benefits of multi-stakeholder platforms and the necessity to engage all key stakeholders (idem). All these have led to “islands of successes” observed around pilot testing sites instead of the expected widespread impact (Makini et al., 2013).

The advent of the innovation systems concept, as expatiated above, while not denying the importance of research and technology dissemination, recognizes innovation as an interactive process, where innovation involves the interaction of individuals and organizations possessing different types of knowledge within a particular social, political, policy, economic, and institutional context (World Bank, 2006). Building upon the same established blocks, the use of innovation platforms thus entails a shift away from traditional linear research-extension-farmer transfer of technology towards agricultural innovation system thinking (Boogaard et al., 2013).

3.4.6 Theories and hypotheses on technology adoption

The classical Diffusion of Innovations theory (Rogers, 1962) postulates stages of knowledge gain, persuasion, decision, implementation, and confirmation during a technology adoption process leading to the categorization of adopters into innovators, early adopters, early majority, late majority and laggards. A number of follow-up theories have been developed and studies conducted on the unevenness of technology adoption (Feder and Umali, 1993).

Rogers (2003) theorized on innovation decision processes, individual innovativeness, the rate of adoption, and perceived attributes contextualized within either top-down or bottom-up adoption and/or diffusion processes. In the Innovation Decision Process Theory potential adopters of an innovation progress over time through five stages in the diffusion process viz: knowledge or awareness gain, persuasion of the value of the innovation, make the decision to adopt or not to adopt, implement the innovation, and the reaffirmation of the decision. The Individual Innovativeness Theory hypothesizes that risk takers and/or innovative individuals tend to adopt an innovation earlier in the diffusion – adoption continuum. On the other hand, the Rate of Adoption Theory analyzes diffusion processes over time focusing on how innovations go through a slow, gradual growth period, followed by dramatic and rapid growth, and then a gradual stabilization and finally a decline. Lastly, the Perceived Attributes Theory showcases five attributes upon which an innovation is evaluated viz: relative advantage (degree to which an innovation is perceived as being better than the idea it supersedes), compatibility (extent to which an innovation is perceived as consistent with the existing values, past experiences, and the needs of the target group), complexity (the level to which an innovation is perceived as relatively difficult to understand and/or use), observability (the scope to which the results of an innovation are visible and communicated to others), and trialability (degree to which an innovation may be experimented with on limited basis).

3.4.7 Role of innovation platforms in technology adoption

Innovation platforms represent a paradigm shift from linear thinking to innovation system thinking, which entails a re-conceptualizing of the roles and contributions of research in development projects (Sumberg, 2005), innovation processes and technology adoption. As an example, institutions influence how decisions are made, how research priorities are set, how research questions are identified, how relationships with other stakeholders are shaped, how knowledge is generated and shared, and how learning and reflection happens (Hall et al., 2003; Leeuwis, 2013). All this influences the credibility, legitimacy, relevance, appropriateness, target domain perceptions, and the level of technology adoption of related innovations.

Technology adoption in innovation platforms is also, to a large extent, driven by a conducive environment within IPs. Such drivers include, inter alia, the presence of a common objective and a shared vision, the existence of functional output markets, incentives, a critical mass of relevant actors, and the ability of the organizations to conduct critical functions, provide services and develop policy, coordinate, and afford mechanisms for reducing risk and transaction costs.

3.5 Productivity and viability

3.5.1 Rationale for productivity and viability

Globally, historical focus of research on food crop technologies, notably on genetic improvement of food crops, has undeniably been successful. Average crop yields in developing countries have increased by 71 percent between 1961 and the turn of the millennium, while average grain yields have doubled (World Bank, 2006). Other studies have shown that a 1 percent increase in agricultural yields in low-income countries leads to a 0.8 percent reduction in the number of people below the poverty line (Thirtle et al., 2003). This shows the link between agricultural productivity, an assumed viability and poverty reduction. To ensure this, most agricultural production has been increasingly been integrated in value chains with forward (marketing) and backward (input supply) linkages. However, this progression has not proceeded without its own challenges.

Population densities within smallholder farming areas continue to increase while the land and other resources available for the expansion of agriculture are becoming increasingly scarce (SADC, 2010; ZimVAC, 2014). Additionally, insecurity of tenure, low levels of mechanization, shortages of inputs, lack of capital and labour bottlenecks (particularly in resource-poor and female-headed households) often limit farmers' propensity and ability to expand their scale of production. Thus, sustainable increases in enterprise productivity and viability, through technological and managerial innovation, continue to be crucial means through which both food security and poverty reduction can be achieved. Like elsewhere within the global village, agricultural producers are also now supplying long and complex value chains that are marketing high value fresh and processed products to a diversity of consumers, the bulk of them being urban dwellers (Cavatassi et al., 2009). This is an opportunity for expanding agricultural markets, thereby providing incentives and an avenue for improving productivity and viability. However, production contexts are always and rapidly changing, yields remain uncertain, prices are volatile due to thin markets, and market access remains limited, with the bulk of smallholder producers continuing to be marginalized (Cavatassi et al., 2009).

Thus innovation platform initiatives designed to improve productivity, product quality, margins and viability (through reduced system inefficiencies and transaction costs), market linkages (via vertical integration or contract farming arrangements), and subsector competitiveness are essential.

3.5.2 Equity and sustainability

Equity entails the quality of being fair or impartial e.g. fairness or justice in the way people are treated. Within the context of innovation platforms, equity addresses cross-cutting issues of gender and the youth. As an example, within an IP, the roles and benefits may not be equally shared among men and women actors, and among these and the youth. According to Makini et al. (2013), this is because an IP may not possess control mechanisms to ensure gender balance and equity across stakeholder groups since actors participate voluntarily, based on interest and may not enforce change in attitudes and/or practices. In Zimbabwe, there are inherent gender imbalances regarding livestock ownership as more men tend to own more animals than women and very little numbers are owned by women or jointly owned in male-headed households (Hanyani-Mlambo and Manyonga-Matingo, 2014). This also entails differences in gender disaggregated roles for men and women (Kristjanson et al., 2010), disparities in livestock marketing decision making patterns (Ruzivo Trust, 2013), variations in the quantity and quality of representation in leadership positions (Hanyani-Mlambo and Manyonga-Matingo, 2014), and hence the need for gender disaggregated data analysis. Youth's current role in farming is peripheral, thereby raising inheritance and sustainability issues notably in smallholder dairying. However, evidence from recent studies have shown that where markets and incomes are involved, young people are keen to engage in agriculture and in taking advantage of arising opportunities (Carr and Hanyani-Mlambo, 2013; Land O' Lakes, 2013).

While this thesis has already addressed issues on innovation platform sustainability, there are also sustainability issues at the farm and farmer level. So the question could be, at that level, what is sustainability? Sustainability at the farm and farmer level is hereby conceptualized as the ability to sustain, support, uphold, or confirm farming activities or specific agricultural enterprises. Although not the focus here, the concept of sustainability at the farm and farmer level is also partially related to environmental sustainability, which hinges on the quality of not being harmful to the environment or depleting natural resources, and thereby supporting the long-term ecological balance.

According to UNDP (2002) sustainability issues to consider can, inter alia, include:-

(i) The number of farmers adopting the introduced technologies in intervention areas and outside the intervention sites.

(ii) The capacity of beneficiaries to continue with the intervention activities without outside support.

(iii) The sustainability of the introduced technologies vis à vis the local context and environment.

(iv) The sustainability of the social and institutional capital built among beneficiaries.

(v) The number of people who can continue to practice the recommended good agricultural practices.

3.5.3 Econometric models for assessing productivity, viability and impact

Ex-ante and ex-post economic impact assessments, as well as productivity, viability and technology adoption studies have remained the dominant paradigm in international agricultural research, particularly in CGIARs. Similarly, the measurement of performance of interventions and innovations in the literature has been characterized by quantitative and process analyses (Hall et al., 2001; Hall et al., 2003). Quantitative analysis, which is derived mainly from neoclassical economics, posits a linear relationship between investment in research, the development of agricultural technology, its subsequent adoption by farmers, and the ultimate impact on productivity and economic viability. This conceptualization has influenced priority setting whereupon research financial allocations came to be based on rates of return to investment without due care of equity issues. The emphasis has also been on factors and characteristics of technology without questioning the effectiveness of current institutional arrangements in generating and disseminating innovations. Conversely, the qualitative approach has tended to focus on the process rather than on the outputs and impact of intervention and innovations. The underlying proposition is that the hierarchical institutional arrangements typical of most centralized agricultural research systems are not capable of dealing with the complex technology needs of small and resource-poor farmers, arguing instead that thriving innovation platforms can only be achieved by a much more holistic understanding of the process of technology development and the institutional arrangements necessary to achieve this.

Thus, the dominant form of assessment and analysis have been economic impact approaches and econometric tools. Ex-ante studies rely mostly on the economic surplus model. Econometric approaches, on the other hand, estimate the empirical importance of different factors explaining adoption (Doss, 2003). They typically have a dependent variable, adoption, being explained by a set of independent variables and include the OLS, Tobit, Probit and Logistic Regression. Identified limitations include the unavailability of adequate input and output data on the research process and subsequent technical change, the difficulty of attributing past, current or future outcomes to particular research investments, and assigning a value to these outcomes (Alston et al., 1995).

3.6 Smallholder dairy farming

3.6.1 International perspectives on smallholder dairying

Most governments in developing countries embark on increased smallholder dairy production since it is seen as a powerful tool for promoting rural development (Bennett et al., 2006; Dube, 2008). Smallholder dairy development can also be viewed as an enterprise-driven approach to livelihood enhancement as well as an instrument of rural poverty reduction by focusing on strategies of generating rural jobs through diversifying into labour-intensive, high-value agricultural production linked to a dynamic rural, non-farm sector (World Bank, 2008; FAO, 2014). The idea to set up smallholder dairy schemes was borrowed from countries such as India, Kenya and Malawi where the bulk of the total milk production is by smallholder farmers (Marecha, 2009). Operation Flood was the world's biggest dairy development programme which made India, a milk-deficient nation, the largest milk producer in the world, with about 17% of global output in 2010. The programme contributed to a "white revolution" similar to the Green Revolution in crop production, increasing milk production in India from 17 million tons in 1951 to 84.6 million tons by 2001 (Verghese, 2007).

Smallholder dairy production systems in the tropics share common characteristics but remain diversified, thus exhibiting heterogeneity traits rather than homogeneity. Based on studies in Asia, Sub Saharan Africa and Latin America, Devendra (2001) classified smallholder dairy production systems in the tropics into three different types viz: (i) traditional, usually with ad hoc marketing arrangements which is typical of most peri-urban smallholder dairy farms, (ii) cooperatives whose foundations are natural aggregation and/or concentration of farms, and (iii) intensive production systems with herd sizes of up to 200 dairy cows. According to Moran (2005), smallholder dairy systems in the tropics can also be categorized on the basis of physical factors (magnitude of scale, stock type, forage and feeding systems), farm characteristics (land and stock ownership, labour, farm income), and institutional factors (marketing channels, farmer support systems, economic policies). One important feature of all tropical smallholder dairy production systems is their rapid expansion on the backdrop of a growing urban demand and the inherent emerging income generating opportunities present.

Market oriented small scale dairying has the potential to increase household income, reduce losses and generate employment in production, processing and marketing, and thus serves as a viable tool for spurring economic growth and alleviating poverty (Bennett et al., 2006). Existing and emerging opportunities for smallholder dairy producers are pinned on the prospects of sharing in opportunities afforded by rising global demand for milk and dairy products. This is closely related to expanding markets for high-value food products, offering an opportunity to diversify farming systems and develop a competitive and labour-intensive smallholder dairy sector (FAO, 2014). Transitory economies in Asia, Latin America and Sub Saharan Africa are home to a large and rapidly growing population of affluent consumers with either a strong tradition of dairy consumption, or changing food preferences in favour of high value animal products, including dairy products. As an example, milk production in the Asia-Pacific region is estimated at 217 billion litres of liquid milk equivalent, while demand and consumption is estimated at 240 billion litres LME (FAO, 2014).

In most countries, there is also plenty of room for import substitution provided that local products are competitive in quality, safety and price. Moreover, whilst the sustainability of smallholder dairy development initiatives must be rooted on private-sector driven economic development, smallholder dairying also provides opportunities for addressing the persistent problem of rural poverty by transferring income from affluent urban households to their poorer rural counterparts, thereby improving food and nutritional security for both poor rural and urban households (FAO, 2014). This can also be a panacea for addressing equity issues raised by growing socio-politico-economic attention to widening income disparities between income groups and geographic locations. Technological and environmental efficiencies also suggest that smallholder dairy industries have a higher likelihood of sustainability than the mono-cultural industries of developed countries (Falvey and Chantalakhana, 2001).

However, despite the huge potential, in reality smallholder dairy farming is characterized by low productivity and dodged by viability challenges. In Bangladesh, smallholder dairying is being weighed down by the scarcity of feeds and fodder, high costs of bought-in concentrates and the lack of technical knowhow (Khan et al., 2010). In the Philippines, the farming system, breeding policy and veterinary services were found to have significant roles in production performances between small scale dairy farming households and non farming households (Uddin et al., 2012). As discussed in greater detail below, smallholder dairying has also been subjected in recent years to increasing strains as a viable source of income generation (Moran, 2005; Khan et al., 2010; Uddin et al., 2012). FAO (2014), also highlights that some of the long-standing constraints to smallholder dairy development have been declining real prices for dairy products, low prices and profitability, resulting in part from competition from subsidized milk from industrialized countries. Elsewhere, viability challenges on small scale dairy farms in the UK, New Zealand, Canada and the USA are either forcing farmers to exit the sector leading to fewer dairy farms or scale-up driven-up by the need for greater efficiency, economies of scale and financial leverage (Levitt, 2014; Woodford, 2014). The sustainability of intensifying smallholder dairy production systems is also threatened by inadequate feeding and nutrition, derisory infrastructure and marketing opportunities, poor institutional support, lack of adequate disease control measures, lack of appropriate dairy research, and the technology gap between the developed and developing countries (Moran, 2005).

Panacea for identified challenges within the smallholder dairy sub value chain has been equally diversified. Multi-criteria programming of small-scale dairy farms in Mexico established a need for a forage strategy based on alfalfa, ryegrass, and corn silage to meet the nutrient requirements of dairy herds, and an economic advantage in rescheduling the calving season to better synchronize higher demand for nutrients with the period of high forage availability (Val-Arreola et al., 2006). Building on the Kenyan approach, an initiative to improve milk handling among traders in Assam in India resulted in a new governance institution, increased risk mitigation, improvements in milk quality, higher sales and increased customer satisfaction. The economic impact in the capital district has been estimated at USD 5.6 million annually (Ballantyne, 2014).

3.6.2 Emerging issues in smallholder dairying in Sub Saharan Africa

Sub Saharan Africa presents a mixed bag of success stories, largely unexploited potential and challenges within numerous smallholder dairying subsector, with structure, conduct and performance being largely dependent variables.

In Kenya, about 90% of marketed milk is from the smallholder sector; where processing plants operate as business hubs offering farmers services including access to finance, agricultural inputs and animal health care; and where commercialization, linkages and coordination ensured success (TechnoServe, 2012). In Cameroon, an economic opportunity survey of small scale dairy farms established that more milk produced per day represented the best economic opportunity, while reduced age at first calving and longer lactation length were established as the next best economic opportunities (Bayemi et al., 2007).

In West Africa, in production environments characterized by milk production within mixed crop-livestock farming systems, a study in The Gambia, Guinea and Guinea Bissau established challenges that included lack of genetic merits in local cattle, a reliance on inappropriate technology, inherent inefficiencies, and the lack of homogenous production groups based on differences in productive resource endowments and reinvestment capacity (Somda et al., 2004). In East Africa, based on the East Africa Dairy Development (EADD) project reviews in Kenya, Rwanda and Uganda, constraints to the use of artificial insemination services resulted in low adoption of AI as a technology (Sewunet, 2011). In Kenya, Tanzania and Uganda, the use of well-adapted and proven forages has become more common. However, the fragmentation of holdings has become a serious challenge, with smallholder dairy producers increasingly finding it difficult to get enough land for both subsistence and fodder crops (Orodho, 2006).

FAO (2010) cited the following constraints to smallholder dairy development in Sub-Saharan Africa: low genetic potential, prevalence of various animal diseases, inadequate feeds and feeding, poor animal management, unfavourable climate and some socio-economic factors including illiteracy, poverty, land tenure systems and institutional bottlenecks. Constraints to increasing the welfare of smallholder dairy farmers were also identified as lack of access to market information, an inability to access markets, lack of collective organizations, high marketing and transaction costs, and a reduction in the incentives to participate in dairying (Kiziba, 2012). FAO (2010) also identified the needs for smallholder dairy development as: adequate farmer education, high quality fodder production, improved conservation of forages, improved utilization of agricultural by-products, provision of adequate artificial insemination services and care, and the provision of high quality dairy services.

3.6.3 Innovation platforms in smallholder dairying

Most of the available literature on innovation platforms in smallholder dairying is based on initiatives in Asia and Sub Saharan Africa. While examples from Asia are restricted to projects in India, case studies from Sub Saharan Africa have been more diversified, with examples from Ethiopia, Kenya, Uganda, Tanzania and Botswana. In India, a smallholder dairy innovation platform was built as an initiative to improve milk handling among traders in Assam. The results, inter alia, included a new governance institution, increased risk mitigation, improvements in milk quality, higher sales, increased customer satisfaction, and an estimated economic impact of USD 5.6 million annually (Ballantyne, 2014a).

In Ethiopia, the initiative to commercialize smallholder dairy and forage systems was mooted after decades of research and developmental interventions failed to propel a take-off of the smallholder dairy subsector largely due to disconnects in the dairy innovation systems. Tefera et al. (2010) and Sewunet (2010) explore the organizational, institutional and policy options; contextual factors determining opportunities and necessities for innovation; patterns of interaction between them; and coordination mechanisms. According to Tefera et al. (2010), sector-wide disconnects have included missing or weak linkages between diverse knowledge sources, technological and non-technological innovations, the development interventions and the local context, production and market, research focus and development challenges, public and private efforts, as well as misfits between policymaking and development practice. Coordination is poor and there are no mechanisms for pooling resources leading to duplication of efforts and inefficient use of scarce resource, while the current performance appraisal and reward systems reinforce organizational independence, rather than interdependence. Recommended policy options included the need for improving economic incentives to encourage innovation, organizing dairy producers and linking them with vertically coordinated value chains, supporting private sector development, promoting public-private partnerships, defining principles for pragmatic participation and coordination, as well as the use of ICTs in facilitating multi-stakeholder interaction and knowledge management (ibid).

Innovation platforms in Kenya, designed to inform policy change in Kenya's dairy industry, resulted in licensing for small-scale milk vendors who previously had to endure public harassment due to non-integration into the formal sector and lack of recognition (Ballantyne, 2014). Other benefits of policy change included improved safety of milk, improved profit margins for small-scale milk vendors, increased access to milk by poorer consumers, while ripple benefits included employment creation within the sector and in downstream industries.

In Uganda, the adoption of improved dairy cows significantly increased milk productivity, milk commercialization, and food expenditure (Ballantyne, 2014b). As part of the intervention ripple or knock-on effects, the adoption of improved dairy cows also substantially improved household and child nutrition, and reduced household poverty and stunting for children younger than age five. Despite the liberalization of the dairy industry, key lessons from a separate review in Uganda highlight the need for avoiding direct subsidies that are known to asphyxiate markets, coordinating business development services, involving farmer organisations, facilitating ongoing discussions and coordination of efforts by stakeholders along the value chain (Ballantyne, 2012). Such stakeholders, according to the author, should include smallholder farmers, traders, development agencies, and policymakers.

In Tanzania, smallholder dairy innovation platforms have brought together stakeholders in identifying solutions to common problems leading to improved profit margins (Macmillan, 2014). Although Tanzania's average annual per capita milk consumption of 45 litres is still way below Kenya's 120 litres and the World Health Organization (WHO)'s recommended 200 litres of milk per person per year smallholder dairy innovation platforms have been making strides in improving this. The Tanga Dairy Platform has also immensely contributed to Tanzania's dairy sector (ILRI, 2014). In Botswana, it was observed that there is a need to understand the critical role played by the private sector in facilitating change at local, regional, and national levels when considering changes to the enabling environment for value chains (Ballantyne, 2012).

3.6.4 Empirical studies on smallholder dairy productivity and viability

As already highlighted, smallholder dairying is characterized by low productivity and viability challenges. In Thailand, an economic analysis of 10 smallholder farms with dairy stock numbers ranging from 6 – 30 milking cows, cow milk yields ranged from 6 – 12 litres per day, while production costs averaged USD0.32 against income revenues of USD0.26, thereby rendering smallholder dairying in Thailand unviable (Skunmun and Chantalakhana, 2000; Moran, 2005). In South Vietnam, a comparative study of the profitability of smallholder dairying in rural and peri-urban areas showed that smallholder dairying, while producing positive returns, was hardly viable, with margins of USD0.04 per litre in rural areas and USD0.01 per litre in peri-urban areas (Cai et al., 2000; Moran, 2005). In Bangladesh daily milk yield per cow was established to be as low as 4.27 and 1.78 litres for a crossbred and indigenous dairy cow, respectively, while net economic returns were estimated at USD1.09 per cow per day for crossbreds and USD0.23 per cow per day for indigenous cows (Khan et al., 2010).

Economic viability assessments on smallholder dairying for resource-poor farmers in West Africa revealed enterprise gross margins of USD911 in The Gambia, USD203 in Guinea Bissau, and USD42 in Guinea (Somda et al., 2004). In East Africa, a study based on three levels of intensification, showed that acclimatized stock of exotic dairy breeds that are stall-fed gave the highest gross margin per litre, although their input costs were also the highest, while farmers who adopted improved technology generally got higher yields and profit margins (Orodho, 2006).

A value chain analysis of the dairy subsector in Zambia estimated the productivity yields of various breeds as follows viz: a potential yield of 18 – 25 litres per cow per day against an actual yield of 15 – 18 litres per cow per day for Friesian pure breeds, 10 – 15 litres versus 10 – 12 litres for Jersey pure breeds, 8 – 10 litres versus 7- 10 litres for crossbreds, and 3 – 4 litres versus 1 – 1.5 litres indigenous cattle (Pandey, 2007; Pandey et al., 2007). Disregarding family labour, the cost of production of smallholder dairy farmers in Zambia were approximated at USD0.14 per litre and about USD0.20 per litre for commercial dairy farmers (Pandey et al., 2007). Though not specified, the study also established that commercial dairy producers in Zambia realized lower enterprise gross margins compared to smallholder dairy farmers given the higher production costs per litre they incurred, but still make up for the difference through economies of scale because of their higher production and sales volumes.

In Zimbabwe, literature on smallholder dairy production has shown that the average dairy herd within the smallholder dairy subsector is six animals, the average number of milking cows is two, whilst the average daily milk yield per cow is 6.8 litres (Dube and Hanyani-Mlambo, 2012). Meanwhile, the net returns per invested dollar (GM/TVC) show small dairy herds as being uneconomic, with dairy herds with one and two milking cows producing returns of –USD0.37 and –USD0.13 respectively, a break-even dairy herd of three milking cows, net returns of USD1.23 for six milking cows, and declining net returns per cow for smallholder dairy herds with more than seven milking cows (ibid.). Past studies have also highlighted reduced herd sizes, low farm level productivity, declining economic efficiency in larger herds, and viability challenges in the Zimbabwean smallholder dairying sector (Hanyani-Mlambo et al., 1998; Zvomuya, 2007; USAID, 2010: Kagoro and Chatiza, 2012). Studies in India, both encompassing and excluding the cost of family labour, have also shown higher profits per litre of milk and more efficiencies for dairy operations with less than 10 cows (FAO, 2014b). In a survey of smallholder dairy farmers in semi-arid areas of Zimbabwe, Chinogaramombe et al. (2008) identified the farmers' year of resettlement, tick-borne diseases, shortage of feed and transport as the factors that largely constrained smallholder dairy productivity and viability.

3.7 Insights from the literature

3.7.1 Conclusions

Although a relatively new phenomenon, innovation platforms have been experimented with across different value chains in Sub Saharan Africa. This literature review provided a conceptual framework, a framework for assessing the effectiveness of innovation platforms, analyzed the notion of innovation platforms, evaluated technology adoption processes, reviewed existing literature on dairy productivity and viability, and explored smallholder dairy innovation platforms in Asia, Latin America and Sub-Saharan Africa. However, as elaborated below, fundamental knowledge gaps still exist.

3.7.2 Lessons learnt

Innovation Platforms are multi-sectoral and multi-institutional coalition of actors in specific value chain systems, which act as mechanisms for encouraging, developing, and/or disseminating innovations for the beneficial use by all stakeholders. A key element of innovation platforms is in identifying bottlenecks and opportunities in production, marketing and the policy environment, and to leverage innovation to address the identified constraints and take advantage of opportunities along the value chain and cross the entire impact pathway.

3.7.3 Insights from the literature

This literature review has produced quite a number of fundamental insights. New insights from the desk studies include:-

(i) Innovation is an interactive process through which knowledge acquisition and learning take place, hence the need for extensive linkages with different knowledge sources.

(ii) Innovation as a concept describes both a process going on and the subsequent results of such processes.

(iii) Innovation platforms focus on innovation rather than production or output.

(iv) Attitudes and practices determine the propensity of actors, organizations and institutions to innovate.

(v) Attitudes and practices also determine how organizations respond to innovation triggers such as changing policies, markets and technology.

(vi) Underlying principles of innovation platforms and innovation systems thinking can be rather unclear or perceived as vague and abstract.

(vii) Though innovation platform values and principles are rooted in theories on innovation systems, their validity and contributions to effective research, development initiatives, and impact on the ground still need to be demonstrated.

(viii) It is assumed that innovation platforms can lead to diverse changes, including an improvement in knowledge, attitudes, practices, innovation capacity of stakeholders and livelihoods but there is limited insight in the process behind this.

(ix) Change emanating from compound innovation processes emerges as the unintended outcome of multiple premeditated actions which interact and interfere with each other in complex ways which makes it difficult to measure the outcomes.

(x) Innovation processes are also characterized by an interplay of many factors, which makes it difficult to attribute changes to a specific cause.

3.7.4 Identified gaps

Literature has not indentified science and technology as an innovation gap but instead issues around access, appropriateness, adoption, ability to scale, and institutional and policy barriers as more important (BMGF, 2013). Other identified gaps include:

(i) Gaps in understanding smallholder farmer needs and ensuring realistic farmer segmentation,

(ii) Gaps between research farm and actual farm yields and the supportive environment required to narrow this gap,

(iii) Gaps in disentangling innovation platforms as concepts, as processes and in understanding the underlying principles.

(iv) Gaps between the dissemination and adoption of technologies,

(v) Ensuring partnerships and coordination necessary for creating an enabling environment for technology creation, dissemination and adoption, and

(vi) The effectiveness of innovation platforms under smallholder farmer conditions and the impact on technology adoption, productivity and viability.

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CHAPTER 4 :INNOVATION DOMAINS FOR ENHANCING TECHNOLOGY ADOPTION AND SOCIO-ECONOMIC DEVELOPMENT: THE CASE OF SMALLHOLDER DAIRYING IN ZIMBABWE[6]

Abstract

Despite various interventions, smallholder dairy farming in large parts of the tropics remain characterised by low productivity, restricted market participation, and viability challenges. The problem lies in the unavailability, low adoption rates and disadoption of available improved smallholder dairying technologies. Using Rusitu and Gokwe smallholder dairy projects in Zimbabwe as a case study, this paper explored broad global issues of innovation domains, characteristics of the different innovation domains, the domains' influence on technology adoption patterns, and the impact of technology adoption on socio-economic development. Through a survey of 227 households and the use of a multivariate analysis approach, Principal Component Analysis identified eight principal components, while follow-up analysis using Cluster Analysis identified five distinct innovation domains. These domains included smallholder dairy producers (61.6% of the surveyed households), smallholder dairy heirs (15.9%), new and emergent producers (4.6%), smallholder dairy pioneers (2.0%), and commercial and market-oriented producers (15.9%).The paper established that innovation domains with higher levels of participation in smallholder dairy innovation platforms had higher rates of dairy technology adoption. The net effects have been higher estimated annual dairy incomes, improved total household incomes, and socio-economic well being. This provides valuable contributions in advancing the theory and practice of innovations.

Keywords: Agricultural research and extension, Cluster Analysis, Innovation Platforms, Principal Component Analysis, Zimbabwe.

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4.1 Introduction

4.1.1 Preamble

Smallholder dairy production systems are largely diverse and consist of a large number of farmers with distinct technical characteristics, socio-economic circumstances and institutional attributes. In reality, seemingly homogenous segments of dairy farms exhibit diverse characteristics *vis á vis* herd sizes, adopted breeding systems, land available for grazing, and feed and herd health management practices (Dantas et al., 2016). Farming households also tend to differ in their resource endowments, production orientation and objectives, past experiences, management capacity, livelihood strategies, and in their attitudes towards risks (Tittonell et al., 2010). However, the determination and appropriate segmentation of dairy production systems into applicable innovation domains remains obscure due to the lack of standardized assessment parameters and procedures (Bidogeza et al., 2009; Nainggolan et al., 2013). This represents a knowledge gap. Nevertheless, farmer segmentation is critical for further research and analysis, target domain mapping, improving the adoptability and performance of innovations, determining potential opportunities and barriers to technology adoption, providing platforms for feedback and learning, and for ensuring the formulation of sector specific policies, appropriate agricultural research and extension programming, and development of practical tools for the apt targeting of interventions (Srairi and Kiade, 2005; Mubiru et al., 2007; Kaouche-Adjlane et al., 2015; Dantas et al., 2016).

Despite various interventions, smallholder dairy farming in large parts of the tropics remains characterised by low productivity, restricted market participation, and viability challenges (Somda et al., 2004; Moran, 2005; Uddin et al., 2012). The problem lies in the unavailability, lack of access, the low adoption rates and disadoption of available improved smallholder dairying technologies (Falvey and Chantalakhana, 2001; Mubiru et al., 2007; Chinogaramombe et al., 2008). In Sub–Saharan Africa, past studies ascertain that the unavailability, poor access and low technology adoption levels result from, *inter alia*, policy gaps, top-down and supply-driven research and extension, lack of information feedback and limited farmer participation, poor segmentation of target innovation domains, and inappropriate technologies (Mudhara and Hildebrand, 2005; Mburu et al., 2007; Pandey et al., 2007; Hebinck and Cousins, 2013). The objective of this study was to fill the existing knowledge gap by conducting a segmentation of smallholder dairy farmers into innovation domains, identify the characteristics of the different innovation domains, determine the domains' influence on technology adoption patterns, and explore the impact of technology adoption on socio-economic well being. This is critical for advancing the theory and practice of innovations, and for the development of the smallholder dairy subsector.

4.1.2 Background to the study

Most governments in developing countries embark on increased smallholder dairy production since it is seen as a powerful tool for promoting rural and socio-economic development (Bennett et al., 2006). Smallholder dairy development can also be viewed as an instrument of rural poverty reduction by focusing on strategies for generating rural jobs through diversifying into labour-intensive, high-value agricultural production linked to a dynamic rural, non-farm sector (World Bank, 2008). The idea to set up smallholder dairy schemes emerged from countries such as India, Kenya and Malawi where the bulk of the total milk production is by smallholder farmers (Marecha, 2009).

In Zimbabwe, the Government launched the Dairy Development Programme (DDP) in 1982. The main objective of the programme was to use smallholder dairying, through enhanced milk production and marketing, as a tool for socio-economic development. Currently, the programme has 21 milk collection centres in five of the country's eight rural provinces. However, past studies have highlighted challenges emanating from low herd sizes, low farm level productivity, declining economic efficiency in larger herds, and viability challenges in the Zimbabwean smallholder dairying sector (Kagoro and Chatiza, 2012; SNV, 2013; Chamboko and Mwakiwa, 2016).

Livestock contributes about 40% of global agricultural GDP and 30% of agricultural GDP in developing countries (Gebremedhin and Hoekstra, 2010). In Zimbabwe, livestock production systems contribute directly to food and nutrition security, income growth and poverty reduction at household, micro- and macro-economy levels (SNV, 2013). Smallholder dairying in Zimbabwe also presents the greatest opportunities for unlocking value, generating the highest and quickest returns to investment due to the diversity of dairy products and the higher margins that can be gained from niche markets. There has also been no detailed or systematic study on effects of institutional factors on smallholder dairying (topically and geographically).

4.1.3 Conceptual and theoretical framework

The concept of innovation refers to the search for, development, adaptation, imitation and adoption of technologies that are new to a specific context. In this realm, innovation goes beyond science and technology, to include design and institutional innovation (Sumberg, 2005). The perception of innovation processes has also changed from a simplistic and linear process. Leeuwis and van den Ban (2004) argue that innovation processes are continuous and iterative processes, and are characterized by joint learning based on successes and failures, reflection, experimentation and adaptation. Innovation domains, on the other hand, are segments of farmers with similar technical, socio-economic and institutional circumstances and farming practices for whom a given recommendation would be broadly appropriate (van den Ban and Hawkins, 1988; Röling, 1988; Rogers, 2003; Plewa et al., 2012). Conversely, adoption describes the decision by an economic unit to use or not use a particular innovation (Abera, 2008).

This study was guided by the Innovation Platforms (IPs) paradigm. Ideas on IPs are firmly rooted in theories of Systems Thinking (Röling, 1988) and Innovation Systems (Hall et al., 2003; Dantas, 2005; Clark, 2006). IPs are multi-sectoral and multi-institutional coalition of actors in specific value chain systems, which act as mechanisms for encouraging, developing, and/or disseminating innovations to users (Nederlof et al., 2011; Makini et al., 2013). See also the IPs definition on page 31 (sub-Section 3.1.5). The IP facilitates dialogue between the main players in the value chain *viz*: farmers, input suppliers, traders, transporters, processors, wholesalers, retailers, regulators, and the research and development fraternity. This makes IPs participatory approaches for problem solving and knowledge creation. See Figure 4.1.

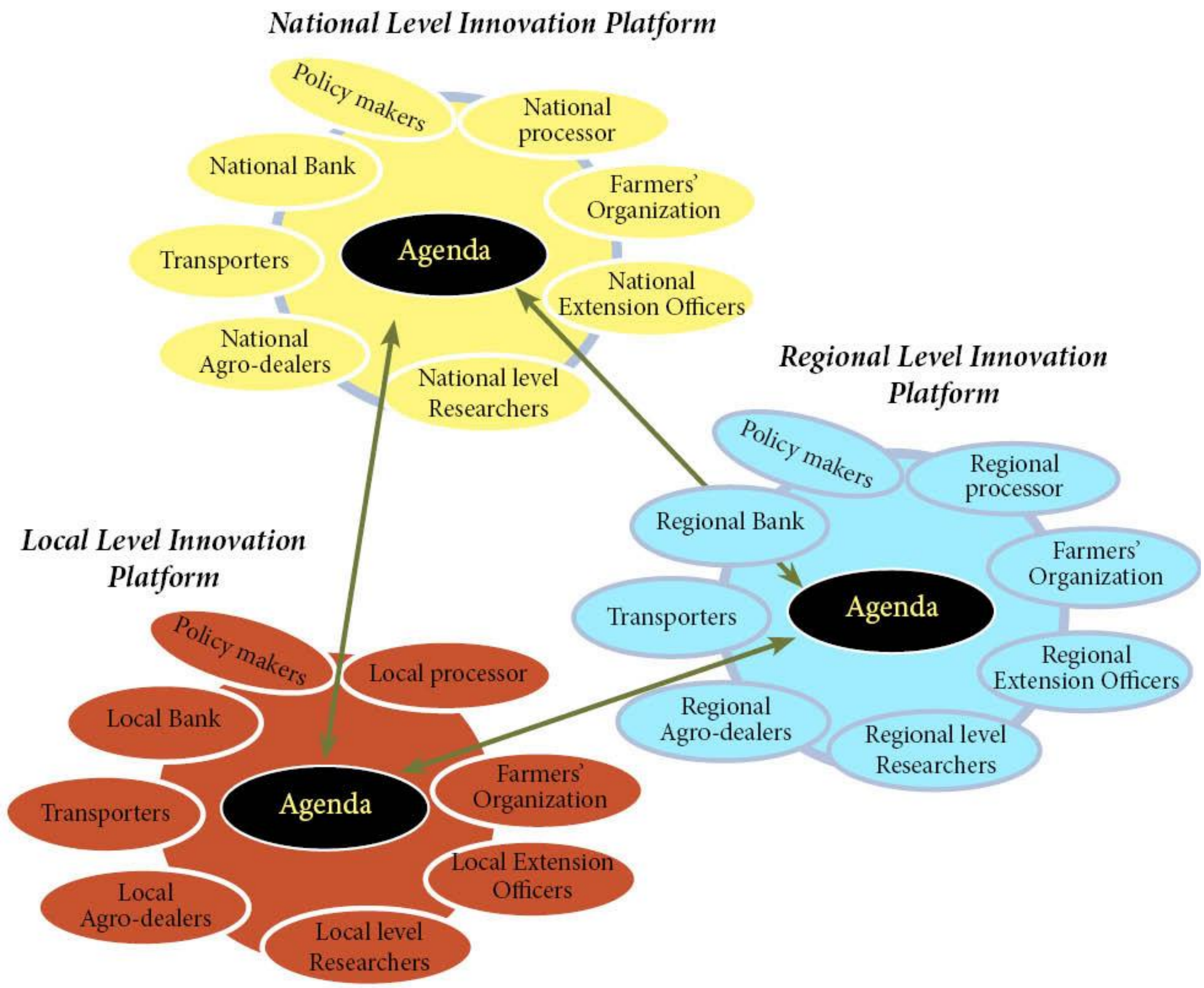

Figure 4.1: *Multi-level Innovation Platforms. Adapted from Makini et al. (2013)*

Within the IP framework, innovation domains are expected to increase technology adoption, with ripple effects on household incomes and welfare. The use of such a comprehensive analytical tool is critical in moving innovations forward, e.g., many of the bottlenecks related to the dissemination and adoption of technology have long been known but with little progress made to overcome those bottlenecks.

4.1.4 Innovation domains in smallholder dairying

Smallholder dairy production systems in the tropics share common characteristics but remain diversified, thus exhibiting heterogeneity rather than homogeneity. Based on studies in Asia, Latin America, and Northern and Eastern Africa, Devendra (2001) classified smallholder dairy production systems into three broad innovation domains *viz:* (i) traditional, usually with *ad hoc* marketing arrangements which is typical of most peri-urban smallholder dairy farms, (ii) cooperatives whose foundations are natural aggregation and/or concentration of farms, and (iii) intensive production systems with herd sizes of up to 200 dairy cows. According to Moran (2005), smallholder dairy innovation domains can also be determined on the basis of physical factors (magnitude of scale, stock type, forage and feeding systems), farm characteristics (land and stock ownership, labour, farm income), and institutional factors (marketing channels, farmer support systems, economic policies).

Dantas et al. (2016) used cluster analysis in identifying four innovation domains in the Eastern Amazon in Brazil, in which two variables *viz:* farmer education and management levels, influenced the rate of technology and innovation adoption. In the Mediterranean Basin in Algeria, Kaouche-Adjlane et al. (2015) characterised breeding dairy cattle systems into four groups of farms based on their structure and management systems. In Morocco, feeding strategies and economic efficiency were used to classify dairy cattle farming systems into five innovation domains using Principal Component Analysis (PCA) and Cluster Analysis (CA) (Srairi and Kiade, 2005). Mubiru et al. (2007), based on intensification level analysis in Uganda, lamented the negligence of systematic parametric variations in smallholder dairying which could provide entry points for research and targeting interventions. In the Kenyan highlands, Mburu et al. (2007), used cluster and discriminant analysis in categorising smallholder dairy farms into four different innovation domains based on risk management strategies, level of household resources, technology adoption, dairy intensification, and their access to services and markets. Social scientists investigating farmers' adoption behaviour in Nigeria also produced evidence showing that various characteristics inherent within innovation domains affect adoption behaviour (Oladele, 2005). No similar studies have been conducted in Zimbabwe and most other countries in Southern Africa. On the other hand, a wholesome adoption of the diverse and overlapping innovation domains highlighted above, based on non-uniform criteria and methods, makes intervention targeting rather subjective and inconsistent. Hence the need for more scientific, systematic and quantifiable segmentation parameters and procedures.

4.2 Research methodology

4.2.1 Research context

The study was carried out within the context of two DDP project sites *viz:* Rusitu and Gokwe. The two research sites were purposively selected to capture their diverse and contrasting agro-ecological, production, historical, intervention and institutional scenarios. Rusitu Dairy Resettlement Scheme is located about 440 kilometres east of Harare in Manicaland Province and falls within latitude 20^0 02’ S and longitude 33^0 48’ E. The scheme is located in agro-ecological region I, characterized by high rainfall, low temperatures, well-drained soils and provides a perfect environment for dairying (SNV 2013). It was established as a pioneer and special smallholder dairy resettlement scheme in 1983, went through various challenges, managed to reinvent itself, and is now marketing raw milk to Dairibord Zimbabwe Limited (DZL). DZL is a nationwide depot network which has been in operation since the 1950s. The Gokwe Smallholder Dairy Scheme, on the other hand, is located 338 kilometres west of Harare in the Midlands Province and falls within latitude 18^0 13’ S and longitude 28^0 56’ E. The scheme is located in agro-ecological regions III and IV characterized by low rainfall, fairly severe mid-season dry spells and is, therefore, marginal for dairying (SNV, 2013). It was one of the follow-up DDP projects in 1994, has maintained consistency, and has a contract farming arrangement for raw milk with Dendairy. Dendairy is an emerging dairy processing firm located within the Midlands Province. The Gokwe Smallholder Dairy Scheme also processes and markets processed dairy products locally. The two schemes are largely representative of smallholder dairy projects in Zimbabwe.

4.2.2 Sampling

Multistage sampling, a complex form of cluster sampling, was adopted to guide sampling for the household questionnaire survey. Rusitu and Gokwe smallholder dairy projects were purposively selected as the two research sites for reasons discussed above. During the second stage, smallholder dairy farmers in both Rusitu and Gokwe were stratified on the basis of their level of participation in dairy innovation platforms. The household was then used as the unit of sampling during the third and final stage of sampling. At this stage and within the strata, a probability sampling method, was used as the basis of selection of households included in the survey. The choice of such a sampling method was based on the need to capture the multi-dimensional characteristics of each project. The total sample was, 227 smallholder dairy households were sampled for the study, with 152 households sampled from Rusitu and 75 households sampled from Gokwe.

4.2.3 Data collection

The study adopted the use of both quantitative and qualitative data collection procedures as a way of improving analytical rigour. Field data collection was based on a phased and concurrent use of case studies, desk studies, Key Informant Interviews (KIIs), Focus Group Discussions (FGDs), and a structured household questionnaire survey. The use of a combination of data collection methods was deliberate since this is a way of triangulating collected data for purposes of verification, validation and improving the reliability of collected data (Babbie et al., 2001; Wagner et al., 2012). Despite their controversy and criticism for lack of rigour, case studies are a robust research tool that provides a platform for exploration and understanding of complex issues (Zainal, 2007). Meticulous and systematic literature review is also recognised across academic domains as critical to the foundation of new knowledge and theory evolution (Gaffar et al., 2015).

A formal survey using a structured household questionnaire was used to collect data on household demographics, participation in innovation platforms, farm amenities and conditions, asset ownership, livestock numbers and dynamics, dairy production and marketing, crop production, household food security, livelihood-based coping strategies, as well as access to livestock technology, inputs and support services. In-depth literature reviews and preliminary KIIs at national level ensured content validity, encompassing guidance on theoretical, conceptual and empirical insights. Drafted data collection instruments were also subjected to a series of reviews by peers, academic advisors and experts in various fields to ensure face validity. In addition, a pilot survey of 20 households was conducted in Chikwaka Smallholder Dairy Scheme in Mashonaland East Province about 30km north-east of Harare for purposes of gaining a conceptual clarification and ensuring that the study was based on relevant questions. The pilot study also presented an opportunity for pre-testing the data collection instruments for ensuring that the study generates accurate, consistent, dependable and reliable data.

4.2.4 Analytical framework

Innovation domains were established through the sequential use of multivariate statistical tools *viz*, (i) PCA using the Statistical Package for Social Sciences (SPSS) version 23, and (ii) CA using STATA. First, the Kaiser–Meyer–Olkin (KMO) test, for assessing the sampling adequacy, was conducted yielding a result of 0.766 which was more than the 0.5 threshold, while the Bartlett's Test of Sphericity was determined to be significant at $p < 0.01$ indicating adequacy of correlation.

PCA, a dimension reduction technique used to classify data, was used to identify non-correlated socio-economic variables for use as proxies for the segmentation of smallholder dairy farms into innovation domains. PCA is regarded as the best tool in survey research for data reduction that includes all critical data (Mick, 1990) despite recent criticism for information loss (Lattin et al., 2005), hence its continued use. A total of 24 variables were used for the PCA, following Kaiser's criterion of limiting the number of variables to less than 30 (Field, 2005). A description of all the 24 explanatory variables used in the PCA empirical model is provided in Table 4.1.

From the results, 21 of the selected 24 variables were loaded into components (>0.5). Only three variables (practising farming as a business, using improved dairy breeds, and access to markets) were not explained by the eight principle components. The number of components to be retained were again determined by Kaiser's criterion which stipulates that components have to have eigenvalues greater than one. Factors were also rotated using the varimax method to improve the interpretability of the results, with only loadings of 0.5 or more being considered as significant.

Table 4.1: *Description of variables used for PCA.*

Variable Name	**Description and units**	**Descriptive Statistics**		
		n	**M**	**SD**
Gender of HHH	1 if HHH is male, 0 otherwise	227	0.79	0.41
Age of HHH	Farmer's age in years	227	56.41	13.88
Years of education	Number of years in formal education	221	8.13	4.12
Farming experience	Years in commercial dairy	213	17.32	10.87
Total household income	Total income in USD	227	3,583.84	6,372.28
Area under fodder	Total area under fodder pastures (ha)	225	0.96	2.73
Dairy cattle	Total number of dairy herd	227	4.44	6.37
Dairy cows	Total number of dairy cows	227	1.92	2.73
Ave milk in wet season	Average litres in wet season	227	14.92	25.85
Ave milk in dry season	Average litres in dry season	226	9.74	16.36
Farming as a business	1 if yes and 0 otherwise	227	0.86	0.34
Improved dairy herd	1 if yes and 0 otherwise	225	0.76	0.43
Heat detection	1 if yes and 0 otherwise	226	0.83	0.38
Artificial insemination	1 if yes and 0 otherwise	222	0.61	0.49
Fodder production	1 if yes and 0 otherwise	225	0.76	0.43
Supplementary feeding	1 if yes and 0 otherwise	226	0.65	0.48
Vaccination	1 if yes and 0 otherwise	227	0.62	0.49
Silage making	1 if yes and 0 otherwise	227	0.90	0.30
Vaccination training	1 if yes and 0 otherwise	227	0.79	0.41
Disease training	1 if yes and 0 otherwise	227	0.92	0.28
Access to MCC	1 if yes and 0 otherwise	227	0.93	0.25
Access to breeding tech	1 if yes and 0 otherwise	227	0.88	0.33
Access to product markets	1 if yes and 0 otherwise	227	0.86	0.35
Distance from MCC	Measured in km	218	4.91	6.81

CA was then run using factors retained from PCA to determine a final distribution of smallholder dairy farms into homogenous segments, as well as ascertaining the attributes of the different clusters based on the significance of the differences between the cluster means. CA has been criticised in the past for failing to determine an appropriate number of clusters (Everitt, 1993) but remains an indispensable statistical tool for developing clusters based on entities displaying similar propensities for given variables (Steel et al., 1997). The sequential use of KIIs, PCA and CA was designed to improve analytical rigor. The final smallholder dairy farm clusters/segments were restricted to five (5). In addition to CA, one–way ANOVA tests were conducted to determine the variance between group (cluster) means.

4.3 Results

4.3.1 Insights from KIIs and FGDs

KIIs and FGDs segmented smallholder dairy farmers into four distinct innovation domains. According to the KIIs and FGDs, the first innovation domain comprises subsistence smallholder dairy producers. These are smallholder dairy farmers who become a part of the dairy enterprise as a result of assimilation, i.e., because they see others doing it. They are not commercially oriented and maybe seasonal dairy producers. Usually they have 1 – 3 milking cows. Their adoption of innovations is low and production levels are very low, with average production of 1 – 5 litres of milk per cow per day. Calving intervals could be as high as 3 years. Feed, health and general cow management is also poor. Unfortunately, these constitute the bulk (about 60 percent) of smallholder dairy farmers in the sampled schemes. The second innovation domain is made up of emerging or semi-commercial smallholder dairy farmers. These are smallholder dairy farmers who are attempting to go into commercial dairy farming but are not yet there. Innovation adoption, while improved, remains poor and inconsistent. Their productivity levels, based on milk yields, calving interval and other parameters such as mortality rates are a slight improvement from the levels attained by subsistence smallholder dairy farmers. As examples, dairy herd sizes may average 3 – 5 milking cows, while milk yields may average 8 – 10 litres per cow per day. Most of these farmers are breaking even while others are making a small profit. According to the conducted KIIs and FGDs, this second segment represents about 20 percent of smallholder dairy farmers.

The third innovation domain constitutes emerging commercial smallholder dairy farmers. They have a dairy herd size that averages 5 – 10 milking cows. Milk yield per cow ranges from 10 – 15 litres per cow per day. Innovations drive the smallholder dairy commercialisation process. The dairy herds have a normal calving interval of 365 days. They have a good animal health management system characterized by routine dipping and vaccinations. Feed and nutrition management is also improved, with adequate feed reserves that match what the dairy herd requires. They may suffer on standards, e.g., struggle with maintaining consistent milk quality, but they are close to standards in the large–scale commercial dairying sector. As such most of the dairy enterprises are viable entities. This group constitutes about 15 percent of smallholder dairy farmers in the sampled schemes. Lastly, the fourth innovation domain signifies a group of commercial and market-oriented smallholder dairy farmers. These are smallholder dairy farmers by scale of production but are qualified to break into large-scale commercial dairying. Their dairy herd sizes ranges from 10 – 60 milking cows, with milk yield levels of between 15 – 25 litres per cow per day. They have gone commercial because they have realized the benefits of dairying. Within this innovation domain are smallholder dairy farmers who want to exit smallholder dairy farmer associations because they may feel that they are subsidising the rest of the cooperative group, e.g. in terms of milk collection centre running costs, and want to move into individual supply chains. While the first three categories depend on each other in terms of marketing arrangements, members of this group can afford to individually supply dairy processors. This group constitutes only 5 percent of smallholder dairy farmers in the research sites.

4.3.2 Principal Component Analysis (PCA) results

PCA produced clear dimensions between the selected variables resulting in distinct farmer segments. A total of 8 principal components having eigenvalues of >1 were deemed capable of effectively explaining the variance in the data set. This entails that 8 innovation domains were initially identified for categorizing smallholder dairy farmers in Rusitu and Gokwe. A notable 68.7% of the variation in the data is explained by the 8 components. The first component explains 22.1% of the total data variance, the second component (13.5%), third component (7.5%), fourth component (6.2%), fifth component (5.5%), sixth component (5.1%), seventh component (4.5%), while the eighth component accounts for 4.3% of the variance. Table 4.2 shows the results of the rotated component matrix, which highlights the loadings and shows the correlations between individual variables and the components.

Table 4.2: *Varimax-rotated component matrix showing the identified principal components, loadings for selected variables, and the percent cumulative variance explained*

	Component							
	1	2	3	4	5	6	7	8
Distance from MCC	-.060	.036	-.033	.090	-.061	**.813**	-.094	-.088
Gender of HH head	.140	.125	-.051	.036	-.114	-.016	.239	**-.756**
Age of HH head	.052	-0.42	.054	-.070	**.862**	-.039	.237	.023
Years in formal schooling	.107	-.026	.092	-.056	**-.748**	-.066	.315	.074
Years in commercial dairying	.167	.351	.169	.172	.488	-.426	-.226	.092
Total annual HH income	**.866**	.010	-.013	-.004	-.011	.034	.092	.080
Area under fodder	.084	.175	-.062	.025	-.155	-.052	.193	**.630**
Dairy cattle owned	**.908**	.083	.110	.074	.035	-.098	-.076	-.011
Dairy cows owned	**.870**	.032	.139	.040	.026	-.106	-.127	-.020
FaaB adoption	.053	.270	.182	.017	.160	.450	.184	.308
Use of imp dairy breeds	.104	**.602**	.212	.087	.133	.119	.011	.204
Heat detection practised	.090	**.729**	.094	.255	-.031	-.099	-.004	.057
AI adoption for breeding	.186	**.696**	.088	-.018	.026	.015	-.096	-.076
Fodder prod on at least 0.1ha	-.065	**.718**	.250	.068	.007	-.022	.139	.036
Basal & supplementary feeding	.138	**.704**	.159	-.001	-.070	.120	.230	-.069
Vaccination adoption	-.070	.139	.038	.070	-.043	-.003	**.881**	-.014
Trained in silage making	.040	.310	**.521**	**.613**	-.021	-.145	-.020	.027
Trained in vaccinations	.056	-.106	.060	**.739**	.055	.356	.086	.108
Trained in disease treatment	.008	.286	.075	**.839**	-.016	-.085	.013	-.114
Access to MCC	.057	.222	**.821**	-.060	-.034	-.046	.026	-.048
Access to impr. breeding techn.	.140	.229	**.729**	.168	-.022	.071	-.076	.048
Access to markets	.047747	.118	**.657**	.098	.061	.018	.081	.010
Avg milk prod/day wet season	**.91919**	.151	.039	.007	-.024	.021	.003	-.034
Avg milk sold/day dry season	**.864**	.180	.038	-.009	-.021	.057	.036	-.052
	22.1%	**13.5%**	**7.5%**	**6.2%**	**5.5%**	**5.1%**	**4.5%**	**4.3%**

For the first component, 5 variables are significant in explaining it. These are the number of dairy cattle owned, the number of dairy cows owned, average milk production per day during the wet season, average amount of milk sold per day during the wet season, and total annual household income. This first component represents the group of *"productivity and market-oriented farmers".* The second component, "*breeding and feeding conscious farmers",* is strongly and positively correlated to 5 variables i.e. the use of improved dairy breeds, adherence to heat detection in dairy cows, adoption of artificial insemination as a breeding technology, fodder production on at least 0.1ha, and adherence to basal feeding of 2kg and supplementary feeding of 0.5kg feed for an additional litre of milk. The third component, "*farmers with access to essential services",* has the following 4 significant variables – training in silage making, access to the milk collection centre, access to improved breeding technologies, and access to markets. An emerging pattern here is that strong necessary conditions/drivers lead to better innovation uptake.

The fourth component, "*capacitated farmers",* had three issues that loaded heavily on the component: training in silage making, training in vaccinations, and training in disease treatment implying that capacity building is a critical determinant of the adoption of innovations. The fifth component, "*old farmers with less formal education",* shows a negative relationship between the age of household head and the number of years in formal schooling implying that older farmers are associated with less education, and maybe less innovation. The sixth component, "*access to markets oriented farmers",* has only 1 dominant factor – the distance from the milk collection centre, while the seventh component "*health concerned farmers",* is heavily weighted by the adoption of vaccinations. The eighth component, "*gender and fodder production sensitive farmers",* shows a negative relationship between the gender of the household head and the area under fodder implying that more female headed households turn to have a higher area of fodder under production. However, insights from the Scree Plot, which determines how many components are to be retained, reduced the number of identified innovation domains that we can effectively work with to five.

4.3.3 Identified innovation domains

The identified five innovation domains were retained and used for Cluster Analysis (CA). Results of one-way ANOVA, where F is significant (<0.1), implies that there are significant variances among the innovation domains for a number of variables. This in turn entails that there are some innovation domains where variables are dominant over others. Results from CA are presented in Table 4.3. The five different innovation domains are each denoted with ID. Of interest is establishing the characteristics that differentiate the five innovation domains.

Socio-economic variables that differentiate the five innovation domains include membership to collective smallholder dairy association groups, milk collection centre membership registration, full payment of membership subscriptions, period of registration as a milk collection centre member, and a household's milk production status. All these socio-economic variables are related to a household's participation in smallholder dairying innovation platforms. However, an unexpected result was the fact that the variable on households' milk delivering status, which is also related to a household's participation in smallholder dairying innovation platforms is not significant. On the other hand, all technology adoption variables are significant, with the exception of branding, which is a form of livestock identification. The characteristics that differentiate the five innovation domains are discussed below.

Core Dairy Producers (ID 1)

This first innovation domain comprised 61.6% of the farm households. This innovation domain can be distinguished from the other innovation domains largely on the basis of milk production and delivering status of producers in this strata. The innovation domain has the highest proportion of households currently producing milk (77%) and delivering milk to milk collection centres (57%). Comparative averages from all the 5 domains are 66% and 52% respectively. The innovation domain thus comprises a core group of smallholder dairy producers. It also has the highest proportion of members with fully paid subscriptions. As expected, the innovation domain recorded the second largest number of technologies adopted by any innovation domain. It recorded the adoption of the use of paddocks, stainless steel bucket for milking, use of artificial insemination in breeding, fodder production on at least 0.1 ha, new fodder crops, and silage making.

Table 4.3: *Characteristics of selected innovation domains (IDs) and results of one way ANOVA testing for equality of group means.*

	ID 1 (n=93)	ID 2 (n=24)	ID 3 (n=7)	ID 4 (n=3)	ID 5 (n=24)	Group M	Group SD	Prob > F
Socio-Economic Variables								
Membership to Dairy Group[1]	1.00	1.00	0.57	1.00	0.99	0.98	0.14	0.00***
Registered MCC Member[1]	1.00	1.00	0.43	1.00	0.99	0.97	0.16	0.00***
Fully Paid Up Membership Subs[2]	0.86	0.79	0.14	0.67	0.84	0.81	0.39	0.00***
Period Registered As MCC Member (yrs)	25.07	10.36	5.29	27.00	15.72	19.36	11.91	0.00***
Position in Local MCC	6.45	7.00	7.00	7.00	6.20	6.46	1.48	0.20
HH Currently Producing Milk[2]	0.77	0.54	0.29	0.33	0.62	0.66	0.47	0.01***
HH Currently Delivering Milk[2]	0.57	0.42	0.29	0.67	0.52	0.52	0.56	0.56
Est. Total Annual Income (US$)	3382.66	2606.88	1605.00	2676.67	4548.24	3614.18	6686.68	0.62
Est. Total Annual Dairy Income (US$)	1391.12	1249.33	83.33	324.00	1885.39	1488.84	3181.91	0.59
Dairy Livestock Sales (US$)	164.99	93.75	57.14	0.00	214.32	166.52	496.29	0.77
Fodder Entrepreneurship (US$)	12.00	3.54	0.00	0.00	3.94	7.52	47.03	0.81
Dividends Received (US$)	35.31	101.74	0.00	0.00	85.95	58.94	299.88	0.75
Total Dairy Gross Income (US$)	2199.92	1489.51	303.57	600.00	4726.09	2894.89	11917.02	0.62
Technology Adoption								
FaaB Approach[3]	0.91	0.79	0.57	1.00	0.90	0.88	0.32	0.04**
Record Keeping[3]	2.83	1.75	1.43	2.33	2.88	2.65	1.36	0.00***
Viability Assessments[3]	2.80	1.54	1.29	1.67	3.00	2.63	1.24	0.00***
Use of Paddocks[3]	2.90	1.50	0.71	2.00	2.54	2.51	1.43	0.00***
Stainless Steel Bucket[3]	3.12	1.71	0.67	1.67	2.97	2.79	1.48	0.00***
Tagging[3]	0.43	0.38	0.00	0.00	0.48	0.42	0.49	0.08*
Branding[3]	0.37	0.34	0.00	0.00	0.42	0.17	0.38	0.49
Timely Weaning[3]	1.92	1.46	0.40	0.67	2.16	1.89	1.46	0.02**
Improved Dairy Breeds[3]	0.89	0.46	0.14	1.00	0.81	0.78	0.41	0.00***
Cross Breeding[3]	2.76	0.83	0.57	2.00	3.00	2.51	1.37	0.00***

	ID 1 (n=93)	ID 2 (n=24)	ID 3 (n=7)	ID 4 (n=3)	ID 5 (n=24)	Group M	Group SD	Prob > F
Artificial Insemination (AI) [3]	0.73	0.17	0.00	0.67	0.67	0.61	0.49	0.00***
Fodder Production[3]	0.89	0.29	0.14	0.33	0.85	0.77	0.42	0.00***
New Fodder Crops[3]	2.56	0.63	0.57	1.33	2.19	2.10	1.38	0.00***
Silage Making[3]	2.69	0.88	0.29	1.67	2.48	2.29	1.44	0.00***
Urea Treatment[3]	1.04	0.71	0.14	0.00	1.75	1.20	1.51	0.00***
Adherence to Dipping Regimes[3]	3.10	2.29	1.43	2.00	3.37	3.02	1.19	0.00***
Vaccination[3]	0.54	0.54	0.29	0.67	0.72	0.59	0.49	0.08*

[1] 1 if member and 0 otherwise

[2] 1 if yes and 0 otherwise

[3] 1 = Never, 2 = Rarely, 3 = Sometimes, 4 = Frequently, and 5 = Always.

*Significant at 0.10 level, **Significant at 0.05 level, ***Significant at 0.01 level.

The Heirs (ID 2)

The second innovation domain, which accounted for 15.9% of the farm households, is peculiar in the amount of dividends received by members of this cluster. The innovation domain encompasses smallholder dairy farmer association members who receive the highest amount of dividends. This is the group of smallholder dairy heirs who inherited enterprises upon the death of the original entrepreneurs. The cluster's average dividend is USD101.74 against an average of USD58.94, with the third and fourth innovation domains receiving USD0.00 dividends. They also have the second least period of registration as milk collection centre members, a handful of milk producers, and the second lowest proportion of members delivering milk to milk collection centres. There is nothing peculiar about their technology adoption patterns.

New and Emergent Producers (ID 3)

The third innovation domain included 4.6% of the farm households. The innovation domain sets itself apart on the basis of two distinguishing features which include the shortest period registered as milk collection centre members at 5.3 years against an average of 19.4 years, and the lowest proportion of households currently producing milk. The group has the lowest proportion of membership to collective smallholder dairy groups, and the lowest proportion of registered milk collection centre membership. Overall, this group of new and emergent producers has the lowest technology adoption levels for all technologies considered in this study, with the exception of urea treatment.

The Pioneers (ID 4)

The fourth innovation domain, which encompassed 2.0% of the farm households, is differentiated by the period of registration as milk collection centre members. The innovation domain is constituted by smallholder dairy farmers with the highest period of registration as milk collection centre members, with a group average of 27.0 years against an average of 19.4 years. This is an assemblage of smallholder dairy pioneers. Technology adoption in this assemblage is insignificant. This is because this group of pioneers has the highest level of adoption of farming as a business approach and use of improved dairy breeds, but also has the lowest adoption of tagging and urea treatment.

Commercial and Market-Oriented Producers (ID 5)

This fifth and final innovation domain consisted of 15.9% of the farm households. This innovation domain dissociates itself from other innovation domains on the basis of generated income. The constellation has the highest estimated total annual household income, at USD4,548 against an average of USD3,614, and the estimated total annually dairy income, at USD1,885 compared to an average of USD1,488. This is the constellation of commercial and market-oriented producers. This constellation has the highest number of technologies adopted at a rate of adoption greater than other innovation domains. Technologies adopted at higher rate include record keeping, viability assessments, tagging, timely weaning, cross breeding, urea treatment, adherence to dipping regimes, and dairy animal vaccinations.

4.4 Discussion

The results of PCA and CA, which yielded the distinct five innovation domains, are consistent with the findings of previous studies conducted elsewhere that classified smallholder dairy production systems on the basis of the level of intensification, management structure and market engagement (Devendra, 2001; Mubiru et al., 2007), physical factors, farm characteristics and institutional factors (Moran, 2005), dairy cattle farm structure and management systems (Kaouche-Adjlane et al., 2015), feeding strategies (Srairi and Kiade, 2005), as well as the risk management strategies of identified dairy production systems and their access to services and markets (Mburu et al., 2007). The paper, however, serves as a departure from conventional farmer typology studies that explicate technology adoption patterns though characteristics such as farm size, dairy herd size, milk production, farmer age, education level and management levels (Mburu et al., 2007; Dantas et al., 2016).

The paper established that smallholder dairy farmers segmented within innovation domains with higher levels of participation in smallholder dairy innovation platforms, such as the *Core Dairy Producers* and *Commercial and Market-Oriented Producers*, had higher rates of technology adoption. This can be explained by several factors. Smallholder dairy farmers in innovation domains with higher levels of participation in smallholder dairy innovation platforms tend to have greater access to extension and other support services (policy, research, credit and finance, market information), and greater interaction with other innovation platform actors (other farmers, researchers, extension agents, traders, processors, wholesalers, retailers, transporters, other private sector placers such as finance institutions, NGOs and policy makers at local, regional and national levels). This notion is supported by the results of earlier studies that argues that this also allows for the joint identification of bottlenecks and opportunities in production, marketing and the policy environment, and the leveraging of innovation to address the identified constraints and take advantage of opportunities across the entire impact pathway (Nederlof et al., 2011; BMGF, 2013), and hence a greater rate of technology adoption.

Results from the case study also support findings in fields outside the smallholder dairy sector. Studies in Zambia showed that the adoption rate of technologies for underutilized crops, including sorghum, were higher within innovation platforms (Mbulwe, 2015). This the author attributed to a higher market demand for inputs and crop commodities. Similarly, an assessment of the effectiveness of the innovation platforms for technology adoption along the maize value chain in the Province of Sissili, Burkina Faso succeeded against the backdrop of drivers such as the existence of champions of change, market opportunities to produce and sell quality seed and grain maize, access to information through community radio; and a string training and capacity building programme (Sanyang, 2012).

For the same reasons cited above, innovation domains with a lower level of participation in smallholder dairy innovation platforms (notably *The Heirs*, and *New and Emergent Producers*) tend to have lower rates of technology adoption. The *Pioneers*, on the other hand, sit on the fence because both their participation in smallholder dairy innovation platforms and rate of technology adoption are inconsequential. The results presented in this paper are also proof that there is a positive relationship between the level of participation in smallholder dairy innovation platforms, the rate of technology adoption, and the incomes generated from the smallholder dairy enterprise. This has implications and positive ripple effects on annual dairy incomes, household incomes, and household welfare.

However, other scholars argue that access to information and technology alone is not a sufficient condition for technology adoption without additional support from resource availability, technical guidance and improved perspectives (Batalha, cited by Dantas et al., 2016). Using a variant of the Innovation Platforms paradigm, the Integrated Agricultural Research and Development (IAR4D) in analysing its impact on adoption of soil fertility management technologies among smallholder farmers in Southern Africa, Nyikahadzoi et al. (2012) also established that socio-economic factors are more important in influencing adoption than participation in innovation platforms.

4.5 Conclusion

Innovation domains have several implications for agricultural research and extension, some positive and others negative. Different innovation domains have different circumstances and needs, hence the need for targeted interventions and recommendations. Thus, farmer segmentation and the categorization of smallholder dairy farms into appropriate innovation domains allows for better targeting and priority setting in dairy improvement research and development, and in improving the participation in intensive production and marketing systems by oftentimes marginalized and neglected smallholder dairy farmers. Interventions in the smallholder dairying sector should, therefore, factor in the characteristics of different innovation domains. An appreciation of the concept of innovation domains and knowledge of existing innovation domains within the target intervention context are also key for designing sectoral policies and strategies for the sustainable development of smallholder dairy value chains across the Sub Saharan Africa region.

Appropriate farmer segmentation is critical for target domain mapping, improving the adoptability and performance of innovations, determining potential opportunities and barriers to technology adoption, providing platforms for feedback and learning, and for ensuring the formulation of sector specific policies, appropriate research and extension programming, and development of practical tools for the apt targeting of interventions. We are thus convinced that information generated by this study will also provide insights on issues critical for the academic advancement of innovation theory, formulation of realistic dairy development policies, as well as feedback to technology development and dissemination processes.

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CHAPTER 5 : SOCIO-ECONOMIC DIFFERENCES BETWEEN INNOVATION PLATFORM PARTICIPANTS AND NON-PARTICIPANTS: THE CASE OF SMALLHOLDER DAIRYING IN ZIMBABWE[7]

Abstract

The concept of innovation platforms as a strategy for enhancing technology development, the dissemination of innovations, and market participation has received much attention in recent times among researchers in Sub Saharan Africa. However, very little is written on the determinants of participation in smallholder dairy innovation platforms, particularly for Southern Africa. This paper investigates the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms, based on results of a cross-sectional survey of 227 households in Rusitu and Gokwe smallholder dairy schemes in Zimbabwe. Results indicated statistically significant differences between the groups with respect to experience in commercial dairying, agricultural training received, household size, availability and access to labour, the main source of household income, dairy herd size, and the number of lactating cows ($p < 0.01$). The study also established statistical significance in differences in asset ownership ($p < 0.01$); dairy management systems ($p < 0.01$); overall Knowledge, Attitudes and Practices (KAP) scores ($p < 0.01$); and household food and nutrition security ($p < 0.05$). Insights from this study have critical implications for smallholder dairy research and advisory services. They suggest a need for improvements in the design of key support services for the provision of training, capacity building, technical backstopping services, enhancing commercial dairying experience and growing the dairy herds for smallholder dairy farmers.

Keywords: *innovation platforms, participation, smallholder dairying, socio-economic, Zimbabwe.*

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5.1 Introduction

5.1.1 Background

The concept of innovation platforms as a strategy for enhancing technology development, the dissemination of innovations, and market participation has received much attention in recent times among researchers in Sub Saharan Africa (Martey et al., 2014). On the other hand, participation in innovation platforms by smallholder farmers also holds considerable potential for allowing access to niche markets, yielding better returns, and ensuring sustainable livelihoods for this historically marginalized sub-sector (Omiti et al., 2009). Innovation platforms, which facilitate interaction amongst actors, coordination, technological and institutional innovation, social learning and adoption of improved practices (Makini et al., 2013; Boogaard et al., 2013), have ushered in new hope, enthusiasm and prospects for improved relevance, effectiveness, and tangible impact through agricultural interventions. The interest in innovation platforms is being further propelled by the realization that barriers to agricultural development are not only technological but also institutional (Flintermanet et al., 2012).

Constraints and challenges within the smallholder dairying sector in developing countries remain subjects of both academic and developmental debate, and as priority intervention areas. Such constraints and challenges include low genetic potential, prevalence of various animal diseases, inadequate feeds and feeding, poor animal management, and unfavourable climate (FAO, 2014). Other common issues facing the smallholder dairy sector in developing countries are the lack of appropriate handling and processing facilities resulting in concerns over milk quality, limited market access, low and volatile prices paid to farmers, poor management practices among producers, logistical bottlenecks, limited opportunities for enhancing productivity and increasing domestic supply, and weak linkages between different actors along the dairy value chain (ICAE, 2015). In Zimbabwe, the smallholder dairy sector is characterized by low productivity, restricted market participation, and viability challenges (Hanyani-Mlambo et al., 1998; Kagoro and Chatiza, 2012; Chamboko and Mwakiwa, 2016). Hence, the need for the development and sustainable support for innovation platforms within this sector.

This paper focuses on smallholder dairying due to the multiple benefits that, when operating effectively and efficiently, the sector can provide to producers. Benefits include a daily, more reliable and substantial source of income, improved household food and nutrition security, both directly through increased economic access to food, and indirectly given that the primary product, milk, is a balanced and nutritious food (ICAE, 2015). Smallholder dairying can also be a vehicle for national and regional development as it creates employment for numerous previously marginalized producers, is a source of not just income but also savings, and is one of the few agricultural enterprises that can be developed under varying environments (Salazar et al., 2016).

Literature has many narratives on socio-economic factors affecting market participation of smallholder farmers for a variety of agricultural commodities. Past studies have identified factors such as gender, marital status, farmers' access to credit and extension, market information, distance to market, land size, infrastructure, and external source of income (Randela et al., 2008; Hlongwane et al., 2014; Gebremedhin et al., 2015). Only a few publications explore determinants of smallholder farmer participation in dairy markets and in innovation platforms. These publications identified household size, gender, age, education, distance to market, ownership of transport, communication facilities, and the number of milking cows as significant determinants of milk market participation among smallholder farmers (Kuma et al., 2013; Kuma et al., 2014; Balirwa et al., 2016; Tadesse et al., 2016). On the other hand, and in addition to the above, research has also established farming experience, literacy levels, and household income as significant determinants of smallholder farmers' participation in innovation platforms (Martey et al., 2014; Akinmusola et al., 2016).

However, very few studies have undertaken comprehensive analyses, with most studies having been based on cursory analysis. Where these studies have been conducted within Sub-Saharan Africa, they have largely been restricted to West and Eastern Africa, with none in Southern Africa. As such, very little is written on the determinants of participation in smallholder dairy innovation platforms, particularly for Southern Africa. This paper investigates the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms. It transcends conventional analyses of household and farm characteristics by also examining dairy management systems; knowledge, attitudes and practices; and effectiveness of innovation platforms.

5.1.2 Conceptual framework

Innovation platforms are physical, virtual, or physico-virtual networks of stakeholders, which have been set up around a commodity or system of mutual interest to foster collaboration, partnership and mutual focus to generate innovation on the commodity or system (Adekunle and Fatunbi, 2012). See also the IPs definition on page 31 (sub-Section 3.1.5). They are fora of entities that share a common interest and come together to solve problems and develop mutually beneficial solutions (Makini et al., 2013). It has, in fact, been argued that a key element of innovation platforms is in identifying bottlenecks and opportunities in production, marketing and the policy environment, and to leverage innovation to address the identified constraints and take advantage of opportunities across the entire impact pathway (Nederlof et al., 2011; BMGF, 2013).

In this paper, innovation platform participants are conceptualized as a group of farmers that comprise smallholder dairy association members who produce and deliver milk to the collection centres for collective marketing purposes. Non-participants, on the other hand, represent smallholder dairy association members who produce milk for occasional deliveries to the collection centres or for side-marketing.

In assessing the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms and determining the effectiveness of innovation platforms, this paper hinges analysis on an adapted innovation platforms framework (Hanyani-Mlambo et al., 2017). The framework consists of five major components *viz*: the necessary conditions (drivers) for effective innovation platforms, innovation platform processes including farmer segmentation and stakeholder participation, innovation platforms, parameters measuring the effectiveness of innovation platforms, and strategic impacts (improved technology adoption, increased productivity and improved sector viability)(See Figure 5.1).

5.2 Materials and methods

5.2.1 Research context

The study was conducted in Rusitu and Gokwe smallholder dairy schemes in Zimbabwe, as a cross-sectional survey in 2015. Rusitu Dairy Resettlement Scheme is located about 440 kilometres east of Harare in Manicaland Province and falls within latitude 20^0 02’ S and longitude 33^0 48’ E. The scheme is located in agro-ecological region I, characterized by high rainfall, low temperatures, well-drained soils and provides a perfect environment for dairying (SNV, 2013). The Gokwe Smallholder Dairy Scheme, on the other hand, is located 338 kilometres west of Harare in the Midlands Province and falls within latitude 18^0 13’ S and longitude 28^0 56’ E. The scheme is located in agro-ecological regions III and IV characterized by low rainfall, fairly severe mid-season dry spells and is, therefore, marginal for dairying (SNV, 2013). However, despite the contextual contrasts, smallholder dairying remains the major source of income in both communities. Whilst milk production is an individual household activity, market participation is driven by cooperatives in a context where smallholder dairy farmer associations facilitate producers' link with both input and output markets.

5.2.2 Sampling methods

Multistage sampling, a complex form of cluster sampling, was adopted to guide sampling for the household questionnaire survey. Rusitu and Gokwe were purposively selected as the two research sites given their contrasting characteristics and representativeness of the generality of smallholder dairy schemes in Zimbabwe. At the second stage, smallholder dairy farmers in both Rusitu and Gokwe were stratified on the basis of their level of participation in dairy innovation platforms. The household was then used as the unit of sampling during the third and final stage of sampling. At this stage and within the strata, a probability sampling method was used as the basis for selecting households included in the survey. A total of 227 households were sampled for the study. Of these, 100 households (44.1%) actively participated in smallholder dairy innovation platforms, while the remaining 127 households (55.9%) were not.

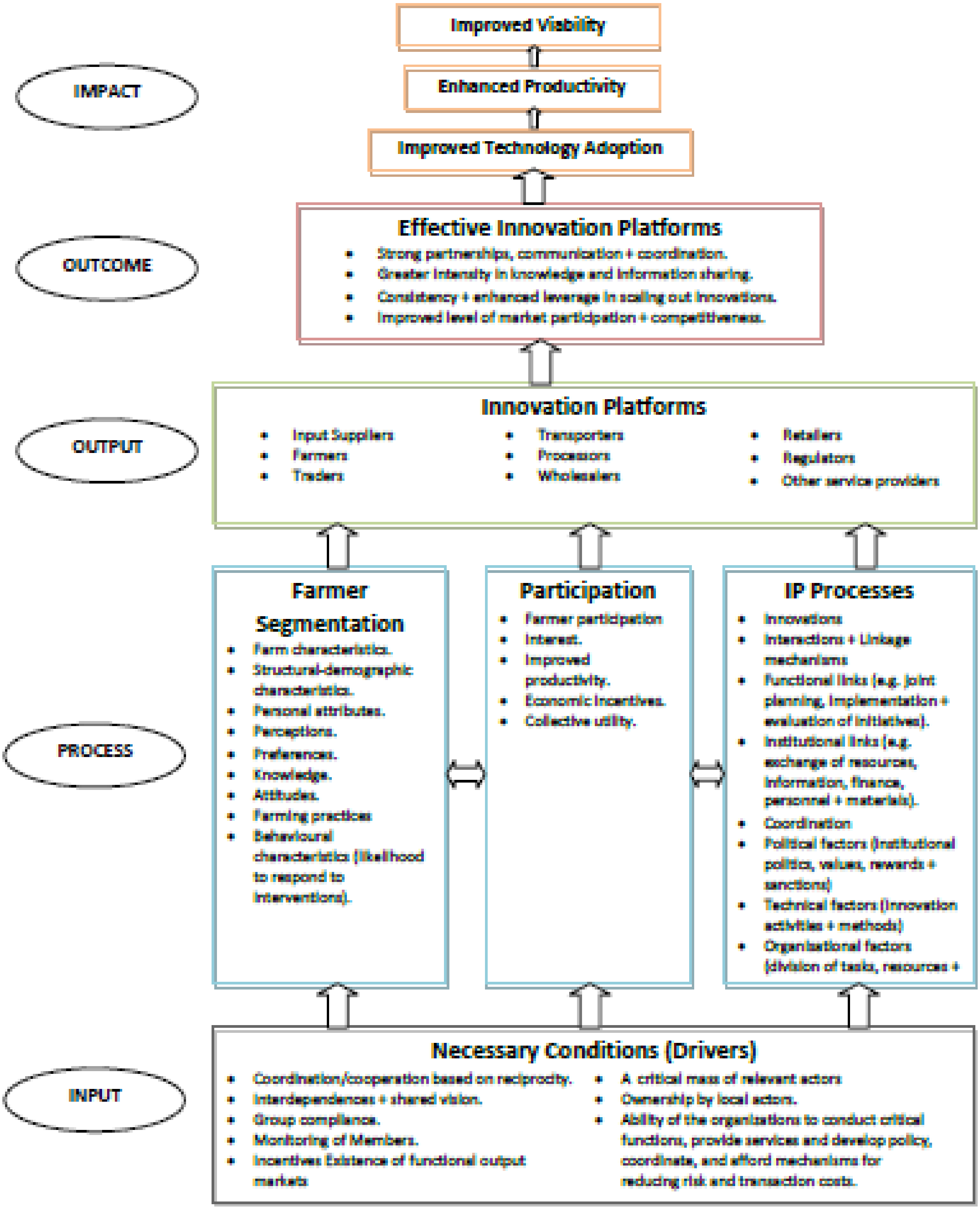

Figure 5.1: *Framework for assessing the effectiveness of IPs (Hanyani-Mlambo et al, 2017)*

5.2.3 Data collection

Field data collection adopted a phased approach and the concurrent use of literature reviews, key informant interviews, focus group discussions, and a structured household questionnaire survey. The use of numerous data collection methods was deliberate as a way of triangulating collected data for purposes of verification, validation and improving the reliability of collected data (Babbie et al., 2001; Wagner et al., 2012). A formal survey using a structured household questionnaire was used to collect data on household demographics, participation in innovation platforms, farm amenities and conditions, asset ownership, livestock numbers and dynamics, dairy production and marketing, crop production, household food security, livelihood-based coping strategies, as well as access to livestock technology, inputs and support services. The data collection instruments were pre-tested to ensure that the study generates accurate, consistent, dependable and reliable data.

5.2.4 Statistical analyses

Socio-economic data was analyzed using the IBM SPSS statistical software version 22. Data analysis focused on five sets of variables *viz:* household and farm characteristics; asset ownership; dairy management systems; knowledge, attitudes and practices; and household food and nutrition security. Descriptive statistics such as frequencies and cross-tabulations were then used to generalize about the sample population and the differences between participants and non-participants in smallholder dairy innovation platforms. Cross-tabulation was used to determine the association between these variables. The significance of the association was determined using the Pearson's chi-square tests, while the significance of differences between the two farmer segments was tested using t-tests. In all cases, p values below 0.1 were taken as statistically significant.

5.3 Results

5.3.1 Household and farm characteristics

Socio-economic factors have been identified as key drivers in determining smallholder dairy farmers' participation in milk markets (Kuma et al., 2014; Balirwa et al., 2016; Tadesse et al., 2016) and in innovation platforms (Martey et al., 2014; Akinmusola et al., 2016; Gyau et al., 2016), albeit with no specific focus on smallholder dairy innovation platforms. Differences in household and farm socio-economic characteristics between smallholder dairy innovation platform participants and non-participants were analyzed on the basis of age, education, experience in commercial smallholder dairying, household size, access to labour, farm size, arable land size and utilized area, dairy herd size, and distance from the Milk Collection Centre (MCC). An analysis of survey results, based on mean differences, indicated statistically significant differences for experience in commercial dairying, household size, the number of household males and females aged 16 – 64 years, dairy herd size, and the number of lactating cows ($p < 0.01$). The rest of the explored socio-economic variables, including age, education, farm size and the distance from the market were statistically insignificant, which was unanticipated given insights from desk studies. See Table 5.1.

The survey results above entail that on average, smallholder dairy innovation platform participants had more experience in commercial smallholder dairying, relatively larger households, more effective labour, and bigger dairy herd sizes in addition to a greater number of lactating cows. Other household categorical data *viz:* agricultural training received and main source of household income, were determined to be significant at $p < 0.01$ using Chi-square tests. On the other hand, gender and the highest level of education attained by the household head were not significant. This further supports the thesis that formal education on its own, without technical backstopping through practical training and the provision of advisory services, is not effective in transforming attitudes, practical skills and practices at the grassroots level (UNESCO, 2017).

Table 5.1*: Comparable household and farm descriptives for innovation platform participants and non-participants*

Variable	Sample M	IP Participants M	Non-Participants M	t-value	Significance Level
Age of HH head (years)	42.0	57.1	55.8	0.703	0.483
Years in formal schooling	9.20	7.91	8.31	-0.714	0.476
Years in commercial dairy	17.3	21.5	13.8	5.476	0.000[a]
HH Size	5.83	7.64	6.37	3.002	0.003[a]
No. HH males 16-64 yrs	1.99	2.03	1.50	2.868	0.005[a]
No. HH females 16-64 yrs	2.07	2.26	1.60	3.784	0.000[a]
Total farm size (ha)	4.26	5.12	4.62	1.112	0.267
Arable land size (ha)	3.86	4.50	3.93	1.181	0.239
Utilized arable area (ha)	3.43	3.10	2.91	0.700	0.485
Dairy herd size	4.99	6.65	2.46	6.813	0.000[a]
Number of lactating cows	2.01	2.30	0.72	9.697	0.000[a]
Distance from MCC (km)	4.91	4.21	5.47	-1.362	0.175

Key: a, b and c significant at α = 0.01, α = 0.05 and α = 0.10, respectively.

5.3.2 Asset ownership

An analysis of asset ownership, based especially on the ownership of productive agricultural implements by the sampled households, show the level of resource endowment, their capacity, and a measure of both socio-economic status and well-being (Langyintuo, 2008). Asset ownership is also a determinant of a household's resilience to climate change and vulnerability to short-term shocks such as animal disease, droughts and flooding. It has also been noted that the number and type of livestock owned by particular households and by individuals within households under review is essential information for characterizing them, just as this is also an essential variable for determining other key indicators such as livestock productivity and incomes (Njuki et al., 2011).

Tests for differences in the proportions of households falling in different wealth categories between innovation platform participants and non-participants had a statistically significant Chi-square value ($p < 0.01$) (See Table 5.2).

Table 5.2: *Percentage (%) of total sample falling in different wealth categories*

Wealth category	**IP Participants**	**Non-Participants**
Asset poor (*0 – 7 different types of working assets)*	3.1[a]	12.1[b]
Asset medium (*8 – 15 different types of working assets)*	25.6 [a]	32.7 [b]
Asset rich (*>15 different types of working assets)*	16.1 [a]	7.2 [b]
Total	44.8	52.0

[ab]proportions in the same row for each variable with different superscripts are significantly different ($p < 0.01$)

The results show that there is a significant difference between the percentages of innovation platform participants and non-participants falling within different wealth categories, based on the number of working assets. This means that participants in smallholder dairy innovation platforms have more assets in general than non-participants. The reason could be the nature of commercial smallholder dairying which is capital intensive, hence innovation platform participants' greater resource endowments. On the other hand, higher incomes generated by innovation platform participants (Hanyani-Mlambo et al, 2017) could probably be transformed into assets as part of smallholder farmers' reinvestments in dairying and risk management strategies.

5.3.3 Dairy management systems

Dairy management systems are characterized by a variety of resources that include, *inter alia*, herd size, arable and grazing land area, forage and feeding management systems, herd health management, breed improvement strategies, milking practices, and marketing channels utilized (Dantas et al., 2016).

Statistically significant differences were established in the proportion of sampled households utilizing a particular dairy management system, forage and feeding system during the dry season, dairy breed (stock type), and extension contact ($p < 0.01$). There were also statistically significant differences between innovation platform participants and non-participants on the basis of the main forage and feeding system used in the wet season and the mode of milk transportation ($p < 0.05$)(See Table 5.3).

Table 5.3: *Percentages of innovation platform participants and non-participants with different dairy management systems*

Variable	**IP Participants (%)**	**Non-Participants (%)**	**Significance Level**
Predominantly use of zero grazing	75.9	24.1	0.000 [a]
Silage/hay used as main forage in wet season	57.9	42.1	0.019[b]
Silage//hay used as main forage in dry season	62.5	37.5	0.000 [a]
Pure breeds adopted as main dairy stock type	66.7	33.3	0.000 [a]
Motor vehicle used for milk deliveries	62.5	37.5	0.000[a]
Producers with daily extension contact	79.2	20.8	0.000[a]

Key: a, b and c significant at $\alpha = 0.01$, $\alpha = 0.05$ and $\alpha = 0.10$

In general, results from Rusitu and Gokwe districts show that participants in smallholder dairy innovation platforms had a higher level of adoption of recommended dairy management innovations. A notable 75.9% of the smallholder dairy farmers participating in innovation platforms adopted zero grazing, compared to 24.1% from the sample of non-participants who adopted the same innovation. Likewise, more smallholder dairy innovation platform participants (62.5%) adopted the use of silage and/or hay as a supplementary feed during the dry season, relied on pure breeds as their main stock type (66.7%), and had more regular contact with extension and advisory services (79.2%). Several factors explain this. The core issues, however, hinge on participants' greater interaction with innovation platform stakeholders, stronger linkage mechanisms, more immense interdependency and coordination, and the sharing of experiences and exchange of information amongst IP participants.

5.3.4 Knowledge, Attitudes and Practices (KAP)

Knowledge, Attitudes and Practices (KAP) surveys are predominantly conducted to collect information on what is known, believed and done *vis à vis* specific issues (Wood and Tsu, 2008). KAP surveys are thus designed to identify what people know or their knowhow (Knowledge), how they feel or their perceptions (Attitudes), and what they do in reality or compliance (Practices), hence their use in diagnostic studies and in gathering valuable insights for designing appropriate interventions (Kaliyaperumal, 2004). In this paper, a KAP survey was conducted not just for comparing the socio-economic differences between innovation platform participants and non-participants, but also for evaluating the effectiveness of smallholder dairy innovation platforms.

In determining KAP scores, knowledge question responses were scored 1 for a “yes” and 0 for a “no”. Attitudes were measured on a Likert 5 type scale, with strongly agree, agree, neutral, disagree, and strongly disagree being scored 2, 1, 0, -1 and -2, respectively. A Likert type scale was also used on practices, with the responses (never, rarely, sometimes, frequently, and always) being scored 0, 1, 2, 3 and 4, respectively. The KAP scores were tested for normality of distribution using one-sample Kolmogorov-Smirnov test. On the other hand, median/mean KAP scores were compared among different farmer segments, i.e. IP participants and non-participants, using the Mann–Whitney. A p-value less than 0.1 is taken as statistically significant. The results are presented in Table 5.4.

Table 5.4: Knowledge, attitudes and practices (KAP) scores among innovation platform participants and non-participants

Variable	Range (Minimum and Maximum Values)	IP Participants	Non-Participants	Significance Level
Knowledge				
Business orientation *(6 questions)*	0 - 6	5.92	5.50	0.001[a]
Housing, infrastructure and equipment *(7 questions)*	0 - 8	7.40	6.86	0.001[a]
Identification and herd management *(4 questions)*	0 - 4	3.81	3.61	0.036[b]
Breed improvement *(4 questions)*	0 - 4	3.89	3.58	0.004[a]
Fodder production, feeding and feed management *(7)*	0 - 7	6.73	6.07	0.000[a]
Animal health *(6 questions)*	0 - 6	5.89	5.80	0.171
Business ethics and social influences *(3 questions)*	0 - 3	2.71	2.56	0.077[c]
Attitudes				
Business orientation *(6 questions)*	-12 - 12	8.20	7.25	0.026[b]
Housing, infrastructure and equipment *(7 questions)*	-14 - 14	10.09	8.66	0.004[a]
Identification and herd management *(4 questions)*	-8 - 8	4.34	3.88	0.036[b]
Breed improvement *(4 questions)*	-8 - 8	5.49	4.97	0.079[c]
Fodder production, feeding and feed management *(7)*	-14 - 14	9.08	7.94	0.020[b]
Animal health *(6 questions)*	-12 - 12	8.40	8.06	0.356
Business ethics and social influences *(3 questions)*	-6 - 6	3.57	3.30	0.238

Variable	Range (Minimum and Maximum Values)	IP Participants	Non-Participants	Significance Level
Practices				
Business orientation *(6 questions)*	0 - 24	17.55	14.23	0.000 [a]
Housing, infrastructure and equipment *(7 questions)*	0 - 28	21.57	15.22	0.000 [a]
Identification and herd management *(4 questions)*	0 - 7	3.94	2.93	0.000 [a]
Breed improvement *(4 questions)*	0 - 16	11.30	8.42	0.000 [a]
Fodder production, feeding and feed management *(7)*	0 - 28	16.89	12.93	0.000 [a]
Animal health *(6 questions)*	0 - 21	14.65	13.42	0.060 [c]
Business ethics and social influences *(3 questions)*	0 - 12	5.96	5.07	0.020 [b]

Remarks: a, b and c significant at $\alpha = 0.01$, $\alpha = 0.05$ and $\alpha = 0.10$

Differences in the level of knowledge between IP participants and non-participants were statistically significant for knowledge on business orientation; housing, infrastructure and equipment; breed improvement; and fodder production, feeding and feed management ($p < 0.01$); identification and herd management ($p < 0.05$); and business ethics and social influences ($p < 0.1$). A divergence of attitudes was adjudicated as statistically significant for housing, infrastructure and equipment ($p < 0.01$); business orientation; identification and herd management; fodder production, feeding and feed management ($p < 0.05$); and breed improvement ($p < 0.1$).

Statistically significant differences were also established in the adoption of practices for business orientation; housing, infrastructure and equipment; identification and herd management; breed improvement; fodder production, feeding and feed management ($p < 0.01$); business ethics and social influences ($p < 0.05$); and animal health ($p < 0.1$). The overall KAP score was 161.05 for smallholder dairy innovation platform participants and 132.64 for non-participants, with the difference again determined as being statistically significant ($p < 0.01$). Non-parametric tests at 0.05 confidence level also confirmed that KAP distributions between IP participants and non-participants are not the same, entailing that KAP results are influenced by one's participation in smallholder dairy IPs.

Differential access to support services such as training, capacity building initiatives and extension contact between the two farmer segments explains these results. In addition, contrary to literature that portray knowledge, attitudes and practices as part of an innovation adoption continuum (Röling, 1988; Bolding et al., 2003), results from the study also show that innovation platforms had greater influence on improving the adoption of practices than the influence they had on improving cognitive skills (knowledge) and attitudes.

5.3.5 Household food and nutrition security

Household food and nutrition security were assessed on the basis of three parameters *viz:* (i) Months of Adequate Household Food Provisioning (MAHFP), (ii) Food Consumption Score (FCS), and (iii) Household Dietary Diversity Score (HDDS). The MAHFP captures the combined effects of a range of interventions such as improved production, storage and increased household purchasing power (Bilinsky and Swindale, 2010). The FCS is a food consumption indicator that is used as a proxy for its reflection of the quality of diets and is, therefore, used as a proxy indicator for nutrition (Njuki et al., 2011). Food consumption indicators are designed to reflect the quantity and quality of people's diet. The FCS is a measure of dietary diversity, food frequency and the relative nutritional importance of the food consumed. Using a 7-day recall period, information was collected on the variety and frequency of different foods and food groups consumed to calculate a weighted score and, based on this score, classify households as having poor, borderline or acceptable consumption.

On the other hand, the HDDS is a proxy indicator for food security and a measure of household food access. It is defined as the number of unique food types consumed over a 24 hour period. The HDDS serves as a good complement to the FCS, as it provides a fuller picture of households' diets (Njuki et al., 2011). Differences between the FCS and HDDS measures were statistically significant ($p < 0.01$), while differences between IP participants and non-participants for MAHFP were statistically significant ($p < 0.05$) (See Table 5.5).

Table 5.5:*Differences between MAHFP, FCS and HDDS measures among innovation platform participants and non-participants*

Variable	**IP Participants**	**Non-Participants**	**Significance of t-value**
MAHFP	11.21 ± 1.56	10.67 ± 2.12	0.028[b]
FCS	76.50 ± 21.37	65.63 ± 19.12	0.000[a]
HDDS	9.33 ± 1.67	8.41 ± 1.97	0.000[a]

Remarks: a, b and c significant at α = 0.01, α = 0.05 and α = 0.10

In general, results from the study show that smallholder dairy innovation platform participants were food secure over a longer period of time, in addition to better nutrition security.

Independent samples tests conducted for MAHFP, FCS and HDDS by district also showed that there was no impact of location, which further buttresses the findings of this study.

5.4 Discussion

Survey results revealed highly significant differences between smallholder dairy innovation platform participants and non-participants based on their experiences in commercial dairying, the agricultural training received, household size, availability and access to labour, the main source of household income, dairy herd sizes, and the number of lactating cows. The rest of the explored socio-economic variables, including gender, age, education, farm size and the distance from the market were statistically insignificant. The results corroborate results from other studies, and yet produced some results that diverged from the findings of mainstream literature. The results present new insights and a new discourse as discussed below.

Tadesse et al. (2016) identified household size, the number of cross breed and local breed lactating cows, access to credit, and the distance from the market as the significant factors affecting dairy farmers' participation in milk markets in southwest Ethiopia. In Ethiopia, Kuma et al. (2013, 2014) identified the age of the household head, dairy farming experience, milk yield per day, milking cow ownership, and the size of the landholding as significant factors in determining milk market participation. In Uganda, gender, age, education, distance to the market, ownership of transport, and communication facilities ($P < 0.01$) had highly positive and significant impact on smallholder dairy farmers' decisions to participate in milk markets (Balirwa et al., 2016).

Whilst no studies have focused on socio-economic differences between smallholder dairy innovation platform participants and non-participants, a number of studies focused on innovation platforms of other agricultural commodities. In an assessment of the factors determining cocoa farmers' participation in innovation platform activities in Nigeria, Akinmusola et al. (2016) identified farmer experience and education as key determinants. Based on a survey of smallholder rice farmers in Northern Ghana, the age of the household head, household size, and household income significantly influenced the willingness to participate in multi-stakeholder innovation platforms (Martey et al., 2014).

Boughton et al. (2007) argue that markets can only stimulate wealth creation amongst those with the capacity to participate given production constraints and the costs of market participation. Using an asset-based approach to analyse the level of market participation for rural households in Mozambique, the authors established that poorer households have limited capacity to participate effectively and hence need interventions to build up either their private stocks of productive assets, or the public goods that support agricultural production and marketing. Njuki and Sanginga (2013), using insights from Kenya, Tanzania and Mozambique, established that women tended to face more challenges when compared to their male counterparts in accessing and benefiting from markets, notably formal markets. Identified challenges included, *inter alia*, limited mobility; time poverty; lack of access to assets that would facilitate their participation; and lack of access to market information. These insights support results from this study which show significant association between participation in innovation platforms and asset ownership, entailing that participants in smallholder dairy innovation platforms have more assets in general than non-participants.

Predominant dairy management systems for innovation platform participants entail a higher level of intensification (including the adoption of zero grazing), the use of silage and/or hay as supplementary feeds during the dry season, adoption of pure dairy breed and crosses, as well as greater extension contact. A number of past studies confirm these findings. Dantas et al. (2016) used cluster analysis in identifying four different segments of dairy producers in Brazil, in a context where farmer education and management levels, influenced the rate of technology and innovation adoption. In Algeria, Kaouche-Adjlane et al. (2015) characterised breeding dairy cattle systems into different groups of farms based on their structure and management systems. In Morocco, feeding strategies and economic efficiency were used to classify dairy cattle farming systems into different farm segments (Srairi and Kiade, 2005). In Kenya, Mburu et al. (2007), used cluster and discriminant analysis in categorising smallholder dairy farms into different innovation domains based on risk management strategies, level of household resources, technology adoption, dairy intensification, and their access to services and markets.

In Kenyan avocado innovation platforms, Gyau et al. (2016) established that age, education, gender, perceptions on knowledge and improved technology influence farmers' decision to participate in collective action. In a study in Africa's Great Lakes Region, Mulema and Mazur (2016) established that active participation in innovation platforms is sustained by the desire to access new knowledge and skills, anticipated economic benefits (markets, income, and credit) and material incentives (agricultural inputs), while participation was restrained by a cocktail of factors that included unfulfilled expectations of tangible immediate benefits, a lack of understanding of the IP concept, lack of resources, and prior commitments. The results from these studies thus, to a large extent, support the paper's findings that show statistically significant differences in the level of knowledge, attitudes and practices between IP participants and non-participants.

The household food and nutrition security results in this paper are comparable to, but better than, national statistical assessments, with a range of 58 – 76.1% of households at national level being food secure between 2013 – 2016, a proportion of 54 – 68% of households having acceptable diets between 2011 – 2016, and an HDDS score of between 5 – 7 for the last five years (ZimVAC, 2014; 2016). Smallholder farmers' engagement in markets is acknowledged as being important for improved household food security and poverty reduction (FAO, 2017). A socio-economic evaluation of farm households in Cambodia, using the endogenous switching model, also yielded insights that showed that farm households participating in markets enjoyed higher household dietary diversity scores, thus supporting the hypothesis that participation in markets results in positive effects on farm households' food security (Seng, 2016). A study of smallholder agricultural households in Papua New Guinea also established a highly significant association between the level of food and nutrition security, on one hand, and market participation, on the other (Wickramasinghe et al., 2014).

Insights generated by this study have critical implications for smallholder dairy research and advisory services. These key support services should be designed to provide training, capacity building, technical support services, enhancing commercial dairying experience and growing the dairy herds for smallholder dairy farmers. There is also need for greater targeting of dairy innovations in pursuance of specific innovation domains that are defined by characteristics beyond the conventional demographic factors, to encompass other non-conventional socio-economic aspects such as asset endowment, dairy management systems, KAP levels, as well as household food and nutrition security.

5.5 Conclusions

There are highly significant socio-economic differences between participants and non-participants in smallholder dairy innovation platforms, entailing that socio-economic factors influence smallholder dairy farmers' participation in innovation platforms.

Statistically significant factors include smallholder producers' experiences in commercial dairying, the agricultural training received, household size, availability and access to labour, the main source of household income, dairy herd sizes, and the number of lactating cows.

In addition to conventional demographic factors and farm characteristics, unconventional socio-economic factors analyses such as dairy management systems; knowledge, attitudes and practices; as well as household food and nutrition security can also be used as parameters to distinguish between innovation platform participants and non-participants.

There is need for the crafting of appropriate policies and the implementation of relevant interventions that can be effective in enhancing technology development, dissemination of innovations, and market participation by smallholder dairy farmers. On the ground, there is need for more target specific training, capacity building, dissemination of innovations, etc that take due consideration of the specific attributes of the groups of participants and non-participants in smallholder dairy innovation platforms. These also need to be contextualized to the geophysical conditions, infrastructure and micro-economic environments in both Rusitu and Gokwe project sites, with similar considerations being recommended for other smallholder dairy production sites.

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CHAPTER 6 : THE EFFECTIVENESS OF INNOVATION PLATFORMS IN ENHANCING PRODUCTIVITY AND VIABILITY: THE CASE OF SMALLHOLDER DAIRYING IN RUSITU AND GOKWE, ZIMBABWE[8]

Abstract

Current literature is saturated with analysis of simulated and transitory innovation platforms. This study sought to assess the effectiveness of organically established innovation platforms within the context of smallholder dairying in Zimbabwe. Specifically, the study sought to determine the impact of participation in innovation platforms on smallholder dairy productivity and viability. This study was guided by the Innovation Platforms paradigm. A total of 227 households were interviewed for the cross-sectional survey. Data were analyzed using the Propensity Score Matching (PSM) and Nearest Neighbour Matching (NNM) methods. Survey results show that the participation in innovation platforms had a positively significant impact on average milk productivity as implied by the ATT of 19.65 ($p < 0.01$), gross income with an ATT of 1512.13 ($p < 0.01$), and improved household nutrition with an ATT of 0.135 ($p < 0.1$). These findings buttress the need for the development and sustenance of private sector driven advisory services and pluralistic dairy extension systems, which support and enhance innovation platforms. The study also provides valuable insights for advancing the theories and practice of innovation platforms.

Keywords

Average treatment effect; innovation platforms; milk productivity; propensity score matching; smallholder dairying; viability of dairy enterprise; Zimbabwe

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[8] This chapter has been submitted and is under review at the *Journal of Agricultural Education and Extension*.

6.1 Background

6.1.1 Preamble

Africa experienced robust economic growth over the past two decades but the continent continues to grapple with an exponentially growing population, climate change, environmental degradation, recurrent droughts, increasing food insecurity, and poverty (World Bank, 2016). Population densities within smallholder farming areas are persistently increasing while the land and other resources available for the expansion of agriculture are becoming scarce (SADC, 2010). On the other hand, climate change threatens the attainment of sustainable food security, household incomes and the livelihoods of the bulk of smallholder farmers eking out a living in marginal environments (FAO, 2010). Additionally, insecurity of tenure, low levels of mechanization, shortages of inputs, lack of capital and labour bottlenecks (particularly in resource-poor and female-headed households) often limit farmers' propensity and ability to expand their scale of production (Cavatassi et al., 2009). Thirtle et al. (2003) have also shown that a 1 percent increase in agricultural yields in low-income countries leads to a 0.8 percent reduction in the number of people below the poverty line. Thus, sustainable increases in agricultural productivity and viability, through technological and managerial innovation, continue to be crucial means to achieve both food security and poverty reduction can be achieved.

Innovation platforms, and other variants of multi-stakeholder platforms, are recent approaches implemented for improving agricultural productivity and viability through agricultural innovations (Boogaard et al., 2013; Bill & Melinda Gates Foundation, 2013; Dusengemangu et al., 2014). Innovation platforms are by definition institutional arrangements designed to facilitate multi-stakeholder collaboration, learning, technology development, the dissemination of innovations, policy dialogue and priority setting (Nederlof et al., 2011; Adekunle and Fatunbi, 2012; Makini et al., 2013). See also the IPs definition on page 31 (sub-Section 3.1.5). A number of studies have already shown that in principle, innovation platforms enhance the adoption rate of improved agricultural innovations (Mbulwe, 2015; Duncan et al., 2015; Weyori et al., 2017; Hanyani-Mlambo et al., 2017a; Hanyani-Mlambo et al., 2017b). Other studies have also provided evidence of the impact of the adoption of agricultural innovations on agricultural productivity and viability (Hall et al., 2001; Hall et al., 2003; Nkala, Mango & Zikhali 2011; Makate et al., 2017).

However, in practice, these platforms are rarely monitored, assessed and/or evaluated (Badibanga, Ragasa & Ulimwenga, 2013). Only a few attempts have been made to test the effectiveness of innovation platforms as an approach or framework (Catavassi et al., 2009; Badibanga et al., 2013; Davies et al., 2017). Past studies, as highlighted below, have also fallen short resulting in glaring knowledge and conceptual gaps. Current literature is also saturated with analysis of simulated and transitory innovation platforms, the bulk of which are initiated and propped by the Consultative Group on International Agricultural Research (CGIAR), whose sustainability remains questionable (Nederlof et al., 2011; Boogaard et al., 2013; Bill & Melinda Gates Foundation, 2013). This scenario provided rationale for a study that focused on assessing the effectiveness of organically developed innovation platforms within the context of smallholder dairying in Zimbabwe.

6.1.2 Smallholder dairying in Zimbabwe

Smallholder dairy development has for a long time been viewed as an instrument of rural poverty reduction by focusing resources on strategies for generating rural jobs through diversifying into labour-intensive, high-value agricultural production linked to a dynamic rural, non-farm sector (World Bank, 2008).

In Zimbabwe, the Government launched the Dairy Development Programme (DDP) in 1982, with the objective of using smallholder dairying, through enhanced milk production and marketing, as a tool for socio-economic development (Marecha, 2009). Currently, the programme has 21 milk collection centres in five of the country's eight rural provinces. However, past studies have highlighted challenges emanating from low herd sizes, low farm level productivity, declining economic efficiency in larger herds, and viability challenges in the Zimbabwean smallholder dairying sector (Hanyani-Mlambo et al., 1998; Chinogaramombe et al., 2008; Chamboko and Mwakiwa, 2016).

Despite the challenges, the smallholder dairy subsector in Zimbabwe still has great potential. Livestock, in general, contributes about 40% of global agricultural Gross Domestic Product (GDP) and 30% of agricultural GDP in developing countries (Gebremedhin and Hoekstra, 2010). In Zimbabwe, livestock production systems contribute directly to food and nutrition security, income growth and poverty reduction at micro- and macro-economy levels (Kagoro and Chatiza, 2012). Smallholder dairying in Zimbabwe also presents the greatest opportunities for unlocking value, generating the highest and quickest returns to investment due to the diversity of dairy products and the higher margins that can be gained from niche markets (SNV[9], 2013).

6.1.3 Conceptual and theoretical framework

Innovation platforms are conceptualized as physical, virtual, or physico-virtual networks of stakeholders set up around a commodity or system of mutual interest to foster collaboration, partnership and mutual focus to generate innovation on the commodity or system (Adekunle and Fatunbi, 2012). They are fora for entities that share a common interest and come together to solve problems and develop mutually beneficial solutions (Makini et al., 2013). A key element of innovation platforms is their capacity to identify bottlenecks and opportunities in production, marketing and the policy environment, and to leverage innovation to address the identified constraints and take advantage of opportunities across the entire impact pathway (Nederlof et al. 2011; Bill & Melinda Gates Foundation, 2013).

This study was guided by the Innovation Platforms paradigm. Ideas on innovation platforms are firmly rooted in theories of Systems Thinking (Röling, 1988) and Innovation Systems (Hall et al., 2003; Dantas, 2005; Clark, 2006). Innovation platforms are thus also conceptualized as a multi-sectoral and multi-institutional coalition of actors in specific value chain systems, which act as mechanisms for encouraging, developing, and/or disseminating innovations to users (Nederlof et al., 2011; Makini et al., 2013). The innovation platform facilitates dialogue between the main players in the value chain *viz*: farmers, input suppliers, traders, transporters, processors, wholesalers, retailers, regulators, and the research and development fraternity. This makes innovation platforms participatory approaches for problem solving and knowledge creation. See Figure 6.1.

[9]Netherlands Development Organization (SNV).

In assessing the effectiveness of innovation platforms in smallholder dairying, this paper hinges analysis on an adapted innovation platforms framework (Hanyani-Mlambo et al., 2017a). The framework consists of five major components *viz*: the necessary conditions (drivers) for effective innovation platforms, innovation platform processes including farmer segmentation and stakeholder participation, innovation platforms, parameters measuring the effectiveness of innovation platforms, and strategic impacts (improved technology adoption, increased productivity and improved enterprise viability). See Figure 6.2.

Three concepts also guided this study *viz:* productivity, viability, and effectiveness. Productivity is the measure of how specified resources are managed to accomplish timely objectives as stated in terms of quantity and quality[10]. Productivity may also be defined as an index that measures output (goods and services) relative to the input (labour, materials, energy, etc., used to produce the output). Within the context of this paper, productivity will be analyzed largely on the basis of milk yields. Viability, which is measured on the basis of an enterprise or system's gross margin, refers to the ability of a business, product, or service to compete at a commercial level. In turn, a gross margin is defined as a return to fixed factors of production which gives a good indication of profitability and is calculated as the difference between the total value of the harvested product and the total variable costs incurred during the production process (Cavatassi et al., 2009). On the other hand, effectiveness, *inter alia*, addresses issues on the extent to which intervention implementation has been achieved against planned targets, the quality of outputs, and how well the partnerships worked (UNDP, 2002).

[10]http://www.referenceforbusiness.com/management/Pr-Sa/Productivity-Concepts-and-Measures.html#ixzz3PG5gbWme

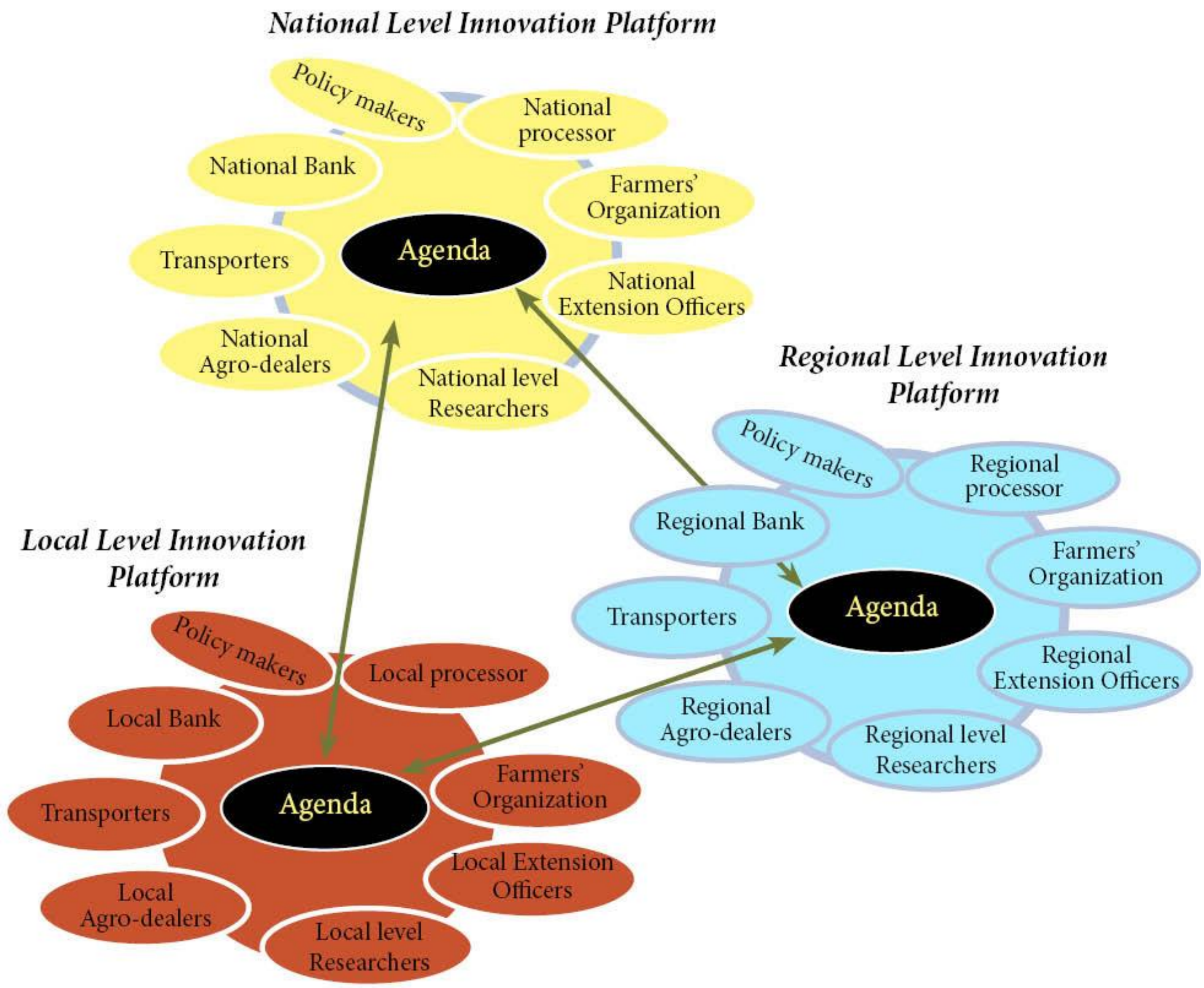

Figure 6.1: *Multi-level Innovation Platforms. Adapted from Makini et al. (2013)*

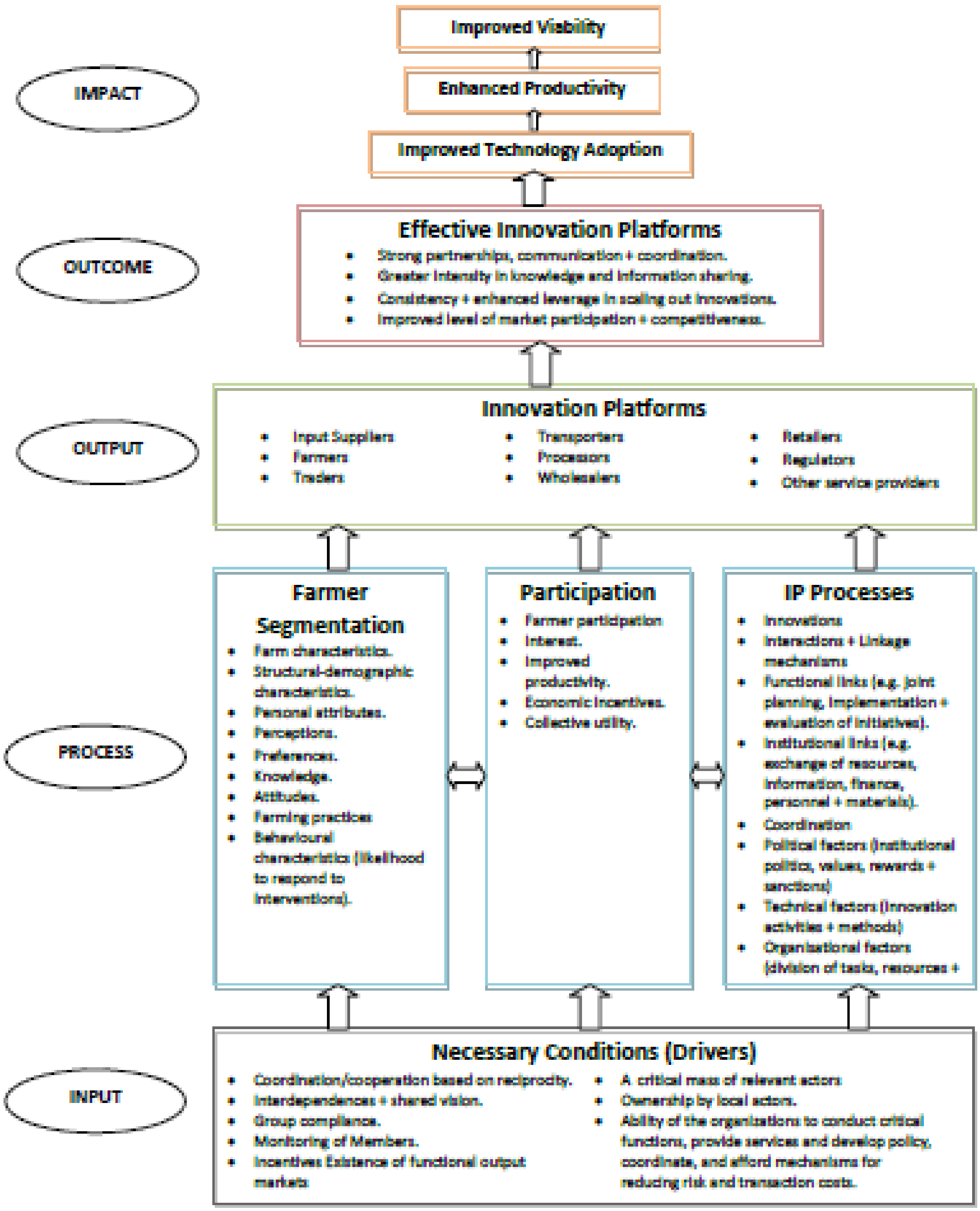

Figure 6.2: *Framework for assessing the effectiveness of innovation platforms (Hanyani-Mlambo et al., 2017a)*

6.1.4 Smallholder dairy productivity and viability

Survey results across a number of countries in Africa show that milk production levels are lower than expected from the dairy animals' genetic potential. In Ethiopia, survey results showed the average milk yields being 1.57 litters and 6.7 litters for local and crossbreed cows respectively (Chelkeba et al., 2016; Wodajo and Ponnusamy, 2016). In a different geographical zone, a value chain analysis of the dairy subsector in Zambia estimated the productivity yields of various breeds as follows *viz:* a potential yield of 18 – 25 litres per cow per day against an actual yield of 15 – 18 litres per cow per day for Friesian pure breeds, 10 – 15 litres *versus* 10 – 12 litres for Jersey pure breeds, 8 – 10 litres *versus* 7- 10 litres for crossbreds, and 3 – 4 litres *versus* 1 – 1.5 litres for indigenous cattle (Pandey, 2007; Pandey et al., 2007).

Economic viability assessments on smallholder dairying for resource-poor farmers in West Africa revealed enterprise gross margins of USD911 in The Gambia, USD203 in Guinea Bissau, and USD42 in Guinea (Somda et al., 2004). In East Africa, a study based on three levels of intensification, showed that acclimatized stock of exotic dairy breeds that are stall-fed gave the highest gross margin per litre, although their input costs were also the highest, while farmers who adopted improved technology generally got higher yields and profit margins (Orodho, 2006).

6.1.5 The effectiveness of innovation platforms

Assessments and evidence of the effectiveness of innovation platforms have been anecdotal and largely qualitative. An assessment of multi-stakeholder platforms in the agricultural sector of the Democratic Republic of the Congo (DRC), established that effectiveness was low, with only 51 percent of the surveyed agricultural and rural management councils achieving results in line with at least one of the main goals while 45 percent failed to achieve any tangible output (Badibanga, Ragasa & Ulimwenga 2013). Swaans et al. (2014) identified the importance of flexible planning processes, social organization, representation, incentives and reflective learning as key factors determining the effectiveness of innovation platforms.

In a detailed assessment of multi-stakeholder potato innovation platforms in Ecuador, the study adopted the use of a standard OLS with multiple controls, propensity score matching, and an intermediate approach of weighted least squares. The results showed higher yields and returns for platform beneficiaries, with the group of platform beneficiaries on average obtaining statistically significantly higher yields of 8.4mt per hectare against an average of 6.3mt per hectare for counterfactual groups (Cavatassi et al., 2009). The highest gross margins for platform beneficiaries were USD259/ha compared to the lowest gross margins of USD18/ha for non-beneficiaries (Cavatassi et al., 2009). Knowledge and conceptual gaps still exist in this area of study.

6.1.6 Purpose and objectives

This study sought to assess the effectiveness of innovation platforms within the context of smallholder dairying in Zimbabwe. The specific contributions of this paper are the provision of insights based on:- (i) an estimation of the impact of participation in innovation platforms on smallholder dairy productivity, and (ii) an approximation of the impact of adoption of innovation platforms on smallholder dairy viability.

6.2 Methodology

6.2.1 The study sites

The study was conducted in Rusitu and Gokwe smallholder dairy schemes in Zimbabwe, as a cross-sectional survey in 2015. Rusitu Dairy Resettlement Scheme is located about 440 kilometres south-east of Harare in Manicaland Province and falls within latitude 20^0 02’ S and longitude 33^0 48’ E. The scheme is located in agro-ecological region I, characterized by high rainfall, low temperatures, well-drained soils and provides a perfect environment for dairying (SNV, 2013). The Gokwe Smallholder Dairy Scheme, on the other hand, is located 338 kilometres west of Harare in the Midlands Province and falls within latitude 18^0 13’ S and longitude 28^0 56’ E. The scheme is located in agro-ecological regions III and IV characterized by low rainfall, fairly severe mid-season dry spells and is, therefore, marginal for dairying (SNV, 2013). See Figure 6.3.

However, despite the contextual contrasts, smallholder dairying remains the major source of income in both communities. The two study sites are also largely representative of smallholder dairy projects in Zimbabwe.

6.2.2 Sampling procedure and sample size

The unit of sampling used in this study was the household. As such, multistage sampling, a complex form of cluster sampling, was adopted to guide sampling for the household questionnaire survey. Rusitu and Gokwe were purposively selected as the two research sites given their contrasting characteristics and representativeness of the generality of smallholder dairy schemes in Zimbabwe. At the second stage, smallholder dairy farmers in both Rusitu and Gokwe were stratified on the basis of their level of participation in dairy innovation platforms. The household was then used as the unit of sampling during the third and final stage of sampling. At this stage and within the strata, a probability sampling method was used as the basis for selecting households included in the survey. A total of 227 households were sampled for the study. Of these, 100 households (44.1%) actively participated in smallholder dairy innovation platforms, while the remaining 127 households (55.9%) were not.

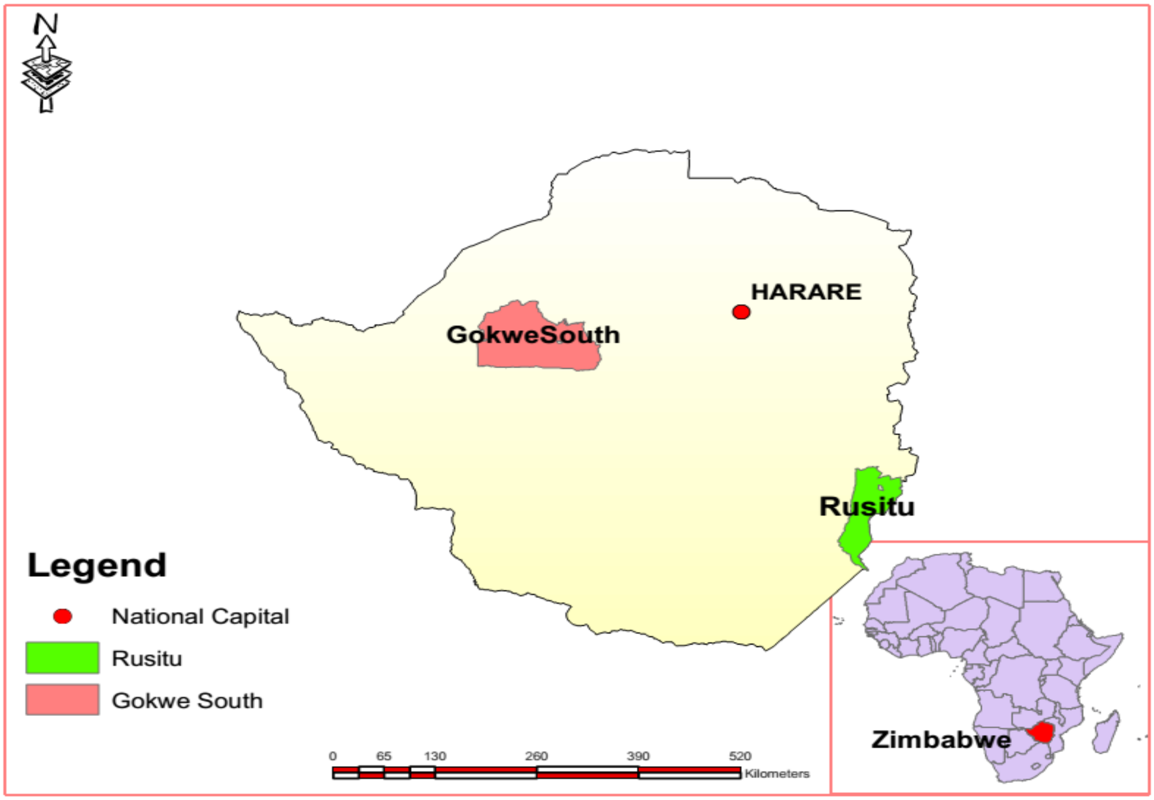

Figure 6.3: *Map of Zimbabwe showing the location of the study sites*

6.2.3 Collection of field data

Field data collection adopted the use of both quantitative and qualitative data collection methods as a way of improving analytical rigour. The fieldwork also followed a phased approach and the concurrent use of literature reviews, key informant interviews, focus group discussions, and a structured household questionnaire survey. The use of numerous data collection methods was deliberate as a way of triangulating collected data for purposes of verification, validation and improving the reliability of collected data (Babbie et al., 2001; Wagner et al., 2012). A formal survey using a structured household questionnaire was used to collect data on household demographics, participation in innovation platforms, farm amenities and conditions, asset ownership, livestock numbers and dynamics, dairy production and marketing, dairy costs and returns, crop production, household food security, livelihood-based coping strategies, as well as access to livestock technology, inputs and support services. The data collection instruments were pre-tested to ensure that the study generates accurate, consistent, dependable and reliable data.

6.2.4 Analytical framework

In assessing the effectiveness of innovation platforms, the study was designed in such a way that the empirical model sought to estimate the impact of adopting smallholder dairy innovation platforms on productivity (as measured by selected variables) and viability (income, variable cost and gross margin). The objective was to approximate the Average Treatment Effect on the Treated (ATT). Given the option to adopt (participate in the smallholder dairy innovation platform) or not to adopt, one can randomly assign individuals to either treatment (adopters of innovation platforms) or control (non-adopters) groups to successfully estimate the ATT as is usually the case in observational studies. Nevertheless, because this study relies on cross-sectional survey data rather than experimental data, assignment into treatment is not randomly distributed. According to Smith and Todd (2005), this implies that the outcomes for adopters and non-adopters might be systematically different. The risk is that the observed differences between the two groups in the absence of randomization might be mistaken for the impacts of innovation platforms (Mapila et al., 2012; Akinola and Sofoluwe, 2012).

The Propensity Score Matching (PSM) method was chosen to estimate the Average Treatment Effect on the Treated (ATT) to deal with the potential self-selection bias highlighted above. Desk reviews show the ATT as a better indicator for measuring the appropriateness of intervention strategies on smaller groups of interest such as smallholder farmers than the population-wide average treatment effects calculated via probit models (Rosenbaum and Rubin, 1983, 1985; Heckman, 1996; Rosenbaum, 2002). A number of researchers have used PSM to control for self-selection bias (Faltermeier and Abdulai, 2009; Akinola and Sofoluwe, 2012; Amare et al., 2012; Mapila et al., 2012; Matchaya and Perotin, 2013). Fundamentally, the PSM technique assumes that each surveyed farmer/household belongs to either the group of innovation platform adopters (treatment) or group of non- adopters (control) but not both. Based on insights from Heckman et al. (1997), let Y_1 denote productivity or viability outcome of a farmer i after adopting innovation platform (T = 1) and Y_0 denoting the productivity or viability outcome of the same farmer when they do not adopt innovation platform (T = 0). The observed productivity or viability outcome Y can thus be calculated as follows:

$$Y = TY_1 + (1–T)Y_0 \qquad (1)$$

where Y1 is the productivity or viability outcome of farmer i when they adopt innovation platform (T = 1); Y_0 is farmer i's productivity or viability outcome when they do not adopt innovation platform (T = 0). The average treatment effect on the treated (ATT) can be calculated as follows:

$$ATT = E(Y_1 - Y_0|T = 1) = E(Y_1|T = 1) - E(Y_0|T = 1) \qquad (2)$$

In equation (2) above, the only observable productivity or viability outcome is for those farmers who adopted innovation platform $E(Y_1 \mid T = 1)$ and not the productivity or viability outcome of non-adopting farmers $E(Y_0 \mid T = 1)$. The idea, as already highlighted earlier, is to match innovation platform adopting farmers to non-adopting farmers using PSM. It is also worthwhile to note that vital for PSM is the conditional independence assumption which assumes random participation conditional on observed covariates (Wooldridge, 2002). Assuming that the conditional independence assumption is satisfied, the ATT can then be specified as follows:

$$ATT = E(Y_1 - Y_0|X, T = 1) = E(Y_1, |X, T = 1) - E(Y_0|X, T = 1) \qquad (3)$$

However, the researchers also took note of latent challenges given that matching the innovation platform adopting farmers to non-adopting farmers based on the observed covariates X might potentially result in the nuisance of the dimensionality problem, particularly in cases of a large number of covariates (Rosenbaum and Rubin, 1983). The researchers, therefore, chose to match the treatment group participants to the control group based on the propensity score p(X) and not on the observed covariates. In this circumstance, the propensity score is defined as the conditional possibility that farmer i adopts innovation platforms and is expressed as follows:

$$p(X) ;prob(T = 1|X) = E(T|X) \qquad (4)$$

where T = {0, 1} is the binary indicator representing the treatment group. A significant condition that has to be adhered to in PSM is the balancing property, expressed as $T \;\; X|p(X)$. According to Lee (2011), the conditional distribution of X, given the propensity score p(X) is the same in the comparative groups, in this case the innovation platform adopting and non-adopting groups.

Considering the propensity score and the conditional independence assumption, the ATT specified in equation (2) above can thus be rewritten as follows:

$$ATT = E(Y_1 - Y_0|p(X), T = 1) = E(Y_1, |p(X), T = 1) - E(Y_0|p(X), T = 1) \qquad (5)$$

where $E(Y_1, |p(X), T = 1)$ measures the observable productivity or viability outcome of the treated farmers (innovation platform adopters) and the second term $E(Y_0 \mid p(X), T = 1)$ measures the productivity or viability outcome of the same farmers had they failed to adopt the innovations i.e. the counterfactual.

The PSM method is a two-step process that involves estimating a probit or logit regression on the first step to calculate the probability p(X) that farmer i is in the innovation platform adopting group conditional on observed covariates as given in equation (4) above. The covariates vector X includes all the variables associated with innovation platform adoption. Once the propensity score in equation (4) above has been calculated, the second step involves matching innovation platform and non-innovation platform farmers based on the similarities or closeness of the propensity scores. To achieve this, the nearest neighbour matching technique, an algorithm that matches each innovation platform farmer to a non-innovation platform farmer on the basis of closely similar propensity scores (Becker and Ichino, 2002) was used to estimate the effect of innovation platforms on the selected farmer productivity or viability outcomes.

To ensure a maximum covariate balance and a low conditional bias, a one-to-one matching with replacement was used based on insights from Abadie and Imbens (2006). The kernel matching algorithm was also used to calculate the ATT, as a robustness check of our results. This algorithm involves matching all the innovation platform farmers with a weighted average of all the non-innovation platform farmers using weights that are inversely proportional to the distance between the two groups' propensity scores (Becker and Ichino, 2002).

6.3 Results and Discussion

6.3.1 Descriptive statistics

An analysis of survey results, based on mean differences between innovation platform adopters and non-adopters, indicated statistically significant differences for all variables except for access to community/farmer-led extension services and access to market information. The t-test results show statistically significant differences for dairy herd size, the number of lactating cows, training received, access to Milk Collection Centre (MCC) services, access to finance/credit, access to input markets for dairy feeds, access to improved breeding technology, access to product markets, average milk production output per day during the wet season, average milk production output per day during the dry season, dairy gross income and total variable costs ($p < 0.01$). Other variables such as access to veterinary/animal health care services and access to public extension services were significant at 5%, while enterprise net profit was significant at 10%. See Table 6.1.

Table 6.1: *Comparison of descriptive statistics among innovation platform adopters and non-adopters*

Variable	Description and Measurement	Innovation Platform Adopter (M)	Non-Adopter (M)	t-test significance level	Combined (M)
Dairy herd size	Dairy herd size	6.61	2.49	0.0000***	4.30
Lactating cows	Total number of lactating cows	2.29	.72	0.0000***	1.42
Training	=1: some training received; 0=otherwise	.67	.39	0.0000***	.52
Milk Collection Centre (MCC)	=1: have access to MCC services; 0 otherwise	1	.88	0.0003***	.93
Credit	=1: have access to finance/ credit; 0 =otherwise	.86	.70	0.0045***	.77
Market access (feeds)	=1: have access to input markets (dairy feeds); 0=otherwise	.96	.77	0.0001***	.85
Animal health care	=1; have access to veterinary/animal health care services; 0=otherwise	.98	.91	0.0321**	.94
Breeding technology	=1; have access to improved breeding technology; 0=otherwise	.99	.79	0.0000***	.88
Public extension	=1; have access to govt/public extension services; 0 =otherwise	.99	.94	0.0424**	.96
Community/farmer-led extension	=1; have access to community/farmer-led extension services; 0=otherwise	.98	.94	0.1181	.96
Market information	=1; have access to market information; 0=otherwise	.88	.81	0.1592	.84
Product markets	=1; have access to product markets; 0=otherwise	.93	.80	0.0063***	.86
Milk productivity (wet season)	Average milk production output per day (total for dairy herd) in litres during wet season	24.70	7.21	0.0000***	14.92
Milk productivity (dry season)	Average milk production output per day (total for dairy herd) in litres during dry season	16.56	4.42	0.0000***	9.74
Gross income	Gross income in USD from dairy enterprise	4847.40	1026.94	0.0099***	2724.92
TVC	Total variable costs in USD	1907.35	722.83	0.0000***	1245.72
Net Profit	Gross income-TVC (USD)	2906.23	308.65	0.0888*	1465.75

Notes: ***Significant at 1% level; **significant at 5% level; *significant at 10% level.
M = mean

Innovation platform adopters tend to have a greater access to resources (finance/input credit, feeds, veterinary drugs, improved breeding stock, etc.), support services (training, capacity building initiatives, research outputs, dairy advisory services and markets), and greater interaction with other innovation platform actors (other farmers, researchers, extension agents, traders, processors, wholesalers, retailers, transporters, other private sector placers such as finance institutions, NGOs and policy makers at local, regional and national levels). This notion is supported by the findings and viewpoints from earlier studies that argue that innovation platforms allow for the joint identification of bottlenecks and opportunities in production, marketing and the policy environment, and the leveraging of innovation to address the identified constraints and take advantage of opportunities across the entire impact pathway (Nederlof et al., 2011; Bill & Melinda Gates Foundation, 2013).

6.3.2 Probit regression results

The study undertook to estimate a probit (logit regression) as a first step of the PSM method to calculate the probability p(X) that farmer *i*i in the innovator group is conditional on observed covariates. Results from this stage are further used to estimate the propensity scores of adoption which are used later in matching to show the Average Treatment Effect on the Treated (ATT) sample (innovators). In the probit regression (Table 6.2), the marginal effects, which show the rate of change in the dependent variable from a unit change in the covariates, were used. Coefficients of the marginal effects that were significant were experience in dairying, access to breeding technology such as artificial insemination ($p < 0.01$) and household size ($p < 0.1$). Marginal effects results show that increasing dairy experience by 1 year will result in an increase of chances of innovation by a factor of 1.1%; increasing the household size by 1 entail increasing the chances of innovation (adoption) by 1.9%; and improving breeding technology by 1 unit will result in increasing the likelihood of innovation by 49.7%. Table 6.2 shows the full results from the probit regression.

The probit regression results entail that the more experienced a smallholder dairy farmer is, the bigger the household and the greater a farmer's access to breeding technology the higher the chances of him/her being an innovator. The lack of significance in coefficients such as access to government/public extension services might, however, been as a result of the numerous challenges bedevilling the government/public extension system (Hanyani-Mlambo, 2000; 2006; Taye, 2013).

Table 6.2: *Probit regression estimates for the adoption of innovation platforms (propensity score matching method)*

	Maximum likelihood estimates		**Marginal effects**	
	Coefficient	Std. Error	Coefficient	Std. Error
Variables				
Male	0.048	0.258	0.014	0.077
Formal education	0.014	0.024	0.004	0.007
Experience in dairy	0.038***	0.011	0.011***	0.003
HH size	0.063*	0.031	0.019*	0.009
Farm size	0.034	0.027	0.010	0.008
Gvt/Public Extension	-0.139	0.589	-0.041	0.175
Distance from MCC	-0.007	0.015	-0.002	0.005
Access to resource center	0.253	0.584	0.075	0.173
Level of use of MCC	0.369	0.225	0.110	0.065
Training	0.214	0.207	0.063	0.061
Access to improved breeds	-0.002	0.372	-0.001	0.111
Access to breeding technology	1.672***	0.506	0.497***	0.148
Access to policy makers	0.298	0.248	0.088	0.073
Level of use of credit	0.157	0.225	0.047	0.067
Agro-ecological region III	-0.644	0.372	-0.189	0.104
Agro-ecological region IV	0.005	0.257	0.002	0.078
Number of observations	226		226	
Log likelihood	-118.3			
Prob>Chi squared	0.000			

Notes: ***Significant at 1% level; **significant at 5% level; *significant at 10% level.

All estimates are based on robust standard errors.

6.3.3 Impact of innovation platforms on smallholder dairy productivity, viability and livelihoods

Subsequent to calculating the propensity score in the equation, the second step involved matching adopters (innovation platform farmers) and non-adopters based on the similarities or closeness of the propensity scores. In this analysis, the study uses the Nearest Neighbour Matching method (NNM). To ensure a maximum covariate balance and a low conditional bias, one-to-one matching with replacement was chosen. The ATT is then interpreted as the significant impact of innovation platforms on the selected outcome variables. Survey results show that the participation in innovation platforms had a positively significant impact on average milk productivity as implied by the ATT of 19.65 ($p < 0.01$), milk sold with an ATT of 16.48 ($p < 0.01$), gross income with an ATT of 1512.13 ($p < 0.01$), and improved household nutrition with an ATT of 0.135 ($p < 0.1$). See Table 6.3.

Overall, survey results show that innovation platforms are effective in improving smallholder dairy productivity, viability and livelihoods. However, although the impact on gross income is significant, the impact on net income is insignificant. This misnomer might be explained by the cost structure e.g. the total variable costs might be too high for adopters of innovation platforms in such a way that dilutes the net income differences between adopters of innovation platforms and non-adopters.

Table 6.3: *Impact of innovation on dairy productivity, dairy viability and livelihoods (nearest neighbour matching method)*

	Improved nutrition	Improved earnings	Improved livelihood options	Avg. milk productivity	Milk sold	Gross income	Net income
	NNM	NNM	NNM	NNM	NNM	NNM	NNM
Variables							
ATT	0.135*	0.115	0.0769	19.65***	16.48***	1512.13***	688.2
	(0.0781)	(0.0929)	(0.0742)	(5.891)	(5.424)	(539.3378)	(747.9)
Mean of outcome variables							
Adopter	0.98	0.98	0.96	32.66	26.34	2833.84	973.51
Non-Adopter	0.73	0.68	0.74	7.20	10.64	1056.671	308.60
Observations	178	178	178	178	178	178	178

Notes: ***Significant at 1% level; **significant at 5% level; *significant at 10% level.

NNM = Nearest Neighbour Matching method.

ATT= Average Treatment effect on the Treated.

Standard errors for the ATT (in parentheses) are calculated using bootstrapping with 500 replications.

The study findings support the evidence and the notion generated by Dusengemungu, Kibwika and Kiazze (2014), who argue that improvements in technology adoption, productivity and viability in innovation platforms are a result of the fact that innovation platforms are mechanisms for developing value chains that act as vehicles for improving access to and the adoption of innovations. The effectiveness of innovation platforms is also, to a large extent, driven by a conducive environment within the innovation platforms. Such drivers include, *inter alia*, the presence of a common objective and a shared vision, the existence of functional output markets, incentives, a critical mass of relevant actors, and the ability of the organizations to conduct critical functions, provide services and develop policy, coordinate, and afford mechanisms for reducing risk and transaction costs (Nederlof et al., 2011; Mapila et al., 2012; Boogaard et al., 2013; Makini et al., 2013).

It has also been argued that the effectiveness of innovation platforms, based on assessments of innovation platform activities, practices and outcomes, depend on the nature of the lead agency that sets up the innovation platform, historical origins of the intervention, the nature of the membership, the degree of engagement with actors beyond the farm, the level of entrepreneurship, and the existence of multiple level platforms (Dorai et al., 2015).

6.4 Conclusions and Implications

This paper has shown that innovation platforms are effective in improving smallholder dairy productivity, viability and livelihoods.

These findings buttress the need for the development and sustenance of private sector driven advisory services and pluralistic dairy extension systems, which support and enhance innovation platforms. Facilitation, in combination with a trigger for innovation (e.g. markets), is an important factor in maintaining and strengthening the required capacities for innovation through multi-stakeholder interaction and learning. There is also an apparent need for both scaling out (diffusion of successful technologies) and scaling up (institutionalization) the use of innovation platforms to enhance adoption potential and thereby improving productivity and viability within smallholder dairy value chains.

Future assessments and continuous monitoring of innovation platforms can also benefit from generic as well as tailor-made practical monitoring and evaluation dashboards that encompass both quantitative and qualitative assessment indicators. This is key for ensuring improved innovation platform management, decision-making and improvement of future performance. The future of agricultural extension and advisory services, however, also hinges on the use of Information and Communication Technologies (ICTs). Hence, there is also potential to integrate the use of innovation platforms with the use of ICTs in driving innovation as well as enhancing smallholder farmer productivity, viability and livelihoods.

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CHAPTER 7 : THE POTENTIAL OF INNOVATION PLATFORMS AND ICTS IN ENHANCING ADOPTION OF CSA INNOVATIONS IN SMALLHOLDER DAIRYING: EVIDENCE FROM ZIMBABWE[11]

Abstract

Climate change models forecast an increase in temperature and drought conditions in Zimbabwe, with negative ramifications on smallholder dairying. Climate Smart Agriculture (CSA), which is designed to sustain increases in agricultural productivity and incomes, can enable farmers to adapt and build resilience to climate change. Based on a cross-sectional survey of 227 households in Rusitu and Gokwe dairy sites in Zimbabwe, this paper investigates the potential of innovation platforms and ICTs in enhancing the adoption of CSA innovations in smallholder dairying. Collected data were analyzed using Multinomial Logit (MNL) regression. Survey results identified dairy herd size, the number of lactating dairy cows, stock type, participation in innovation platforms and ICT use as the statistically significant factors determining the adoption of CSA innovations such as artificial insemination and fodder production ($p < 0.01$). The results indicate a great potential for innovation platforms and ICTs in enhancing the adoption of CSA innovations in smallholder dairying. This provides valuable insights and lessons for extension and advisory services vis à vis approaches and strategies for scaling up CSA innovations. In conclusion, innovation platforms and ICTs are critical drivers for enhancing the adoption of CSA innovations in smallholder dairying. The study recommends support for the development and sustenance of private sector driven advisory services and pluralistic dairy extension services, which enhance innovation platforms and the use of ICTs.

Keywords: climate smart agriculture, innovation platforms, ICTs, smallholder dairying, technology adoption, Zimbabwe.

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7.1 Introduction

Climate change poses a severe threat to the attainment of sustainable food security, agricultural growth and development in Sub-Saharan Africa (FAO, 2010). In Zimbabwe, it threatens the country's inclusive growth agenda and poverty reduction efforts as poor and marginalized groups will incur the greatest burden (UNICEF, 2014; CRS, 2016). Climate change models forecast an increase in temperature, and a significant probability of drying conditions in Zimbabwe (Brown et al., 2012), with negative ramifications on key livelihood enterprises such as commercial smallholder dairying. Unlike other sectors, dairy farming both significantly contributes to and is affected by climate change. The sector is a major factor in greenhouse gas emissions, particularly methane, which contributes to climate change (Siemes, 2008; FAO, 2010). Climate change and variability also affects the availability and quality of water resources and pastures, and increases the prevalence of diseases, intensity of the heat load, as well as temperature and humidity-related discomfort in dairy animals (Kasulo et al., 2012; Zewdu et al., 2014; Kirui et al., 2015). These changes impact directly on feed intake, herd productivity, reproduction, net revenues, and dairy enterprise viability (Kirui et al., 2015; IFAD, 2017).

Climate Smart Agriculture (CSA) innovations, which are designed to offset negative impacts of climate change and sustainably increase productivity and incomes, can also enable farmers to adapt and build resilience to climate change (Zougmore et al., 2016). However, despite the multiplicity of efforts underway to scale-up/out CSA innovations, constraints such as the lack of labour, capital and information on suitable fodders (Mutoko, 2014), the lack of access to adequate land, basic tools and equipment, skills, labour-saving technologies, rural energy, and transport have been acting as barriers (Barnard et al., 2015; Murray et al., 2016). This paradox creates immense demand for greater innovation. Literature reviews indicate that the adoption of CSA innovations can be enhanced by innovation platforms (Tefera et al, 2010; Makini et al., 2013; Duncan et al., 2015) and Information and Communication Technologies (ICTs) (Masuka et al., 2016; Tata & McNamara, 2016; Mutunga & Waema, 2016). However, grassroots evidence for this remains inadequate.

Literature also notes that, the smallholder dairy sector plays a critical role in sustaining the livelihoods of rural and often resource-poor Zimbabweans, as a source of food, income and employment (Hanyani-Mlambo et al, 1998). However, most of the existing literature on adoption of CSA innovations in smallholder dairying has been limited in both its conceptual and geographical focus. Very few studies have delved into the nexus between innovation platforms, ICTs and the adoption of CSA practices in Southern Africa (Kasulo et al., 2012; Tata & McNamara, 2016). Most other related studies have been restricted to Asia, Latin America, West and East Africa (Wambugu et al., 2014; Duncan et al., 2015; Tadesse & Bahiigwa, 2015; Zougmore et al., 2016; Khatri-Chhetri et al., 2017; Shikuku et al., 2017). This thus presents both a conceptual and practical knowledge gap.

This paper undertakes to explore the potential of innovation platforms and ICTs in enhancing the adoption of CSA innovations in smallholder dairying. Artificial Insemination (AI) and fodder production rank as some of the CSA innovations with the greatest potential of sustaining increases in dairy productivity and incomes, thereby enabling smallholder dairy producers to adapt and build resilience to climate change (Gauly et al., 2012; Zewdu et al., 2014; Wambugu et al., 2014), hence the decision to focus on these two CSA innovations. The specific contributions of this paper are: (i) assessing socio-economic variables that are key for multinomial logit regression modelling, (ii) investigating the extent to which innovation platforms and ICTs contribute to the adoption of AI and fodder production in smallholder dairying.

7.2 Research methodology

7.2.1 Study area description

In order to explore the nexus between innovation platforms, ICTs and the adoption of CSA practices the study targeted two smallholder dairy production project sites in Rusitu and Gokwe. The Rusitu smallholder dairy project is located about 440 kilometres east of Harare in Manicaland Province and falls within latitude 20^0 02’ S and longitude 33^0 48’ E. The scheme is located in agro-ecological region I, characterized by high rainfall, low temperatures, well-drained soils and provides a perfect environment for dairying. The Gokwe smallholder dairy scheme, on the other hand, is located 338 kilometres west of Harare in the Midlands Province and falls within latitude 18^0 13’ S and longitude 28^0 56’ E. The scheme is located in agro-ecological regions III and IV characterized by low rainfall, fairly severe mid-season dry spells and is, therefore, marginal for dairying.

7.2.2 Sampling procedure and sample size

Multistage sampling, a complex form of cluster sampling, was adopted to guide sampling for the household questionnaire survey. Rusitu and Gokwe were purposively selected as the two research sites given their contrasting characteristics and representativeness of the generality of smallholder dairy schemes in Zimbabwe. At the second stage, smallholder dairy farmers in both Rusitu and Gokwe were stratified on the basis of their level of participation in dairy innovation platforms. The household was then used as the unit of sampling during the third and final stage of sampling. At this stage and within the strata, a probability sampling method was used as the basis for selecting households included in the survey. A total of 227 households were sampled for the study. Of these, 100 households (44.1%) actively participated in smallholder dairy innovation platforms, while the remaining 127 households (55.9%) were not.

7.2.3 Field data collection

Primary data were collected through the use of desk studies, key informant interviews, focus group discussions, and a structured household questionnaire survey. The use of numerous data collection methods was deliberate since this is a way of triangulating collected data for purposes of verification, validation and improving the reliability of collected data (Babbie et al., 2001; Wagner et al., 2012). The formal household questionnaire survey collected data on household demographics, participation in innovation platforms, use of ICTs, asset ownership, livestock numbers and dynamics, dairy production and marketing, as well as access to livestock technology, inputs and support services. The questionnaire was pre-tested before use for purposes of ensuring that the study generates accurate, consistent, dependable and reliable data.

7.2.4 Analytical model: Multinomial Logit (MNL) regression analysis

The decision on the methodological framework and econometric model used in this study depended on the research objectives and the hypotheses to be tested. Given that adoption decisions involve multiple options (*1=full adoption, 2=partial adoption,* and *3=non adoption*), multinomial regression techniques were adopted to evaluate choice decisions. The precise methodology applied was the Multinomial Logit regression with the objective of analyzing the determinants of farmers' choice decisions since this approach has been widely adopted for use in adoption studies involving multiple options (Hassan and Nhemachena, 2008; Joshi and Bauer, 2006; van Edig and Schwarze, 2012) and is usually simpler and produces more accurate results than other possible options such as Multinomial Probit (MNP) (Tse, 1987; Kropko, 2008). The main limitation of the MNL model is the independence of irrelevant alternatives (IIA) property, which postulates that the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set (Tse, 1987). Despite this weakness, as argued above, the model is still very useful and acceptable in analyzing decisions involving multiple choices.

The MNL model was applied as follows; let A_i be a random variable representing the adaptation measure chosen by any farming household. The researchers assume that each farmer faces a set of discrete, mutually exclusive choices of adaptation measures. These measures are assumed to depend on a number of climate attributes, socioeconomic characteristics and other factors X . The MNL model for adaptation choice specifies the following relationship between the probability of choosing option A_i and the set of explanatory variables X (Greene, 2003).

$$\Pr ob(A_i = j) = \frac{e^{\beta_j' x_i}}{\sum_{k=0}^{j} e^{\beta_k' x_i}}, \; j = 0,1......J \qquad (1)$$

where β_j is a vector of coefficients on each of the independent variables X. Equation (1) can be normalized to remove indeterminacy in the model by assuming that $\beta_0 = 0$ and the probabilities can be estimated as:

$$\Pr ob(A_i = j | x_i) = \frac{e^{\beta_j' x_i}}{1 + \sum_{k=1}^{j} e^{\beta_k' x_i}}, j = 0,1,2.....J, \beta_0 = 0 \qquad (2)$$

Estimating equation (2) yields the J log-odds ratios

$$\ln\left(\frac{P_{ij}}{P_{ik}}\right) = x_i'(\beta_j - \beta_k) = x_i'\beta_j, \text{if } k = 0 \qquad (3)$$

The dependent variable is, therefore, the log of any one alternative (adaptation strategy) relative to the base alternative (no adaptation). The MNL coefficients are difficult to interpret, while associating the β_j with the j^{th} outcome is tempting and misleading. To interpret the effects of explanatory variables on the probabilities, marginal effects are usually derived (Greene, 2003):

$$\delta_j = \frac{\delta P_j}{\delta x_i} = P_j\left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P_j(\beta_j - \overline{\beta}) \qquad (4)$$

The marginal effects measure the expected change in the probability of a particular choice being made with respect to a unit change in an explanatory variable (Greene, 2003). The signs of the marginal effects and respective coefficients may be different, as the former depend on the sign and magnitude of all other coefficients.

7.2.5 Model variables, expected signs and data sources

The dependent variables in the empirical estimation for this study is the level of adoption of the CSA practices in dairy production (AI and fodder production), and falls into three different categories (*1=full adoption, 2=partial adoption,* and *3=non adoption*). Non adoption was taken as a reference category, while the choice of explanatory variables and expected sign of influence is largely guided by empirical literature that includes studies by Hassan and Nhemachena (2008) and Ahmed (2016). The same model was used for both AI and fodder production since the two dependent variables are affected by almost the same variables. Table 7.1 summarizes the explanatory variables used for empirical estimation, together with their expected influence on farm level adaptations.

Table 7.1: Description of explanatory variables and expected signs

Explanatory variable	**Description**	**Expected sign for CSA adoption**
Age	Age of household head (years)	+
Gender	Gender of household head (1 if male, 0 otherwise)	+/-
Educ	Number of years of formal education of household head	+
Agrictraining	Household head completed agricultural training (1=yes, 0=no)	+
Stocktype	Dominant herd stock type (1=indigenous, 0=otherwise)	-
Herdsize	Size of the dairy herd	+
Lactcows	Total number of lactating cows	+
Dairyincome	Estimated annual income from dairy activities ($)	+
ICTuse	Use of ICTs in dairy activities (1=yes, 0=no)	+
Innovation	Farmer participation in innovation platforms (1=yes, 0=no)	+

7.3 Results

7.3.1 Descriptive statistics

The average smallholder dairy herd size was four animals, with on average one lactating cow and generating an estimated income of US$1,346 per annum. Most surveyed households (65%) keep pure or crossbreds, with the rest relying on indigenous cattle. The bulk of smallholder dairy producing households (79%) were male-headed, with a household head whose age ranged from

21 to 88 years. The average number of years spend in formal education is eight, which is consistent with national statistics which show literacy levels of over 90% (ZIMSTAT, 2014). However, less than half of the interviewed households (41%) completed agricultural training (Table 7.2).

Table 7.2: *Descriptive statistics for variables selected for the MNL regression model (N=227)*

Explanatory Variable	**Minimum**	**Maximum**	**M**	**SD**
Total number of animals in dairy herd	1	48	4.30	5.01
Number of lactating cows	0	8	1.45	1.43
Gender of HH Head	0	1	0.79	0.41
Age of HH Head	21	88	56.41	13.88
HH completed agricultural training	0	1	0.41	0.49
Participation in innovation platforms	0	1	0.57	0.50
Fodder production adoption	1	3	1.78	0.83
HH using ICTs in dairy	0	1	0.72	0.45
AI Adoption	1	3	2.02	0.85
Stock type	0	1	0.35	0.48
Estimated Total Annual Dairy Income ($)	0.00	33,600	1,346.00	2,850.00
Years of formal education for HH Head	0	22	8.10	4.08

The results are similar to the findings from previous studies that also highlighted the numerous socio-economic variables affecting smallholder dairying in Zimbabwe (Hanyani-Mlambo et al., 1998). The study findings also reflect the characteristics found in other typical mixed crop-livestock systems (Somda et al., 2004). More than half the surveyed households (57%) participated in innovation platforms, while most households (72%) used ITCs to guide dairy production and marketing. Most smallholder dairy producing households had also either partially or fully-adopted fodder production and/or use of artificial insemination in crossbreeding programmes.

7.3.2 Factors influencing the adoption of artificial insemination

The MNL regression model is estimated using the maximum likelihood method. MNL model assessments found the Log-likelihood Ratio (LR) to be significant ($p<0.01$) (Table7.3). This means that the independent variables selected into the model statistically significantly improved the model in predicting the influence on smallholder dairy producers' adoption of artificial insemination. This entails that the choice of variables is good. In addition, the measure of Goodness-of-fit shows that the model specification is good. Pseudo-R^2 measures also show that a greater proportion of the variation in the dependent variable is being explained by the given explanatory variables. The conclusion is that the MNL model employed is reliable and appropriate. Results show that the dairy herd size, the number of lactating cows, estimated annual dairy income, ICT use in dairying, and the stock type are statistically significant in explaining the adoption of AI. The result implies that the decision to fully, partially or not adopt at all is mostly explained by the five factors. The results of the MNL regression analysis of factors influencing the adoption of artificial insemination as a CSA innovation are presented in Table 7.3.

Factors that are statistically significant, for comparisons of the level of adoption between full adoption and non adoption, are dairy herd size, number of lactating cows, participation in innovation platforms, ICT use and stock type. The implication is that smallholder dairy producers are more likely to fully adopt artificial insemination if the herd size is limited, have a large number of lactating cows, are participating in innovation platforms, are using ICTs, and the dairy stock type is not indigenous. For partial adopters, it is likely that they will partially adopt when compared to non-adopters when there is a high number of lactating cows, they participate in innovation platforms, are using ICTs in dairying, and that the stock type is not indigenous.

***Table 7.3 :** MNL regression for factors influencing artificial insemination adoption (N=227)*

Category	Variables	ß	SE	Wald	Df	Sig.	Exp(ß)
Fully	Intercept	-5.382	2.722	3.909	1	0.048	
Adopted	Herdsize	-0.270	0.150	3.245	1	0.072*	0.763
	Age	0.026	0.030	0.713	1	0.399	1.026
	Lactcows	1.877	0.536	11.126	1	0.001***	6.535
	Dairyincome	0.000	0.000	0.716	1	0.397	1.000
	Educ	-0.056	0.085	0.436	1	0.509	0.945
	Gender	1.101	0.955	1.329	1	0.249	3.008
	Agrictraining	0.277	0.805	0.119	1	0.730	1.320
	Innovation	-1.258	0.756	2.768	1	0.096*	0.284
	ICTuse	-3.144	0.893	12.395	1	0.000***	0.043
	Stocktype	5.356	1.033	26.896	1	0.000***	211.819
Partially	Intercept	-3.685	2.489	2.192	1	0.139	
Adopted	Herdsize	-0.153	0.149	1.056	1	0.304	0.858
	Age	0.022	0.028	0.595	1	0.441	1.022
	Lactcows	1.725	0.553	9.710	1	0.002***	5.611
	Dairyincome	-0.001	0.000	1.644	1	0.200	0.999
	Educ	-0.061	0.077	0.633	1	0.426	0.941
	Gender	0.608	0.889	0.469	1	0.494	1.837
	Agrictraining	0.524	0.778	0.453	1	0.501	1.688
	Innovation	-1.332	0.715	3.468	1	0.063*	0.264
	ICTuse	-2.433	0.812	8.964	1	0.003***	0.088
	Stocktype	4.731	0.844	31.441	1	0.000***	113.416
-2 Log Likelihood		233.807			Cox and Snell	.685	
χ^2		262.034			Nagelkerke	.772	
Df		20			McFadden	.528	
p-value		0.000					

***, ** and * significant at P<0.01, P<0.05 and P<0.1 respectively.

7.3.3 Factors influencing the adoption of fodder production

The Log-likelihood Ratio (LR) is significant at the 1% level. Again, this shows that the model statistically significantly predicts the dependent variable better than the intercept-only model, thus the choice of explanatory variables is good. Other preliminary assessments highlight the χ^2 result as showing that the selected factors are significantly different from zero at $P<0.01$ for the adoption of fodder production. The McFadden's R-square or Pseudo R^2 is 0.310. This implies that up to 31% of the variations in probabilities of adopting fodder production by the sampled smallholder dairy producers was explained by the selected explanatory variables. Results show that the factors that are significant in explaining the adoption of fodder production are the dairy herd size, estimated annual dairy income, participation in innovation platforms, and the use of ICTs. The other factors are not significant enough to explain the adoption of fodder production. The results of MNL regression on determinants of fodder production adoption are presented in Table 7.4 using non adoption as a reference category.

Results in Table 7.4 show that for full adoption, the major determining factors are the number of lactating cows, the dairy herd size, participation in innovation platforms and ICT use. This means that the sampled smallholder dairy producers are likely to be full adopters than a non-adopter of fodder production if the household has a high number of lactating cows, have a large dairy herd, if it is participating in innovation platforms, and are using ICTs in dairy activities. Similarly, when compared to a non-adopters, households partially adopt fodder production when the dairy herd size is larger, dairy income is high, are participating in innovation platforms and are using ICTs in dairy activities. As before, the other factors are insignificant.

7.4 Discussion

The two sets of MNL regression results both identified dairy herd size, the number of lactating cows, participation in innovation platforms and ICT use as the determinants of adoption of CSA innovations such as AI and fodder production. Stock type is the other factor identified as influencing artificial insemination adoption. On the other hand, factors such as the gender, age of the household head, education, agricultural training, and estimated annual dairy income were found to be insignificant.

Table 7.4 : *MNL regression for factors influencing fodder production adoption (N=227)*

Category	Variables	ß	SE	Wald	Df	Sig.	Exp(ß)
Fully	Intercept	3.017	1.634	3.408	1	0.065	
Adopted	Herdsize	0.492	0.147	11.130	1	0.001***	1.635
	Age	-0.006	0.018	0.100	1	0.752	0.994
	Lactcows	-0.565	0.298	3.595	1	0.058*	0.568
	Dairyincome	0.000	0.000	0.139	1	0.709	1.000
	Educ	-0.043	0.062	0.482	1	0.488	0.958
	Gender	0.287	0.554	0.270	1	0.604	1.333
	Agrictraining	-0.614	0.548	1.257	1	0.262	0.541
	Innovation	-2.552	0.648	15.499	1	0.000***	0.078
	ICTuse	-2.468	0.566	19.004	1	0.000***	0.085
	Stocktype	0.314	0.575	0.297	1	0.586	1.369
Partially	Intercept	1.671	1.680	0.989	1	0.320	
Adopted	Herdsize	0.474	0.149	10.153	1	0.001***	1.606
	Age	0.009	0.018	0.247	1	0.619	1.009
	Lactcows	-0.480	0.307	2.447	1	0.118	0.619
	Dairyincome	0.000	0.000	2.919	1	0.088*	1.000
	Educ	-0.068	0.062	1.197	1	0.274	0.934
	Gender	0.149	0.559	0.071	1	0.790	1.160
	Agrictraining	-0.273	0.565	0.233	1	0.629	0.761
	Innovation	-2.059	0.670	9.439	1	0.002***	0.128
	ICTuse	-2.212	0.573	14.923	1	0.000***	0.109
	Stocktype	0.738	0.588	1.576	1	0.209	2.093

-2 Log Likelihood	329.976	Cox and Snell	.479
χ^2	147.905	Nagelkerke	.545
Df	20	McFadden	.310
p-value	0.000		

***, ** and * significant at P<0.01, P<0.05 and P<0.1 respectively.

The findings are in line with a number of studies that highlight socio-economic variables such as the availability of cross breed cows, dairy herd size, the number of lactating cows, participation in innovation platforms or extension access, and ICT use as having a significant influence on CSA innovation adoption (Tefera et al., 2010; Dehinenet et al., 2014; Wodajo and Ponnusamy, 2016). However, these results also contrast the findings from research that has established that gender, education level, agricultural training, age of the household head and total dairy income have an impact on technology adoption decision-making processes (Mekonnen et al., 2010; Tata & McNamara, 2016; Dillon et al., 2016). These findings also create points of discourse from results of other studies. In a study of technology adoption among new entrant dairy farmers, McDonald et al. (2016) also established that AI and feed management were driven more by financial considerations than any other factors. Other factors identified as being significant in driving the adoption of CSA innovations in smallholder dairying include the distance to artificial insemination centres (Chelkeba et al., 2016), the willingness and ability of farmers to adopt appropriate new dairy technologies (Howley et al., 2012), the cost of implementation of adopted dairy technologies (Khatri-Chhetri et al., 2017), household size, farming experience, the availability of improved dairy practices, access to financial markets, and the participation in off-farm activities (Dehinenet et al., 2014; Wodajo and Ponnusamy, 2016).

Results that highlight the influence of participation in innovation platforms on the adoption of CSA innovations support findings from past studies. In Zambia, research showed that the adoption rate of technologies for underutilized crops, including sorghum, were higher within innovation platforms largely due to a higher market demand for inputs and crop commodities (Mbulwe, 2015). In India and Tanzania, contextualization and good facilitation of established innovation platforms were key drivers for success (Duncan et al., 2015). In Burkina Faso, technology adoption along the maize value chain succeeded more in innovation platforms where drivers such as improved access to information and market opportunities existed (Sanyang, 2012). However, other scholars argue that access to information and technology alone is not a sufficient condition for technology adoption without additional support from resource availability, technical guidance and improved perspectives (Batalha cited by Dantas et al., 2016). In other contexts, it was established that socio-economic factors are more important in influencing adoption than participation in innovation platforms (Nyikahadzoi et al., 2012) and the need for commercialization of smallholder livestock production enterprises as a pre-requisite for successful innovation platforms (Tefera et al., 2010).

ICTs have contributed immensely to China's agricultural revolution by improving the efficiency of advisory services, improving agricultural productivity and incomes, and reducing the digital gap between rural and urban areas (Zhang et al., 2016). The same can be said of contexts where market-oriented agricultural production is supported by ICT regulations, appropriate policies and adequate infrastructure such as is the situation in Kenya (Mutunga & Waema, 2016). However, in other countries such as in Ethiopia, the impact of mobile phone use has been minimal largely due to a smaller proportion of farmers who use mobile phones as a source of technical production and/or marketing information and the lack of relevant information that can be accessed through such ICTs (Tadesse & Bahiigwa, 2015). In India, research established that although farmers had access to ICTs, they relied more on middlemen, local and official sources for agricultural information (Kameswari et al., 2011). Where poor adoption of ICTs were cited, the factors were, *inter alia*, variances between the design of the information system adopted and smallholder farmers' perceptions of the communication capabilities of the ICTs they have access to (Wyche & Steinfield, 2015).

Having said all this, it is also worth noting that the adoption of innovations is also determined by the perceived attributes of an individual innovation such as its relative advantage, compatibility, complexity, trialability and observability. Equally important is the need to interrogate the variations in the results of the current study against those from elsewhere. Plausible explanations for these variations could include differences in:-

(i) Research contexts.
(ii) Study objectives and the related issues of focus.
(iii) Research variables.
(iv) Sample sizes.
(v) Data collection tools.

7.5 Conclusion and Recommendations

This paper has identified, *inter alia*, artificial insemination and fodder production as scalable and sustainable climate smart livestock technologies that can be disseminated through innovation platforms and ICTs to increase resilience and lower emissions in the dairy value chain. Thus, innovation platforms and ICTs are critical drivers for enhancing knowledge and awareness, and changing attitudes and perceptions, which are the prerequisites for CSA innovation adoption and adaption. This calls for support for the development and sustenance of private sector driven advisory services and pluralistic dairy extension systems, which enhances innovation platforms and use of ICTs.

There is thus an apparent need for both scaling out (diffusion of successful technologies) and scaling up (institutionalization) the use of innovation platforms and ICTs to enhance adoption potential, facilitate sustainable adoption of CSA innovations, and boost the potential impact in smallholder dairying, as mechanisms of enabling farmers to adapt and build resilience to climate change. However, for innovation platforms and ICTs to be more effective, there is also a need to address key institutional barriers such as poor access to information. Efforts to unlock the potential of smallholder dairy farmers through innovation platforms and ICTs should also focus on strategic and systemic implementation of training, technical backstopping and capacity building at both policy and technical levels.

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CHAPTER 8 : CONCLUSIONS, POLICY IMPLICATIONS AND RECOMMENDATIONS

8.1 Recap of the purpose of the study

This study sought to assess the effectiveness of innovation platforms within the context of smallholder dairying in Zimbabwe. The study's specific objectives were to (i) explore the innovation domains and their influence on technology adoption patterns, (ii) investigate the socio-economic differences between participants and non-participants in smallholder dairy innovation platforms, (iii) assess the effectiveness of innovation platforms in enhancing smallholder dairy productivity and viability, and (iv) determine the potential of innovation platforms and ICTs in enhancing the adoption of CSA innovations in smallholder dairying.

8.2 Conclusions and implications for policy

Characteristics of different innovation domains and their level of participation in innovation platforms do have an influence on technology adoption patterns. As such, an appreciation of the concept of innovation domains and knowledge of existing innovation domains within the target intervention context are key for designing sectoral policies and strategies for the sustainable development of smallholder dairy value chains across the Sub Saharan Africa region. It was also noted that there are highly significant socio-economic differences between participants and non-participants in smallholder dairy innovation platforms, entailing that socio-economic factors influence smallholder dairy farmers' participation in innovation platforms.

Innovation platforms were also found to be effective in improving smallholder dairy productivity, viability and livelihoods. These findings buttress the need for the development and sustenance of private sector driven advisory services and pluralistic dairy extension systems, which support and enhance innovation platforms. Innovation platforms and ICTs are also critical drivers for enhancing knowledge and awareness, and changing attitudes and perceptions, which are the prerequisites for CSA innovation adoption and adaption. This calls for support for the development and sustenance of private sector driven advisory services and pluralistic dairy extension systems, which enhances innovation platforms and use of ICTs.

8.3 Policy recommendations

Appropriate farmer segmentation is critical for target domain mapping, improving the adoptability and performance of innovations, and for ensuring the formulation of sector specific policies, appropriate agricultural research and programming for agricultural advisory services, and development of practical tools for the apt targeting of interventions. Related to this is the need for the crafting of appropriate policies and the implementation of relevant interventions that can be effective in enhancing technology development, dissemination of innovations, and market participation by smallholder dairy farmers.

Specific and more practical policy issues to be addressed include:-

(i) Integrating the issue of innovation platforms in curricula for agricultural and rural development training at university, other tertiary institutions, induction courses and on-the-job training.
(ii) Promotion of innovation platforms at national, provincial and district levels.
(iii) Ensuring political will through financial support of processes that support and sustain innovation platforms.
(iv) Ensuring the inclusion of innovation platforms in the new national agricultural extension policy as a strategic model for enhancing innovation dissemination.
(v) Harmonizing the new agricultural extension policy with other supportive cross-sectoral policies and legislature.

There is also an apparent need for both scaling out and scaling up the use of innovation platforms to enhance adoption potential and thereby improving productivity and viability within smallholder dairy value chains.However, for innovation platforms to be more effective, there is also a need to address key institutional barriers such as poor access to information. Efforts to unlock the potential of smallholder dairy farmers through innovation platforms should also focus on strategic and systemic implementation of training, technical backstopping and capacity building at both policy and technical levels.

8.4 Study limitations and suggested areas of further research

By adopting the case study approach for this analysis, the researcher was quite conscious of the potential limitations in terms of the generalisability of the findings. Case studies cover many facets of the total picture and extend over a long period of time and are, therefore, costly exercises. This said, it then became unfeasible to conduct several case studies to allow for greater generalization. To reduce bias and enhance the applicability of generated findings, efforts were made during sampling of the research sites to make them as representative of smallholder dairy projects in Zimbabwe as possible. In some instances data collection also had to rely on recall, with the challenge that in some cases respondents were unable to recall past events and details. As such, the use of multiple data collection methods and probing ensured a greater reliability of collected data. Furthermore, there were also possibilities for unobservable differences between comparator groups, thus making comprehensive comparative analysis difficult.

Beyond the assessment of the effectiveness of innovation platforms, further research could look into:-

(i) Use of panel data over a longer time frame, e.g. at least 5 years, to denote the dynamic changes in adoption patterns across different innovation domains, including groups participating in innovation platforms and non-participants.

(ii) A value chain analysis of the smallholder dairying sub-sector to examine and establish its full socio-economic potential.

(iii) Reviews and the development of monitoring and evaluation dashboards that encompass both quantitative and qualitative assessment indicators, that can be used for ensuring improved innovation platform management, decision-making and improvement of future performance.

APPENDICES

Appendix A: Household Survey Questionnaire

The Effectiveness of Innovation Platforms in Enhancing Technology Adoption, Productivity and Viability: The Case of Smallholder Dairying in Rusitu and Gokwe, Zimbabwe.

B.T. Hanyani-Mlambo. bmlambo2010@gmail.com

HOUSEHOLD (HH) QUESTIONNAIRE

INTRODUCTION

My name is …………………………………………………………………… We are conducting a socio-economic survey in Rusitu and Gokwe smallholder dairy project areas, here in Zimbabwe. The researcher, B.T. Hanyani-Mlambo, is a PhD student at UKZN. This survey is thus part of academic studies. However, the results of the survey will inform Government policy and interventions. The Government and its development partners can also use the information from this survey for their planning and programming. For this reason, this survey has been sanctioned by Government. Your household is among several randomly selected households to represent your neighbourhood. The interview will take about 1½ hours to complete. Any information that you provide will be kept strictly confidential and will not be shown to other people. Your participation is voluntary. However, we hope that you will participate since your views are important. Would you like to participate in this survey by answering questions about your household? [Yes] [No]

SECTION A: QUESTIONNAIRE IDENTIFICATION & BACKGROUND DATA

A1. Enumerators' Name		**A7. Date of Interview**	
A2. Province Name		**A8. Name of Milk Collection Centre (MCC)**	
A3. District Name		**A9. Household Size**	
A4. Ward Name (+Number)		**A10. Total Farm Size**	**ha**
A5. Household Name		**A11. Arable Land Size**	**ha**
A6. Respondent's Full Name		**A12. Size of Utilized Arable Land/Area**	**ha**
A13. Size of Dairy Herd (total number of animals in dairy herd)		**A14. Number of lactating (milking) cows**	
A15. Distance from the Milk Collection Centre (MCC) in kilometers	**km**	**A16. Distance from the Nearest Town/Growth Point**	**km**

A17. Type of Settlement	**1= Small Scale Commercial 2= Old (Phase 1) Resettlement 3= Communal**
A18. Agro-Ecological Region	**1= I 2= II 3= III 4= IV 5= V**
A19. Dominant Type of Soil on the Farm	**1= Clays 2= Clay Loams 3= Sandy Loams 4= Kalahari Sands**
A20. Predominant Management System Used	**1= Zero grazing 2= Paddock system 3= Free/Open range 4= Other (specify)**
A21. Main Forage & Feeding System Used during Wet Season	**1= Natural pasture 2= Forage 3=Silage/Hay 4= Other (specify)**
A22. Main Forage & Feeding System Used during Dry Season	**1= Natural pasture 2= Forage 3=Silage/Hay 4= Other (specify)**
A23. Stock Type (Predominant Dairy Breeds) on the Farm	**1= Pure breeds 2= Crosses 3= Indigenous 4= Other (specify)**
A24. Mode of Milk Delivery Transportation	**1=On Foot 2=Bicycle 3=Animal Drawn Cart 4=Motor Cycle 5=Motor Vehicle 6= Other (specify)**
Supervisor Name and Signature	

SECTION B: MCC MEMBERSHIP & PARTICIPATION IN SMALLHOLDER DAIRY INNOVATION PLATFORMS

B1. Do you belong to a collective smallholder dairy group? (IP membership) e.g. membership of dairy association/cooperative?		1= Yes 0= No	
B2. Are you a registered MCC member (paid joining fee)?		1= Yes 0= No	
B3. If yes, are you fully paid up on your membership subscriptions?		1= Yes 0= No	
B4. For how long have you been a registered member of the MCC?		Years.	
B5. What position do you occupy in the local MCC?		1= MCC Chairperson 2= Deputy Chairperson 3= Treasurer 4= Secretary 5= Deputy Secretary 6 = Committee Member 7= Ordinary Member	
B6. Is any member of your household closely affiliated with anyone in an MCC leadership position?		1= Yes 0= No	
B7. Are you currently producing milk?		1= Yes 0= No	
B8. Are you currently delivering milk to the MCC?		1= Yes 0= No 2= N/A	
B9. Frequency of Extension Contact (based on the number of times the HH was in contact with DDP, LPD, DVS or AGRITEX over the last 12 months)?		1= Daily 2= Twice Weekly 3= Weekly 4= Fortnightly 5= Monthly 6= Once in 3 Months 7= Once in 6 Months 8= Once a Year 9= Never 10= Other (specify)	
B10. Farmer's level of participation in the local Smallholder Dairy Innovation Platform. (First - study carefully and understand the different group characteristics in the next column. Secondly - ask the farmer to describe their level of participation, input in decision-making, and initiatives taken. Thereafter, use the farmer's respond to categorize the farmer's level of participation in the IP).	Characteristics of Level of Participation	Classification of Participation	Circle appropriate response
	Registered but not producing milk and not involved in any MCC activities	Passive Participant	1
	MCC members provide information for external decision-making in which they have no influence	Participation in Information Giving	2
	MCC members provide information that directly or indirectly influences external decision-making	Participation by Consultation	3
	Only participate in circumstances where farmers access economic incentives e.g. pass-on scheme	Participation for Material Incentives	4
	MCC members that have the ability and desire to join in (be a part of the processes)	Functional Participation	5
	Farmers take control of the processes	Interactive Participation	6
	Farmers take the initiative on any new idea/process	Self Mobilization	7

SECTION 1: HOUSEHOLD DEMOGRAPHICS + CHARACTERISTICS						
1.1	Gender of Household Head	1 = Male 2 = Female				
1.2	Marital Status of Household Head	1= married 2= divorced/separated 3= widowed 4= single/ never married				
1.3	Age of Household Head	Years.				
1.4	What is the highest level of education completed by the Household Head?	0 = No formal schooling 1 = Primary 2 = ZJC/Std 6 3= Secondary 4 = Tertiary 5 = Other (specify)				
1.5	What is the number of years in formal schooling for the Household Head?	Years.				
1.6	Agricultural Training received by the Household Head	0= None 1= Trainee Master Farmer (attempted or in training) 2= Master Farmer Certificate 3= Advanced Master Farmer Certificate 4= Diploma 5= Degree				
1.7	What is the main source of income for the Household?	1= Dairying 2= Livestock keeping including sales 3= Crop farming 4= Trading in agricultural products (not own produce) 5= Formal salary 6= Informal employment 7= Petty trade 8= Pension 9= Other (specify)				
1.8	Number of years in commercial smallholder dairying	Years.				
1.9	Number of HH members who are………………		Age/Gender	0 – 15 years	16 – 64 years	65+ years
			Male			
			Female			
			Disabled			
			Total			

SECTION 2: HOUSEHOLD CHARACTERISTICS (AMENITIES AND CONDITIONS)	
2.1	What is the main material used to construct the walls of the main dwelling? (Circle only one code) 1= Stone/Finished walls/ cement2 = Cement Blocks 3= Farm bricks 4= Pole and dagga 5 = Shelter (no walls) 6 = Wood planks 7 = Dirt/ rudimentary walls 8= other (specify)
2.2	What is the main material used to construct the roof of the main dwelling? (Circle only one code) 1 = Grass thatching 2 = Corrugated iron 3= Asbestos sheets 4 = Tiles 5 = Wood 6 = other (specify)

SECTION 4: HOUSEHOLD ASSETS									
4.1 Name of Functional Asset (in working condition)	4.2 Total Number of Functional Assets Owned	4.3 Relative/Average Age (Number in this age group)			4.1 Name of Functional Asset (in working condition)	4.2 Total Number of Functional Assets Owned	4.3 Relative/Average Age (Number in this age group)		
		< 3 years	3 - 7 years	>7 years			< 3 years	3 - 7 years	>7 years
Domestic Assets									
Electric Cooker					**Productive Assets**				
Gas Stove					Stainless steel bucket (milking)				
Refrigerator					Stainless steel can (deliveries)				
Lounge suite / sofa					Silage chopper				
Radio / stereo					Milk weighing scale				
Television					Burdizzo				
DVD / CD Player					Dehorning iron				
Mobile phone					Tractor				
Chairs					Rump/oil pressers				
					Grinding hammer mill (powered)				
					Solar panel				
					Private water pump				
Transport					Hoes				
Car/truck					Spades/shovels				
Motorcycle					Ploughs				
Bicycle					Cultivators				
Animal-drawn cart					Crop sprayer				
					Sewing machine				
					Generator				

SECTION 5: HOUSEHOLD INCOME & EXPENDITURE								
5.1		What were the ten **most important sources of income for this household for the past 12 months? (October 2014 – September 2015). Put a different score on each of the options below; from 10 points (most important) to 1 point (least important).**						**Scores**
	1.	Dairying						
	2.	Sale of livestock and other livestock products (eggs, meat, wool/mohair, etc.)						
	3.	Sale of crop produce (cereals, cash crops, root crops, vegetables & fruits)						
	4.	Formal employment (teacher, health agent, government administrator)						
	5.	Informal employment (farm labourer, security guard, maid, carpenter, electrician, brick making, beer brewing, etc)						
	6.	Irregular daily labour (casual worker)						
	7.	Petty trade (buying & selling)						
	8.	Family business (retail shop, hardware, grinding mill, etc.)						
	9.	Pension/Maintenance/Disability Grant,						
	10.	Remittances from migrants (inside or outside Zimbabwe)						
5.2		What is your **estimated total household income** in a calendar year (January - December)? ***include income from all HH income sources**						**US$**
5.3		What is your **estimated annual dairy income** in a calendar year (January - December)? ***include income from side-marketed milk**						**US$**
5.4		**Is income from dairying (milk sales) regular?**	1= temporary/casual		2= seasonal		3= stable/permanent	
5.5		Has your **dairying (milk sales) income changed in the past 12 months**	1= No change		2= Decreased		3= Increased	
5.6		Using proportional piling, based on ten (10) units, what **proportion (%) of your HH income** do you **spend on** different key household needs? Total should = 100%.	Food	Education	Health	Tillage & Agric Inputs	Non-Agric Productive Expenditure	Other (specify)

SECTION 6: DAIRY INFRASTRUCTURE & FACILITIES						
6.1 Type, source, delivery mechanisms, frequency, effectiveness and adoption of dairy innovations.						
Dairy Infrastructure & Facilities	**Did you receive advice or training on this?**	**Main source of advice or training** 1=Processor 2=DDP 3=LPD 4=AGRITEX 5= DVS 6=NGOs 7=Manufacturer 8=Wholesaler 9=Local agro- dealer 10=Other farmers 11=ZADF 12= Dairy Services 13= Other *(specify)*	**Extension Methods** 1=Group Methods e.g. demonstrations 2=Individual Methods 3=Mass Media e.g. TV/ Radio 4=Other *(specify)*	**Frequency of Training/Advice** 1=Daily 2=Twice Weekly 3=Weekly 4=Fortnightly 5=Monthly 6=Quarterly 7=Once a year	**HH Evaluation of Advice/Training Received** 1= Very Good 2= Good 3= Satisfactory 4= Poor 5= Very Poor	**Adoption of Innovation** 1= Fully Adopted 2= Partially Adopted 3= Adopted and then Disadopted (stopped) 4= Never Adopted but Willing to Adopt 5= Never Adopted and Not Willing to Adopt
Calf Pen	0= No 1= Yes					
Cattle handling facilities	0= No 1= Yes					
Paddocks	0= No 1= Yes					
Cattle kraal	0= No 1= Yes					
Watering & Feeding Facilities	0= No 1= Yes					
Milking Parlour	0= No 1= Yes					
Milking Machine	0= No 1= Yes					
Hay Shed	0= No 1= Yes					
Silage Pit	0= No 1= Yes					

SECTION 7: FODDER PRODUCTION

7.1 Area under fodder/cultivated pastures in ha (during the 2014/15 season): ha

7.2 Fodder/Pasture Production Statistics (Oct 2014 – Sept 2015 season):

Crop	Area Planted (Ha)	Quantity Harvested (50 kg bags)	Quantity Fed as Green Material (kg)	Quantity Processed into Fodder (kg) e.g. silage/hay
Maize grain				
Maize/Sorghum Silage				
Grasses (Bana, Nappier, Star grass, etc.)				
Legume Crops (Velvet beans, lablab, cowpeas, etc.)				
Forage Trees (Acacia, Luecaena, Gliricindia, etc.)				
Other (specify)				

7.3 Major source of advice to establish fodder crops/engage in fodder production:

1=Processor 2=DDP 3=LPD 4=AGRITEX 5= DVS 6=NGOs 7=Manufacturer 8=Wholesaler 9=Local agro- dealer
10=Other farmers 11=ZADF 12=Other *(specify)*

SECTION 8: LIVESTOCK NUMBERS & DYNAMICS (OCTOBER 2014 – SEPTEMBER 2015)								
8.1 Livestock Code	8.2 Livestock Type	8.3 How many of this livestock type does your household own now (present at your homestead or away)? IF NONE, RECORD ZERO	8.4 How many [LIVESTOCK Type] did your household own 12 months ago?	8.5 During the last 12 months, how many [LIVESTOCK Type] were born? IF NONE, RECORD ZERO.	8.6 During the last 12 months, how many [LIVESTOCK Type] did your household purchase/buy to raise? IF NONE, RECORD ZERO	8.7 During the last 12 months, how many have you sold alive? IF NONE, RECORD ZERO	8.8 During the last 12 months, how many [LIVESTOCK Type] did your household slaughter for sales or consumption? IF NONE, RECORD ZERO.	8.9 During the last 12 months, how many [LIVESTOCK Type] were lost to disease?
1	Dairy Cattle (total)							
2	Dairy Calf							
3	Dairy Heifer							
4	Dairy Cow							
5	Dairy Steer							
6	Dairy Bull							
7	Beef Cattle (total)							
8	Beef Calf							
9	Beef Heifer							
10	Beef Steer							
11	Beef Cow							
12	Beef Bull							
13	Beef Ox							
14	Horse							
15	Donkey							
16	Goat							
17	Sheep							
18	Pig							
19	Poultry							

SECTION 9: ANIMAL HEALTH

9.1 Livestock Code	9.2 Livestock Name	9.3 How many of your [LIVESTOCK] are currently vaccinated? IF NONE, RECORD ZERO	9.4 Who provided the vaccination services for [LIVESTOCK]?	9.5 Against which diseases did your household vaccinate [LIVESTOCK]? REFER TO THE DISEASE CODES on the right side.
1	Dairy Cattle			
2	Beef Cattle			
3	Donkeys			
4	Goats			
5	Sheep			
6	Pigs			
7	Poultry			
8	Other (specify)			
9				

Codes for 9.4

1= DVS 2= LPD, 3= AGRITEX, 4= Private Company
5= Agric Cooperative 6= Other farmers 7= other (specify)

Codes for 9.5
1= Anthrax (tungundu)
2= Foot & Mouth Disease (mahwanda)
3= Black Quarter (chipfawo)
4= Lumpy Skin Disease (mapundu)
5= Gumboro (poultry bursal disease)
6= Gall Sickness (makwekwe)
7= Heartwater (makwekwe)
8= Rabies (chimbwa mupengo)
9= New Castle Disease
10= Small Pox
11= Foot Rot (kuora kwemakumbo)
12= Mareks
13= Mange (nhata)
14= Tetanus
15= African Swine Fever
16= Anaplasmosis (red water)
17= Anaemia (kushaya ropa)
18= Babesiosis
19= Brucelosis (CA)
20= Contagious Bovine Pleuropneumonia (CBPP) (mabayo)
21= Contagious Caprine Pleuropneumonia (CCPP) (mapapu)
22= Helminthiosis (makonye emudumbu)

SECTION 10: INNOVATIONS, TECHNOLOGY ADOPTION & KNOWLEDGE, ATTITUDES AND PRACTICES (KAP)	
Business Orientation	
10.1 Are you aware that you should adopt Farming as a Business (FaaB) Approach?	0= No 1= Yes
10.1 Farming as a Business (FaaB) Approach is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.1 I have consistently adopted Farming as a Business (FaaB) Approach	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.2 Are you aware that dairying hinges on knowledge & self reliance?	0= No 1= Yes
10.2 Knowledge & self reliance is important in dairying (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.2 I have consistently used knowledge & self reliance in dairying	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.3 Are you aware that dairying is driven by sustainable improvements?	0= No 1= Yes
10.3 Sustainable improvements are important in dairying (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.3 I have consistently implemented sustainable improvements in dairying	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.4 Are you aware that an aversion to risk attitude inhibits dairy enterprise development?	0= No 1= Yes
10.4 Avoiding an aversion to risk attitude is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.4 I have consistently avoided an aversion to risk attitude	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.5 Are you aware that record keeping is key in dairying?	0= No 1= Yes
10.5 Record keeping is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.5 I have consistently kept records related to my dairy business	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.6 Are you aware that viability assessments are key for sustainable dairying?	0= No 1= Yes
10.6 Viability assessments are important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.6 I have consistently conducted viability assessments in dairying	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
Animal Housing, Dairy Infrastructure & Equipment	
10.7 Are you aware that dairy calves should be housed in calf pens?	0= No 1= Yes
10.7 Housing of dairy calves in calf pens is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.7 During the last 12 months I have consistently housed dairy calves in calf pens	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.8 Are you aware that dairy cattle should be housed in cattle pens?	0= No 1= Yes
10.8 Housing of dairy cattle in cattle pens is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

10.8 During the last 12 months I have consistently housed dairy cattle in cattle pens	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.9 Are you aware that dairying requires use of cattle handling facilities?	0= No 1= Yes
10.9 Use of cattle handling facilities in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.9 During the last 12 months I have consistently used cattle handling facilities	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.10 Are you aware that dairying requires use of paddocks?	0= No 1= Yes
10.10 Use of paddocks in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.10 During the last 12 months I have consistently used paddocks	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.11 Are you aware that dairying requires feeding & watering facilities?	0= No 1= Yes
10.11 Use of feeding & watering facilities is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.11 During the last 12 months I have consistently used feeding & watering facilities	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.12 Are you aware that milking should be done at a milking parlour?	0= No 1= Yes
10.12 Use of a milking parlour during milking is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.12 During the last 12 months I have consistently used a milking parlour	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.13 Are you aware that milking should be done in stainless steel buckets?	0= No 1= Yes
10.13 Use of stainless steel buckets during milking is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.13 During the last 12 months I have consistently used stainless steel buckets	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
Livestock Identification & Herd Management	
10.14 Are you aware that dairy livestock should be tagged?	0= No 1= Yes
10.14 Tagging of dairy livestock is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.14 All of my dairy livestock are tagged	0= No 1= Yes
10.15 Are you aware that dairy livestock should be branded?	0= No 1= Yes
10.15 Branding of dairy livestock is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.15 All of my dairy livestock are branded	0= No 1= Yes
10.16 Are you aware that livestock which you own has to be registered on the stock card?	0= No 1= Yes
10.16 A stock card is necessary to have (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.16 All my cattle are registered on the stock card	0= No 1= Yes
10.17 Are you aware that timely weaning of calves is critical in dairying?	0= No 1= Yes
10.17 Timely weaning of calves is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

10.17 I have consistently timely weaned all my dairy calves	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always

Breed Improvement	
10.18 Are you aware that you should use improved dairy animal breeds?	0= No 1= Yes
10.18 Use of improved dairy animal breeds is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.18 I have consistently used improved dairy animal breeds	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.19 Are you aware that cross-breeding is key for breed improvement?	0= No 1= Yes
10.19 Cross-breeding is important for breed improvement (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.19 I have consistently used cross-breeding for breed improvement	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.20 Are you aware that heat detection is key for successful breeding?	0= No 1= Yes
10.20 Heat detection is important for successful breeding (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.20 I have consistently used heat detection for successful breeding	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.21 Are you aware that Artificial Insemination (AI) is key for successful breeding?	0= No 1= Yes
10.21 Artificial Insemination (AI) is important for successful breeding (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.21 I have consistently used Artificial Insemination (AI) for successful breeding	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
Fodder Production, Feeding and Feed Management	
10.22 Are you aware that dairying requires fodder flow planning & feed budgeting?	0= No 1= Yes
10.22 Fodder flow planning & feed budgeting is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.22 I have consistently used fodder flow planning & feed budgeting	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.23 Are you aware that dairying requires fodder production?	0= No 1= Yes
10.23 Fodder production in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.23 I have consistently produced fodder on at least 0.1ha	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.24 Are you aware that you should use new fodder crop varieties?	0= No 1= Yes
10.24 Use of new fodder crop varieties in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.24 I have consistently used new fodder crop varieties	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.25 Are you aware that fodder conservation (silage making) is key in dairying?	0= No 1= Yes

10.25 Fodder conservation (silage making) is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.25 I have consistently conserved fodder (practiced silage making)	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.26 Are you aware that fodder conservation (hay making) is key in dairying?	0= No 1= Yes
10.26 Fodder conservation (hay making) is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.26 I have consistently conserved fodder (practiced hay making)	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.27 Are you aware that urea treatment of stova is key in dairying?	0= No 1= Yes
10.27 Urea treatment of stova in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.27 I have consistently urea-treated dairy stova	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.28 Are you aware that supplementary feeding is key in dairying?	0= No 1= Yes
10.28 Supplementary feeding in dairying is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.28 I have consistently provided a basal feed of 2kg + 0.5kg supplementary feed per each additional litre of milk	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
Animal Health	
10.29 Are you aware of livestock dipping regimes for wet and dry seasons?	0= No 1= Yes
10.29 Following dipping regimes is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.29 During the last 12 months I have consistently adhered to dipping regimes	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.30 Are you aware that you must pay dipping fees?	0= No 1= Yes
10.30 Payment of dipping fees is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.30 I consistently pay my dipping fees	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.31 Are you aware that you should give worm remedies to your livestock?	0= No 1= Yes
10.31 Giving worm remedies to livestock is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.31 During the last 12 months, I have given worm remedies to my livestock	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.32 Are you aware that vaccinations are critical for managing animal health?	0= No 1= Yes
10.32 Vaccinations are important	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.32 I have consistently vaccinated against dairy animal diseases	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.33 Are you aware that you have to report disease incidents in your area?	0= No 1= Yes
10.33 Reporting disease incidents is important	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.33 During the last 12 months, have you reported any disease incidents	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always 6 =N/A

10.34 Are you aware that you have to seek movement permits for your animals?	0= No 1= Yes
10.34 Seeking movement permits when moving my livestock is important (circle one)	1 =Strongly disagree 2 =Disagree 3 =Neutral 4 =Agree 5 =Strongly Agree
10.34 I consistently use a permit when I moved my animals	0= No 1= Yes 2=N/A
Business Ethics & Social Influences	
10.35 Are you aware that there is an act on the prevention of cruelty to animals?	0= No 1= Yes
10.35 The prevention of cruelty to animals act is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.35 Was there ever an occasion where you thought you were cruel to animals (feeding time, housing, whipping)	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.36 Are you aware that you have to pay marketing levies after the selling of livestock?	0= No 1= Yes
10.36 Payment of marketing levies is important (circle one)	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.36 I have paid marketing levies to responsible authorities each time I sold my animals	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
10.37 Are you aware that you should adopt an intergenerational orientation? e.g. integrating youth in the dairy enterprise to ensure enterprise sustainability from one generation to another.	0= No 1= Yes
10.37 Adoption of an intergenerational orientation is important (circle one) e.g. integrating youth in the dairy enterprise to ensure enterprise sustainability from one generation to another.	1 = Strongly disagree 2 =Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree
10.37 I have consistently adopted an intergenerational orientation e.g. integrating youth in the dairy enterprise to ensure enterprise sustainability from one generation to another.	1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always

SECTION 11: DAIRY PRODUCTION PRACTICES & INSTITUTIONAL SUPPORT						
11.1 Type, source, delivery mechanisms, frequency, effectiveness and adoption of dairy innovations:						
Type of Innovation	**Did you receive advice or training on this?**	**Main source of advice or training** 1=Processor 2=DDP 3=LPD 4=AGRITEX 5= DVS 6=NGOs 7=Manufacturer 8=Wholesaler 9=Local agro- dealer 10=Other farmers 11=ZADF 12= Dairy Services 13=Other *(specify)*	**Extension Methods** 1=Group Methods e.g. demonstrations 2=Individual Methods 3=Mass Media e.g. TV/ Radio 4=Other *(specify)*	**Frequency of Training/Advice** 1=Daily 2=Twice Weekly 3=Weekly 4=Fortnightly 5=Monthly 6=Quarterly 7=Once a year	**HH Evaluation of Advice/Training Received** 1= Very Good 2= Good 3= Satisfactory 4= Poor 5= Very Poor	**Adoption of Practice** 1= Fully Adopted 2= Partially Adopted 3= Adopted and then Disadopted (stopped) 4= Never Adopted but Willing to Adopt 5= Never Adopted and Not Willing to Adopt
Fodder Production (improved pastures)	1=Yes 0=No					
Hay Making	1=Yes 0=No					
Silage Making	1=Yes 0=No					
Supplementary Feeding	1=Yes 0=No					
Ration Feed Formulation & Use	1=Yes 0=No					
Feed Planning & Budgeting	1=Yes 0=No					
Artificial Insemination (AI)	1=Yes 0=No					
Weaning (≤ 35 days)	1=Yes 0=No					
Tagging (Identification)	1=Yes 0=No					
Dehorning	1=Yes 0=No					
Vaccinations	1=Yes 0=No					
Dosing/De-worming	1=Yes 0=No					
Disease Treatment	1=Yes 0=No					
Record-Keeping	1=Yes 0=No					
Other *(specify)*	1=Yes 0=No					

SECTION 12: ACCESS TO SERVICES & EFFECTIVENESS OF INNOVATION PLATFORMS (IPs)		
	Access to Services	Level of Use of Services 1 = Never 2 = Rarely 3 = Sometimes 4 = Frequently 5 = Always
12.1 Do you have access to Milk Collection Centre (MCC) services? e.g. "rubatsiro" or "mukana"	0= No 1= Yes	1 2 3 4 5
12.2 Do you have access to resource/information centres? e.g. "rubatsiro" or "mukana"	0= No 1= Yes	1 2 3 4 5
12.3 Do you have access to finance, short-term or long-term credit? e.g. dairy cattle loans?	0= No 1= Yes	1 2 3 4 5
12.4 Do you have access to other financial services? e.g. banking services	0= No 1= Yes	1 2 3 4 5
12.5 Do you have access to input markets - dairy feeds?	0= No 1= Yes	1 2 3 4 5
12.6 Do you have access to input markets for veterinary products? e.g. acaricides, antibiotics, etc.	0= No 1= Yes	1 2 3 4 5
12.7 Do you have access to improved dairy stock? e.g. pure breeds or crosses.	0= No 1= Yes	1 2 3 4 5
12.8 Do you have access to veterinary or animal health care services?	0= No 1= Yes	1 2 3 4 5
12.9 Do you have access to improved breeding technology e.g. artificial insemination services?	0= No 1= Yes	1 2 3 4 5
12.10 Do you have access to fodder/crop production inputs (seed, fertilizer, labour, etc)?	0= No 1= Yes	1 2 3 4 5
12.11 Do you have access to govt/public extension workers?	0= No 1= Yes	1 2 3 4 5
12.12 Do you have access to community/farmer-led extension services?	0= No 1= Yes	1 2 3 4 5
12.13 Do you have access to policy makers?	0= No 1= Yes	1 2 3 4 5
12.14 Do you have access to market information?	0= No 1= Yes	1 2 3 4 5
12.15 Source of market information?	1=Processor 2=MCC 3=DDP 4=LPD 5=AGRITEX 6=NGOs 7=Traders 8=Local agro- dealer 9=Other farmers 10=ZADF 11=Other *(specify)*	
12.16 Do you have access to reliable, viable and sustainable markets?	0= No 1= Yes	1 2 3 4 5
12.17 Did MCC membership improve your access to dairy inputs?	0= No 1= Yes	
12.18 Did MCC membership improve your access to extension information?	0= No 1= Yes	
12.19 Did MCC membership improve the adoption of dairy technologies/innovations?	0= No 1= Yes	
12.20 Did MCC membership improve dairy production and marketing?	0= No 1= Yes	
12.21 Did MCC membership improve your access to more reliable, viable & sustainable markets?	0= No 1= Yes	
12.22 Has smallholder dairy production changed your household nutritional intake?	0= No 1= Yes	
12.23 Has smallholder dairy production improved household income earnings?	0= No 1= Yes	
12.24 Has smallholder dairy production improved beneficiaries' livelihoods and livelihood options?	0= No 1= Yes	

SECTION 13: DAIRY HERD PRODUCTIVITY		
13.1. Average milk production, amount sold, allocations and mortalities.		
	Rainy Season (Oct 2014 – Mar 2015)	**Dry Season (Apr – Sept 2015)**
Average milk production output per day (total for dairy herd) in litres		
Average amount of milk sold per day (litres)		
Average amount of milk allocated to feeding dairy calves per day (litres)		
Average amount of milk allocated to household consumption per day (litres)		

13.2. Average milk yield, lactation length, age at first calving, calving intervals, and weaning age *(for farmer's dairy breed)*.

	Mashona	Tuli	Red Dane Crosses	Jersey Crosses	Holstein Crosses	Friesland Crosses
Average milk yield per cow per day (litres)						
Average lactation length (days)						
Age at first calving (months)						
Calving rate (number of calves per cow in last 3 years)						
Average calving interval (months)						
Average calf weaning age (days)						

SECTION 14: MARKET PARTICIPATION/ENGAGEMENT & DAIRY ENTERPRISE VIABILITY				
14.1 Engagement of Output Markets & Dairy Income (October 2014 – September 2015). ***** For Dairy Income, take into consideration the seasonal (month by month) changes in milk output and unit prices.*				
	Did You Use this Output Market? **0= No** **1= Yes**	Quantities Sold/Retained (litres/kg)	Average Unit Price/Value (US$/litre)	Total Income (US$)
Value of fresh milk sold to the **milk collection centre** (Oct 2014 – Sept 2015) Estimate from average production records from Question 13.1.				
Value of fresh milk sold **within village/locally** (Oct 2014 – Sept 2015)				
Value of cultured milk – *amasi/hodzeko* – sold **locally** (Oct 2014 – Sept 2015)				
Value of milk retained for home consumption (Oct 2014 – Sept 2015)				
Value of milk retained for feeding calves (Oct 2014 – Sept 2015)				
Gross income from dairy livestock sales (Oct 2014 – Sept 2015)				
Gross income from fodder entrepreneurship (Oct 2014 – Sept 2015)				
Total dividends received (Oct 2014 – Sept 2015)				
Total Gross Income for dairy enterprise (October 2014 – September 2015)				

14.2 Engagement of Input Markets & Variable Costs (October 2014 – September 2015) **** *For Variable Costs, take into consideration the seasonal (month by month) changes in input and variable costs.*				
	Did You Use this Input Market? **0= No** **1= Yes**	Quantities Used	Unit Price (US$)	Total Variable Cost (US$)
Total costs for purchased feeds (stock feeds, concentrates, molasses, etc)				
Total costs for fodder production (forage-seed, fertilizer, hay/ silage, etc) ****All costs except labour*				
Total costs for fodder conservation (hay/ silage making) ****All costs except labour*				
Total costs for production of home-grown feeds (e.g. grains seed, fertilizer, etc)				
Total breeding costs (artificial insemination costs)				
Total veterinary costs (drugs + vaccines)				
Total costs for hired labour				
Total costs for family labour				
Total transport costs				
Total Variable Costs (October 2014 – September 2015)				

SECTION 15: 2014/15 SEASON'S CROP HARVEST

Crop	15.1 What was the total area under this crop		15.2 How much has your household harvested?		15.3 How much of the current harvest have you sold		15.4 How much of the current harvest does your household expect to sell?		15.5 What storage facilities does the household use to store harvest SEE CODES BELOW
	Quantity	Code	Quantity	Code	Quantity	Code	Quantity	Code	
1. Maize									
2. Sorghum									
3. Millet									
4. Tubers (sweet potatoes, potatoes, cassava, yams)									
5. Groundnuts (unshelled)									
6. Sunflowers									
7. Other (specify)									

Quantity Codes

1 = kg	**2** = 5 Litre Tin	**3** = 20 Litre Tin	**4** = 50kg bag	**5** = 90kg bag
6= bale	**7**= tonnes			

Codes for Question 15.5

1 = Improved Brick granary;	**2 = 1.5mt Metallic Silo**	**3 = 2mt Metallic Silo**
4 = 3mt Metallic Silo;	**5 = Hermatic Bags;**	**6 = Traditional Granary**
7 = Other (specify		

SECTION 16: HOUSEHOLD CONSUMPTION PATTERN AND DIETARY DIVERSITY		
16.1	How many meals did the **members in your household aged 5yrs and above** eat **yesterday**?	
16.2	Is this the usual number of meals these members have in a day?	**0** = No **1**= Yes

16.3 Over the last **seven days**, how **many days** did your household consume the following food items and ***what*** was the **main source** of each food item? ***(Add 99 for Main Sources if food item was not consumed)***

Food Items (use standard items)		**16.4** Eaten yesterday	**16.5** Number of daysin the past 7 days ***(0 to 7)***	**16.6** Main source (***see codes)***
1. Maize , maize porridge, rice, sorghum, millet, pasta, bread and other cereals		0 = No 1 = Yes		
2. Cassava, potatoes and sweet potatoes, other tubers, plantains		0 = No 1 = Yes		
3. Beans. peas, groundnuts and cashew nuts		0 = No 1 = Yes		
4. Vegetables (leafy vegetables, cabbages, tomatoes, onion, carrots, cucumbers, etc.)		0 = No 1 = Yes		
5. Fruits		0 = No 1 = Yes		
6. Meat	beef, goat, pork, game	0 = No 1 = Yes		
	Poultry, eggs	0 = No 1 = Yes		
	Fish/Kapenta	0 = No 1 = Yes		
7. Milk yogurt and other dairy products		0 = No 1 = Yes		
8. Sugar and sugar products, honey		0 = No 1 = Yes		
9. Oils, fats, peanut butter and butter		0 = No 1 = Yes		
10. Spices, tea, coffee, salt, tomato sauce (condiments)		0 = No 1 = Yes		

Main Food Source Codes
1 = Own production
2 = Purchases (cash and barter)
3 = Remittance from **Outside** Zimbabwe
4 = Remittances from **Within** Zimbabwe
5 = Government Food Assistance (in-kind, cash or vouchers)
6= Grain loan scheme
7= Non State Agencies Food Assistance (in-kind, cash or vouchers)
8= Gifts (from non-relative well wishers)
9 = Labour exchange
10= Borrowed
11 = Hunting and gathering from the wild
12 = Gleaning
13 = Other

Section 17: Household Food Security								
17.1 In the last 12 months, have you been faced with a situation when you did not have enough food to feed the household?								
October 2014	November 2014	December 2014	January 2015	February 2015	March 2015			
1= yes 0= No	1= yes 0= No	1= yes 0= No	1= yes 0= No	1= yes 0= N0	1= Yes 0= No			
April 2015	May 2015	June 2015	July 2015	August 2015	September 2015			
1= yes 0 = No	1= yes 0= No	1= yes 0= No	1= yes 0= No	1= yes 0= No	1= yes 0= No			
17.2 What was the cause of this situation? List up to 3 in order of importance use codes below						1st	2nd	3rd
CODES FOR QUESTION 17.2								
1= Inadequate household food stocks due to drought/ poor rains 3= Inadequate household food stocks due to small land size 5= Inadequate household food stocks due to large dependency ratio. 7= Unable to reach the market due to high transportation costs 9= Floods/water logging 10= Other (Specify)				2= Inadequate household food stocks due to crop pest damage 4= Inadequate household food stocks due to lack of farm inputs. 6=Food in the market was very expensive 8= No food in the market				

End of Questionnaire. Thank You.

Appendix B: Key Informant Interview Checklist

The Effectiveness of Innovation Platforms in Enhancing Technology Adoption, Productivity and Viability: The Case of Smallholder Dairying in Rusitu and Gokwe, Zimbabwe.

B.T. Hanyani-Mlambo. bmlambo2010@gmail.com

KEY INFORMANT INTERVIEW (KII) CHECKLIST

Aim: To obtain vital information on smallholder dairy innovation platforms that can reflect a conceptual appreciation by target stakeholders. Standard introduction by name, research focus, and purpose of interview.

Target: Key informants: smallholder dairy participants, stakeholders and experts who are knowledgeable about the smallholder dairy value chain.

Key Informants:representatives of Smallholder Dairy Farmers, Milk Collection Centres (MCCs), MCC committee representatives, traders and livestock buyers, ARDA, DDP, NADF, LPD, DVS, AGRITEX, DR&SS, Dept of Economics and Markets, MAMID, Processors (DZL, Dendairy, Kefalos, Alpha & Omega, Kershelmar), local agro-dealers, private input suppliers (feed manufacturers, veterinary chemical companies, etc), commodity associations, veterinary and agricultural colleges, relevant universities, policy makers, RDCs, DA, NGOs (notably DANIDA, SNV & SCC), Ministry of health as represented by community or district nursing officers or district nutritionists, Farmer Associations (ZFU, ZCFU, ICFU), community leaders, and other dairy extension service providers.

Notables:

(i) Date of interview.
(ii) Name(s) of informant(s).
(iii) Institution/organization represented.
(iv) Informant's capacity within institution/organization.
(v) Contact details – email + cell number.
(vi) Project role + input.

Introduction:

Good morning/afternoon. Thank you for taking the time to talk with me about this smallholder dairy study. My name is..................... I am a PhD student at UKZN. I wish to talk to you about the innovation platforms in smallholder dairying (give brief summary thereof).

The purpose of this discussion is to understand your thoughts, views, and experiences with innovation platforms in smallholder dairying. I will communicate in English. Please feel free to express your points of view even if they differ from expected norms. I want to understand issues on farmer segmentation, innovation platform processes, the effectiveness of innovation platforms, and drivers for effective innovation platforms. Anything you share with me will be confidential. Nothing you say will be personally attributed to you in any reports that result from this discussion. Your participation in this interview is voluntary. Are you willing to take part? Any questions before we start?

Contextual Analysis:

1. How prevalent is rural poverty in Chipinge/Gokwe South district?
2. What is the status of food security in the district?
3. What are the key IGAs in the target districts?

Farmer Segmentation:

1. Characteristics distinguishing participants and non-participants in smallholder dairy IPs (those delivering and not delivering milk to MCCs).
2. Farmer segmentation based on **physical factors** (magnitude of scale, stock type, forage and feeding systems), **farm characteristics** (land and stock ownership, labour, farm income) and **institutional factors** (marketing channels, farmer support systems, economic policies).
3. Farmer segmentation based on similar structural-demographic characteristics + personal attributes.
4. Farmer segmentation based on perceptions, preferences, knowledge, attitudes, practices + behavioural characteristics (likelihood to respond to interventions).
5. Other notable differences among diverse farmer segments e.g. access to resources, services, institutional support, innovations, markets, etc.
6. Household incomes + levels of poverty.
7. Modes and intensity of farmer participation in research, innovation dissemination and utilization (adoption).

Smallholder Dairy Innovation Platforms (Value Chain Analysis):

1. Value chain activities + services.
2. Value chain nodes - input supply, production, processing, marketing, wholesaling, exporting + retailing.
3. Actor analysis of smallholder dairy IPs (who are the VC stakeholders?).
4. Conceptualization of IPs. When is the IP an IP? When are stakeholders an IP or just stakeholders? *e.g. if LPD is doing what is was mandated to do by an IP then it's an IP BUT if LPD is doing it as part of their government mandate then it's not an IP.*
5. Contributions by input providers, producers, processors, buyers + other service providers.
6. Governance – how is the chain coordinated? Which actors/players have influence on the chain and how is it exercised? Who ensures that the chain remains intact (coordination)? How is information relayed across different chain actors? How are the chain actors linked?

7. Volumes in different nodes of the value chain – input, production, wholesale, processing, retail + transport.
8. Costs, prices + margins in different nodes of the value chain.
9. Embodiment (personification), roles, partnership mix, nature of collaboration, boundaries, status, fluidity of membership.
10. Bottlenecks in SHD production, marketing and the policy environment (value chain challenges).
11. Factors influencing sector or sub-sector performance.
12. Opportunities in SHD production, marketing and the policy environment.
13. Opportunities for upgrading – issues of innovation? Process, product, functional + chain upgrading? Ways of improving the governance of the value chain system?

Innovation Platform Processes:

1. Instances of social learning, institutional learning, reflection + common visioning.
2. Processes + examples of technology development, dissemination, adaptation, imitation and adoption. Institutional arrangements necessary to achieve this.
3. Hardware innovations e.g. dairy animal breeds, equipment + animal disease management techniques.
4. Processes + examples of technical, attitudinal, practice, policy, design, organizational + institutional changes / improvements / innovation. Institutional arrangements necessary to achieve this.
5. Context-specific factors affecting innovation.
6. Dynamics + complexities of innovation processes.
7. Existence of continuous feedback loops between different stages of the innovation platform.
8. Level + intensity of stakeholder (including farmer) participation in technology development, dissemination, adaptation, imitation and adoption.
9. Interactions among SHD value chain players (joint planning, implementation and evaluation of initiatives; information exchange, exchange of other resources e.g. finance, personnel + materials).
10. Linkages.
11. Information exchange.
12. Interdependences.
13. Coordination between multiple actors.
14. Instances of joint learning, joint identification of common problems, joint determination of solutions.
15. Instances and examples of collective action e.g. bulk purchase + group acquisition of inputs and marketing of milk.
16. Facilitation.
17. Factors influencing interactions, linkages, coordination + collective action.
18. Innovation platform system constraints.
19. Conflicts, interfaces + negotiations.
20. Social Network Analysis.

Effectiveness of Smallholder Dairy Innovation Platforms:

1. Strengths of established partnerships.
2. Level of coordination.
3. Functionality of innovation platforms.
4. Functionality of knowledge and information networks.
5. Level + intensity of knowledge and information exchange/sharing.
6. Network connectedness (among components) + consistency (shared interests between components).
7. Leverage (power/influence) in scaling out innovations.
8. Access to **resources** (dairy stock, new dairy breeds, new fodder crop varieties, inputs, credit, etc.) and **services** (*1. Technical services* - artificial insemination services, animal health care, extension; *2. Financial services; 3. Business services* - marketing, policy makers, other stakeholders, etc.). **Differential access** for SHD IP participants and non-participants. Causes of such differences.
9. Access to smallholder dairy technologies/innovations. Differential access for SHD IP participants and non-participants. Reasons for high/poor access.
10. Functionality of the markets.
11. Access to market information. Access to markets. Differential access for SHD IP participants and non-participants.
12. Effectiveness of innovation platforms in disseminating innovations.
13. SHD IP influence on innovation credibility, legitimacy, relevance, appropriateness, target domain perceptions + the level of technology adoption.
14. Rate of technology adoption for participants and non-participants. Differences? If so, why?
15. For SHD IP participants and non-participants, what are the current levels of:-
    (i) Productivity – age at first calving, lactation length, milk yields, quantity + quality (premiums) on delivered milk.
    (ii) Market participation.
    (iii) Viability.
    (iv) Competitiveness (pricing).
    (v) Reinvestment into smallholder dairying.
    (vi) Economic and social development.
16. What has been smallholder dairy innovation platforms' influence on:-
    (i) Interventions.
    (ii) Farmer segmentation.
    (iii) Technology adoption.
    (iv) Productivity - age at first calving, lactation length, milk yields, quantity + quality (premiums).
    (v) Market participation.
    (vi) Viability.
    (vii) Competitiveness (pricing).
    (viii) Reinvestments into smallholder dairying.
    (ix) Economic and social development.
17. Factors affecting the effectiveness of smallholder dairy innovation platforms.

Necessary Conditions:

1. Necessary conditions (drivers) for improving intervention, farmer segmentation, technology adoption, productivity, and viability.

2. Examples – access to finance (credit)?, access to inputs?, access to dairy extension services?, access to market information?, access to guaranteed viable markets?, provision of a total package?, commercialization?, linkages?, system coordination?
3. Reciprocity?
4. Interdependence?
5. Common objective + shared vision?
6. Group compliance + group's monitoring capacity?
7. Functional output markets?
8. Participation, benefits + incentives?
9. Critical mass of relevant actors?
10. Continuous technical backstopping from external stakeholders.
11. Ownership by all stakeholders (including local actors)?
12. Ability of IP organizations to conduct critical functions, provide services, develop policy, coordinate + afford mechanism for reducing risk and transaction costs.

Conclusion:
Is there anything you wish to add or comment on regarding this discussion? Is there anyone/stakeholder whom you particularly recommend that we speak to on these issues?

Researcher briefly sums up discussion and ends with: We thank you for participating in this interview and for your input.

Appendix C: Focus Group Discussions Guide

The Effectiveness of Innovation Platforms in Enhancing Technology Adoption, Productivity and Viability: The Case of Smallholder Dairying in Rusitu and Gokwe, Zimbabwe.

B.T. Hanyani-Mlambo. bmlambo2010@gmail.com

FOCUS GROUP DISCUSSION (FGD) GUIDE

Introduction:

Good morning/afternoon. Thank you for taking the time to talk with me about this smallholder dairy study. My name is....................I am a PhD student at UKZN. I wish to talk to you about the innovation platforms in smallholder dairying (give brief summary thereof).

The purpose of this discussion is to understand your thoughts, views, and experiences with innovation platforms in smallholder dairying. I will communicate in vernacular. Please feel free to express your points of view even if they differ from expected norms. I want to understand issues on farmer segmentation, innovation platform processes, the effectiveness of innovation platforms, and drivers for effective innovation platforms. Anything you share with me will be confidential. Nothing you say will be personally attributed to you in any reports that result from this discussion. Your participation in this interview is voluntary. Are you willing to take part? Any questions before we start?

Preamble (Ice Breaker):

(i) Introductions by name, nickname, farming area, and dairy motto.
(ii) What are the key IGAs in this area?
(iii) How prominent is smallholder dairying amongst local farmers?
(iv) What is the socio-economic status of smallholder dairy farmers?

Farmer Segmentation:

(i) What are the local criteria for farmer segmentation?
(ii) What are the existing farmer segments and sub-groups?
(iii) Which characteristics distinguish participants and non-participants in smallholder dairy IPs (those delivering and not delivering milk to MCCs)?
(iv) What other notable differences exist among diverse farmer segments? E.g. access to resources, services, institutional support, innovations, markets, etc.
(v) Are there observable differences in modes and the intensity of farmer participation in research, innovation dissemination and utilization (adoption)?
(vi) Are there tangible differences in household incomes and levels of poverty?

Smallholder Dairy Innovation Platforms (Value Chain Analysis):

(i) Which actors make up the smallholder dairy IPs (who are the VC stakeholders)?
(ii) How is the chain coordinated and governed? Which actors/players have influence on the chain and how is it exercised? Who ensures that the chain remains intact (coordination)? How is information relayed across different chain actors? How are the chain actors linked?
(iii) What are the costs, price + margin structures in input supply, production, processing + retailing?
(iv) What is the nature of the roles, partnership mix, collaboration, boundaries, status, and fluidity of membership?
(v) What are the bottlenecks in SHD production, marketing and the policy environment (value chain challenges)?
(vi) Which factors influence sector or sub-sector performance?
(vii) Which opportunities exist in SHD production, marketing and the policy environment?
(viii) Are there opportunities for innovation, chain upgrading + improving the governance of the value chain system?

Innovation Platform Processes:

(i) Are there instances of social learning, reflection + common visioning within the IP?
(ii) What have been the processes + examples of technology development, dissemination, adaptation, imitation and adoption?
(iii) What are the context-specific factors affecting innovation?
(iv) What is the level + intensity of farmer participation in technology development, dissemination, adaptation, imitation and adoption?
(v) Are there interactions among SHD value chain players (joint planning, implementation and evaluation of initiatives; information exchange, exchange of other resources e.g. finance, personnel + materials)?
(vi) Are there instances and examples of collective action e.g. bulk purchase + group acquisition of inputs and marketing of milk?
(vii) What are the innovation platform system constraints?

Effectiveness of Smallholder Dairy Innovation Platforms:

(i) How functional are the existing innovation platforms?
(ii) How functionality are the knowledge and information networks?
(iii) What is the level + intensity of knowledge and information exchange/sharing?
(iv) Looking at SHD IPs, are there differences between in IP participants and non-participants (those delivering milk to MCCs and those that are not) in terms of access to resources, services, smallholder dairy technologies/innovations, market information, and markets? What are the causes of such differences?
(v) How effective have been innovation platforms in disseminating innovations?
(vi) Are there differences in the rate of technology adoption for participants and non-participants, and if so, why?
(vii) What has been smallholder dairy innovation platforms' influence on interventions, farmer segmentation, technology adoption, productivity, market participation, level of viability, competitiveness (pricing), reinvestments into smallholder dairying, and in economic and social development?

Necessary Conditions:

(i) What are the necessary conditions (drivers) for improving intervention, farmer segmentation, technology adoption, productivity, and viability?

Conclusion:

Is there anything you wish to add or comment on regarding this discussion? Is there anyone in the community whom you particularly recommend that we speak to on these issues?

Facilitator briefly sums up discussion and ends with: We thank you for participating in this interview and for your input.