UNIVERSITY *of the* WESTERN CAPE

DIGITAL INFRASTRUCTURE AND FOOD SYSTEMS IN RURAL COMMUNITIES OF ZIMBABWE

By

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A thesis submitted in fulfilment of the requirements for the degree of Doctor of Philosophy in Development Studies, Institute for Social Development, Faculty of Economic and Management Sciences, University of the Western Cape

November 2019

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ABSTRACT

This study examines the relationship between digital infrastructure and the sustainability of livestock systems in Beitbridge, Zimbabwe. The study aims to answer the question: Do digital infrastructure transformations impact the sustainability of livestock systems in rural communities? By answering this question, the study contributes towards efforts to enhance food security in rural communities, achieve Sustainable Development Goals (1, 2, 5 & 9) at grassroots levels as well as achieve the Zimbabwe Agenda for Sustainable Socio-Economic Transformation. The study details a digital infrastructure intervention in Beitbridge and applies post-positivist approaches towards the intervention's impact assessment to develop recommendations on whether digital infrastructure interventions should be prioritized in rural communities towards improving food security. The study was conducted in four villages of Ward 15 in Beitbridge and the target population were livestock system actors. Using a mixed methods approach, data collection, with the assistance of locally recruited research assistants, was conducted between 2015 and 2018. Qualitative data were collected using community visioning workshops, key informant interviews, focus group discussions and participant observations. Household survey questionnaires were used to gather quantitative data. Data analysis was completed using a mixed methods approach. The first objective of the study, using the Socio-Ecological System framework, was to characterise the livestock system, explore livestock contribution towards household food security and determine the livestock system's sustainability. The study established that livestock play multiple roles towards household food security contributing to different dimensions of food security. Households sell livestock to generate income to purchase (access) food and include animal source foods in their diets even though different consumption patterns of different livestock species were observed. Apart from this, livestock also play sociocultural roles. However, the study established that the livestock system is fragile, stemming from multiple factors such as poor governance and a lack of appropriate infrastructure. Secondly, using Kleine's Choice Framework, the study investigated the potential of digital technologies to contribute towards sustainable livestock systems. Study findings suggest that digital technologies can enhance the dimensions of choice of livestock system actors. However, a lack of digital infrastructure inhibits the integration of digital technologies in the livestock system. The potential of these technologies and the fragility of local value chains has however triggered interventions by government and non-governmental organisations including the MOSMAC project in Beitbridge rural. Therefore, the third objective of the study explored the

impacts of the MOSMAC intervention on the livestock system's sustainability. To achieve this, the study also investigated how context impacts the process of digital infrastructure transformation. The intervention outcomes show that there are important challenges for development practitioners relating to intervention selection, particularly failure to comprehend context, and implementation. This is evidenced by limited success of the intervention. However, there were unintended positive consequences and spill-over effects as the intervention was repurposed to support ICT learning in local schools. Furthermore, impact assessment is an on-going process and the impacts of the intervention on the livestock system's sustainability may continue to emerge with time. Therefore, the transformation of digital infrastructure contributes towards sustainable livestock systems but needs to be complemented by other transformations such as changes in individual agency.

Keywords: Digital technologies, Digital infrastructure, Food security, Livestock system, Socio-ecological systems, Rural communities, Sustainability, Zimbabwe

DECLARATION

I, Leon Tinashe Gwaka, declare that the work contained in this dissertation entitled **DIGITAL INFRASTRUCTURE AND FOOD SYSTEMS IN RURAL COMMUNITIES OF ZIMBABWE** is my own work and I have not previously submitted it, in part or in its entirety, to any university for a degree or examination. All the sources used in the dissertation or quoted have been indicated and acknowledged by means of references.

Leon Tinashe Gwaka November 2019

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Signed

ACKNOWLEDGEMENTS

In completing this work, I am heavily indebted to many people who supported me throughout my studies. Firstly, I thank my supervisors, Professors William Tucker (Bill) and Julian May for accepting to supervise me. I am grateful for your intellectual contributions to this work. You challenged me to think critically, and through your mentoring, improved this study in many ways. Thank you for providing financial support to attend conferences and conduct my field work. To the University of the Western Cape (Bridging Application and Network Gaps: BANG), thank you for your support. I also thank Dr. Corrie Uys for assisting me with statistics. In no lesser way, I acknowledge my family's support throughout my academic studies. To my mother, Precillah, thank you for your hard work, love and support. This is for you. To my young brother, Tadiwanashe, you endured my absence while I completed my studies, but you kept me motivated, thank you. To my friend, Bonolo Mosime, you witnessed my frustrations as well as joys with this study and offered support throughout, *ke a leboga*. To Mr. Munyede, thank you for your encouragement and insightful comments. I also want to thank Dr. Maredza of RAEIN-AFRICA for working with me during the initial phases of this study. In Beitbridge, I acknowledge the support of Ms. Goora, Mr. Mugodzwa, Mr. Pembere, Mr Mugadza, Betty and the local leadership. It was sad to learn of the passing of councillor Ndou who played a significant role during data collection, may his soul rest in peace. I also thank Mr. Gudyani, my MOSMAC assistant and Mr. Mukunga, the local ICT champion. To all the community members who participated in this study, *ndo livhuwa nga maanda*. In addition, I also thank the USAID ResilientAfrica Network (Makerere University) and the SARILAB (University of Pretoria) for the financial and technical support. I also acknowledge AFSA (Alliance for Food Sovereignty in Africa) funding to attend a conference in Addis Ababa, Ethiopia. The BCFN YES! Foundation (Barilla Center for Food and Nutrition Foundation Young Earth Solution) sponsored me to present my work in Milan, Italy. Professor Eric Morgan funded me to attend a workshop in Gaborone, Botswana while The Foundation Daniel & Nina Carasso funded my conference participation at the *3rd International Conference on Global Food Security* and the Centre of Excellence for Food Security (UWC) funded my travel to East London, South Africa. Thank you all. To the three examiners, thank you for the critical comments.

Ultimately, thank you Lord for taking me this far!

DEDICATION

In loving memory of my late father, Douglas.

To my mother, this is for you, *ndinotenda.*

GLOSSARY OF ACRONYMS

AFSA	Alliance for Food Sovereignty in Africa
AIDS	Acquired Immune Deficiency Syndrome
ARPU	Average Revenue Per User
BANG	Bridging Application and Network Gaps
BBRDC	Beitbridge Rural District Council
BCFN YES	Barilla Center for Food and Nutrition Foundation Young Earth Solution
CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
CF	Choice Framework
CFS	Committee on World Food Security
CLF	Converged Licensing Framework
CNs	Community Networks
CRID	Collaborative Resilience Intervention Design
CSC	Cold Storage Commission
CSV	Comma-separated values
DA	District Administrator
DLPD	Department of Livestock Production and Development
DTs	Digital Technologies
ESAP	Economic Structural Adjustment Program
FAO	Food and Agriculture Organisation of the United Nations
GDP	Gross Domestic Product
GIS	Geographic Information Systems
HH	Household
HHH	Household Head
HIV	Human Immunodeficiency Virus
HLPE	High Level Panel of Experts
ICT	Information and Communication Technology
ICT4D	Information and Communication Technology for Development
ICT4S	Information and Communication Technology for Sustainability
ITU	International Telecommunication Union
MDGs	Millennium Development Goals

MOSMAC	Mobile Solutions for Marginalised Communities
POTRAZ	Postal and Telecommunication Regulatory Authority of Zimbabwe
RAN	ResilientAfrica Network
RDC	Rural District Council
RIC4FIG	Resilience Innovation Challenges for Food Security and Improved Income Generation
RILabs	Resilience Innovation Labs
RLMS	Remote Livestock Marketing System
SDGs	Sustainable Development Goals
SES	Socio-Ecological System
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
USAID	United States Agency for International Development
US$	United States Dollar
USSD	Unstructured Supplementary Service Data
VSAT	Very Small Aperture Terminal
ZAR	South Africa Rand
ZimAsset	Zimbabwe Agenda for Sustainable Socio-Economic Transformation

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CHAPTER ONE: INTRODUCTION

1.1 BACKGROUND AND CONTEXT

Food insecurity is one of the major challenges facing humankind in modern day societies (Rao *et al*., 2017). By the year 2050, the global population is expected to reach at least 9 billion people (Yatcilla & Bracke, 2017), and much of this population are expected to be food insecure if current trends within the global food systems continue unchanged (Godfray *et al*., 2010; Tomlinson, 2013). Currently, food insecurity is affecting millions of people across the globe to an extent that it has become a driver of the agenda of international organisations, governments and many other institutions across the world (Leroy *et al.,* 2015). From a global agenda perspective, addressing the food insecurity challenge was part of the Millennium Development Goals (MDGs) between 2000 and 2015 (Brussaard *et al.,* 2010) and currently forms part of the Sustainable Development Goals (SDGs) as goal number 2 stated as, "*End hunger, achieve food security and improved nutrition and promote sustainable agriculture*" by the year 2030.[1] In addition to being on the global agenda, the food insecurity challenge is also dominating national development plans of most developing countries, for instance, Zvavahera and Chigora (2015) show that food security and nutrition is one of the four clusters of the Zimbabwe Agenda for Sustainable Socio-Economic Transformation (ZimAsset) which guides the development initiatives and priorities of the national government.

The complexity of food insecurity has prompted many studies focusing on various facets of the challenge such as the causes, impacts, as well as the potential solutions (Gladwin *et al*., 2001; Swaminathan, 2010). As the discussions and deliberations on solving global food insecurity continue, it is increasingly becoming evident that livestock species play critical roles towards household food security, particularly in rural communities, through income generation, provision of multiple services and being sources of nutritious food (Food and Agriculture Organisation [FAO], 2011; Godber & Wall, 2014; High Level Panel of Experts on Food Security and Nutrition [HLPE], 2016). In support of this, the 43rd Committee on World Food Security (CFS) (2016)

[1] United Nations Sustainable Goals: Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture. Retrieved June 28, 2018 from: https://www.un.org/sustainabledevelopment/hunger/

ratified livestock species' importance towards achieving global and household food security. This ratification was critical considering Thornton *et al's*. (2009) earlier findings that over the years, there has been general neglect of livestock species as part of the poverty alleviation strategy and even as part of the fight against food insecurity.

Despite the importance placed on livestock species towards achieving global and household food security (CFS, 2016; Jaber *et al*., 2016; Smith, 2017) research has not recognised that livestock systems across the globe, and more particularly in rural communities, face many threats including climate change, volatile economic and political climates and poor supporting infrastructure; and thus, are fragile (Herrero & Thornton, 2013; Duru & Therond, 2015). Mavedzenge *et al*. (2008) argue that in rural communities, existing infrastructure relating to livestock systems is inadequate and no longer appropriate. With the livestock systems in rural communities facing all these challenges, the current trajectory points towards these livestock systems failing to make meaningful contributions towards solving the food insecurity challenge. Current studies show that if livestock systems are to play the key role which they are expected to play towards improving food security, there is need to transform the current livestock system (Mavedzenge *et al*., 2008; Barrett *et al*., 2017) but there is no consensus yet among researchers on what exactly needs to be transformed (Foran *et al*., 2014; Oliver *et al*., 2018). This reflects differences in how individuals understand the livestock system supporting Checkland and Scholes (1990) suggestion that "systems are only in the eye of the beholder"[2]

Parallel to the prevalence of food insecurity and livestock systems' fragility is the ubiquity of digital technologies (DTs) (Seele & Lock, 2017). Cognisant of this, Choi and Graham (2014) believe that these emerging digital technologies have the potential to play a critical role towards reconfiguring food systems (Deichmann *et al*., 2016) and this is despite the potential of rural communities benefitting from digital technologies being a persistent question (Malecki, 2003). Concurring with Choi and Graham's remarks, Majchrzak *et al*. (2016) also suggest that the proliferation of digital technologies in modern-day societies, even in rural communities, has

[2] The food system is defined by Ericksen (2008) as "a set of activities and outcomes ranging from production through to consumption, which involve both human and environmental dimensions" Similarly, Oliver et al. (2018:2) define a food system as "the network of activities and processes from production to consumption, including manufacture, packaging, transport, retail and associated business. However, for this study, in addition to adopting both perspectives, the term is also interchangeably used to refer to livestock systems. See section 3.1.2 for further discussion.

implications on the attempts to solve the complex challenges in societies, food insecurity included. However, the major complexity with this perception is the general lack of supporting infrastructure in rural communities. To this end, Rogers and Mitzner (2017) indicate that if digital technologies are to play a role in solving community complex problems (including food insecurity), there is a need to develop necessary supporting infrastructure in the rural communities.

The lack of infrastructure, including digital infrastructure, in rural communities is a result of several factors including the fact that most governments in developing countries have limited resources to transform the infrastructure.[3] Furthermore, in most developing countries, those with the resources to undertake infrastructure transformation are often frustrated by stringent policies in place. This is in addition to being discouraged by a perceived lack of demand for the digital services and products (Andrew & Petkov, 2003). Consequently, in a bid to improve the welfare of rural communities (e.g. health care, education and even agriculture, including livestock systems), efforts to transform digital infrastructure in rural communities are now spearheaded by international and national development agencies (donors) such as the United States Agency for International Development (USAID) and the Catholic Relief Services (CRS).[4] However, while donor interventions in poor countries have increased recently, there are several concerns with these donor interventions in underdeveloped areas, particularly the failure of these interventions to deliver substantial change in the areas. Sein *et al.* (2018) indicate that accurately measuring the impacts of the donor interventions is complex. However, there are no signs of donor-funded interventions, particularly infrastructure development initiatives, slowing down in rural communities; prompting a need to explore the impacts of these interventions on solving community problems.

Therefore, this thesis investigates the impacts of a digital infrastructure transformation intervention in a rural community on the sustainability of a livestock system; or more broadly, of food systems in rural communities. Empirical evidence is drawn from the Mobile Solutions for Marginalised

[3] Mills (2012; 2018) provides a counter argument that African countries do not lack resources but rather, the African leaders have become adept at externalizing blame, holding others responsible for Africa's failings. Omoregie and Radford (2006) also demonstrate that the lack of infrastructure in Africa is partly due to poor contract management (Non-adherence to contract conditions, mistakes and discrepancies in contract documents) as well as fraudulent practices and kickbacks (p.85). Further concerns include abandoned and incomplete projects which all amount to billions of dollars lost in poor investments.

[4] There are several grassroots non-governmental organisations (NGOs) but most funding which sustain these grassroots NGOs is provided by international donors.

Communities (MOSMAC) project implemented in Ward 15 of Beitbridge, Zimbabwe by the doctoral student through partnership with the SA RILab at the University of Pretoria. The project's aim was to improve the agricultural returns for the smallholder farmers, including livestock farmers, through digitisation of the value chain. The project implementation and subsequently the research inquiry, is developed from the presupposition that digital infrastructure transformation interventions in rural communities are driven by their potential to contribute towards overcoming societal challenges such as the fragility of the food systems.[5] By undertaking a critical analysis of the impact of an intervention, the study contributes towards the process of identifying and selecting interventions which work and which need to be scaled or promoted within rural communities. Furthermore, through extensive analysis of the livestock system, this nature of inquiry contributes to the existing efforts to establish "where the problems lie and what [needs] to be done" (Anadon *et al*., 2015:4) within the rural livestock systems.

1.2 RESEARCH PROBLEM

Food systems, including livestock systems, in rural communities are fragile, contributing to the intensification of food and nutrition insecurity (Battisti & Naylor, 2009). Many studies such as Mavedzenge *et al.* (2008), Barrett *et al*. (2017) and Kopainsky *et al*. (2017) concur on the need to transform the current structure of food systems (production patterns, market systems, infrastructure, and policy aspects among many aspects) if global food security is to be achieved. The food systems' structure is made up of multiple components and this has resulted in several and often conflicting suggestions on what needs to be transformed to achieve sustainable food systems (cf. Foran *et al*., 2014; Garnett, 2014). In the same vein, there are many questions about the sources of vulnerabilities of food systems and the potential solutions (Anadon *et al.*, 2015; Oliver *et al*., 2018). Notenbaert *et al*. (2017:154) posit that, in part, it is likely that the vulnerability of food systems including the livestock systems is prolonged by poor "selection, targeting and prioritization of interventions" particularly in rural communities[6]. In the context of interventions, there have been increasing suggestions that information and communication technologies (ICTs), or more broadly, digital infrastructure, can play a role towards solving societal challenges,

[5] See, http://sarilab.ranlab.org/content/mobile-solutions-marginalised-communities-mosmac-innovation

[6] In the context of this study, the term 'interventions' is used to refer to "Projects of interventions [which] are initiated either by external donor agencies or the state" (Quarles van Ufford *et al.*, 2003, 30-31).

including overcoming livestock systems' fragility (Majchrzak *et al.,* 2016; Choi & Graham, 2014; Gwaka, 2017; Prinsloo & De Villiers, 2017). These suggestions are prompting huge investments, mostly initiated by external parties such as humanitarian agencies, in interventions relating to digital infrastructure in rural communities. Despite these efforts, there is limited and conflicting empirical evidence on the impacts of the interventions on solving societal challenges (Friederici *et al*., 2017; Aker & Ksoll, 2016; Burrell & Oreglia, 2015). This challenge is further exacerbated by the complexity of understanding the specific systems that are plagued by problems. As Oliver *et al*. (2018:1) indicate, "… our knowledge regarding food system transformation is fragmented hindering the development of coordinated solutions" and in all this confusion "a significant challenge is to prioritize suites of interventions that can effectively transform the food system." Furthermore, van Berkum *et al*. (2018:25) concur with these remarks and indicate that, "the complexity of the food system makes it extremely difficult to precisely pinpoint the relationships and feedback mechanism between the different parts of the system (and with other systems) and to say what will work in order to improve system outcomes." To this end, this study argues that there is limited knowledge on the extent to which interventions targeting digital infrastructure transformation in rural areas, such as the Mobile Solutions for Marginalised Communities (MOSMAC) intervention in Beitbridge probed in detail by this thesis, contribute to the transformation and sustainability of the food system thereby "providing lasting solutions to the problems of vulnerability" in rural communities such as Beitbridge (cf. McCarthy, 2014:145). To establish this, Pawson (2006:14) suggests undertaking intervention impact assessments which "[n]o longer aim at the simple issue of charting the success or failure of specific interventions" but ask "evaluation questions [which] rove over the topics of when, where, why, for whom and in what respects [interventions] work, as well as how, in what manner and at what cost."

1.3 RESEARCH QUESTIONS

The primary research question investigated in this study reads as: Do digital infrastructure transformations in rural communities of Zimbabwe impact the sustainability of livestock systems, and if so, how and in what ways? This primary research question is further supported by the following sub-questions:

i. What roles do livestock species play towards household food security in rural communities and how sustainable are the livestock systems in rural communities?
ii. How does the adoption and use of digital technologies in rural communities contribute towards the sustainability of the livestock systems?
iii. How does context impact the process of digital infrastructure transformation and in what ways can the impact of the digital infrastructure transformations intervention in rural communities be assessed?[7]
iv. Do the impacts of digital infrastructure interventions on livestock systems warrant their prioritization as interventions to improve food security in rural areas?

1.4 RESEARCH OBJECTIVES

The primary objective of this study is to establish whether digital infrastructure transformations in rural communities of Zimbabwe impact the sustainability of livestock systems, and if so, how and the ways it does. This primary objective is further supported by the following secondary objectives:

i. To characterise the livestock system in the study area, establish livestock contribution towards household food security and the study area's livestock system sustainability.
ii. To establish if the adoption and use of digital technologies contribute towards sustainable livestock systems in rural communities.
iii. To understand how the Zimbabwean 'context' impacts the establishment of ICT for Development (ICT4D) initiatives and critically assess an intervention's impact on the sustainability of the livestock system.

1.5 STUDY CONTRIBUTION

In answering the research questions set out in this study, this thesis broadly contributes towards the efforts to establish interventions which work in order to enhance food security in rural communities. At a global scale, the study contributes towards achieving the SDGs, specifically

[7] In this study, context refers to the political environment (including governance systems), social and economic dynamics of the community. Moran and Dourish (2001:89) define context as "the physical and social situation in which computational devices are embedded". However, Hayes and Westrup (2012:23) also suggest that context is relational and dynamic; and researchers need to focus more on *how* it is represented than adequacy of the representation.

goal number 2, at grassroots level. At a local level, the study contributes towards achieving the clusters of the Zimbabwean national development plan, the ZimAsset. In addition to this, other specific contributions stemming from this study, which are further elaborated in Chapter 8, are as follows:

- In applying the Socio-Ecological Systems (SES) framework to analyse the Beitbridge livestock system and its sustainability, the research provides new insights critical for the understanding of the potential underlying causes of the livestock system fragility in rural areas (cf. Alarcon *et al*., 2017). The thesis demonstrates the application of the SES framework to explore key local value chains highlighting the merits and shortfalls of the framework. The thesis further shows how the SES framework is useful in problem identification within a SES as well as solution formulation. In addition to this, the thesis demonstrates how theories and frameworks drawn from different and to an extent, unrelated disciplines, can be integrated to address a complex challenge. The challenge presented in this study is socio-technical in nature and the thesis has combined SES, Choice Framework (CF) and Technology Affordance (TA) theory to address this challenge. By linking these theories and frameworks together, the thesis demonstrates potential extensions of each theory and framework.

- Further, the debates on food security (food systems) and ICTs continue to dominate the research agenda. In recent years, there has been an urgent need for evidence building particularly to inform policy. This thesis contributes towards evidence building in the two broad fields of food systems and ICTs. In terms of food systems, the study has demonstrated the role of livestock; particularly clarifying when and how livestock contribute to household food security. Also, by critically engaging literature, the study, in Chapter 3, contributes towards clarifying the concept of food security by extensively exploring the various food security dimensions. Further, through the SES approach, the study demonstrates the various attributes of a food system which need to be addressed when dealing with the food security challenge; *i.e.* the thesis demonstrates that food systems comprise governance systems, actors, resource systems and resources units. In addition, the food system is situated within a broader social, economic and political context.

- In terms of evidence building for ICT4D, the thesis demonstrates potential alternatives to address the lack of ICT facilities in rural areas and integration of ICTs in local value chains. Through the MOSMAC intervention, the study develops evidence on how context impacts ICT interventions. Further to this, the thesis demonstrates that an intervention's trajectory is unlikely to follow its planned pathway. The thesis demonstrates how ICT interventions become embedded in the society and thus, become part of assemblages. In addition to this, the thesis also contributes to ICT intervention impact assessment. The thesis demonstrates various ways of impact assessment and further critiques these approaches. Through this, the thesis provides evidence supporting the need for the development of robust and comprehensive impact assessment approaches.

- In addition to evidence building, the thesis also makes contributions to research methods on complex systems. This thesis applies an interdisciplinary approach to address the multiple challenges faced within communities; *i.e.* food insecurity and infrastructure deficit. The thesis demonstrates that research on complex systems can benefit from borrowing research methods from other disciplines. Drimie and McLachlan (2013: np) indicate that application of transdisciplinary approaches is innovative in that it demonstrates the "linking [of] cutting edge natural science and technology with cultural and social needs." The community visioning approach used in this thesis is often used in urban studies, within developed countries, and it has been applied in this study yielding critical findings. In addition, the study demonstrates a participatory research approach which promotes inclusiveness (thus, researching with the participants and not researching about the participants). To an extent, the thesis also demonstrates reflexivity, where I, as a researcher, situate myself within the study. Overall, the orientation of the study within interdisciplinary approaches, theories and frameworks is novel towards solving complex global challenges.

- In the context of digital infrastructure transformation in rural communities, specifically community networks initiatives, the study acts as a 'preparatory guide' for would-be investors, policy makers and other stakeholders for community network initiatives in Zimbabwe. The Postal and Telecommunication Regulatory Authority in Zimbabwe (POTRAZ) is on the verge of countenancing the development of community networks yet

the historical cases of Zimbabwe telecoms portray a hostile environment for potential investors. Evidence presented in this thesis serves to demystify misconceptions of and/or clarity about the context of Zimbabwe and ICT initiatives. Thus, practically, this study has contributed to the development of a local community information centre (see *section 5.3.1*) and local community network (work in progress) which improves access as well as affordability of ICTs in rural communities. This development is supporting primary schools in the community in delivering ICT education which is entrenched in the new education curriculum.

1.6 THESIS STRUCTURE

This thesis consists of eight chapters. **Chapter One** has introduced the topic investigated in this thesis, presented the research questions guiding the thesis and stated the contributions made by the thesis.

Chapter Two provides a contextual background of the study area. The chapter describes the study area's geographic features, human population dynamics and the biodiversity distribution. These descriptions are then connected to the livelihood options practiced by the households within the study area which include livestock systems, natural resources, donor interventions and interaction with the border. The chapter then turns to focus on the development challenges affecting the study area. In the chapter, it is argued that drought/climate change and infrastructure deficit are the key development challenges impacting general livelihoods, and the livestock system's sustainability, in the study area. Furthermore, the chapter demonstrates the interconnectedness of the different development challenges. The chapter concludes by describing the development trajectory of the study area showing that most development initiatives are led by external non-governmental organisations since the government and local authorities have limited resources to undertake key projects.

Chapter Three then focuses on discussing the key terms used in the study as well as the theories and frameworks on which the study is anchored. The chapter also provides a review of the related work. The chapter examines different perspectives on the study's key terms which are: food security, livestock systems, sustainability, digital infrastructure and impact assessment which is followed by drawing up the working definitions for the study. The chapter also discusses the

application of the selected theories and frameworks showing how the constructs of these theories and frameworks are applied to the study as well as how they complement each other. Specifically, the chapter discusses Ostrom's Socio-Ecological Systems framework, Kleine's Choice Framework and the Technology Affordances theory. Further, the chapter provides a review of related studies on food security and livestock systems, digital infrastructure (ICTs) and impact assessment to situate the study in the current debates (scholarship) and identify the existing gaps which the study purports to address.

Chapter Four is a discussion of the research methodology and design. The chapter provides details on how data used in the study were collected, analysed and presented. Furthermore, the chapter gives details of community selection, entry and engagements. The chapter also addresses issues relating to ethics as well as research limitations of the study.

Chapter Five provides study findings relating to the study area's socio-economic system, *e.g.* demographics, livelihood options, household food security and livestock system dynamics. The major contribution of the chapter is that it provides details on the state of food security in the study area, livestock contributions towards household food security and assesses the sustainability of the livestock system. The chapter adopts Ostrom's (2009) SES framework to achieve this. Some of the empirical findings presented in this chapter were presented at the 3rd International Conference on Global Food Security.

Chapter Six is a combination of work from two journal articles published during the completion of the thesis which are: *Digital Technologies and Sustainable Livestock Systems in Rural Communities* (Gwaka, 2017) and *Towards low-cost community networks in rural communities: the impact of context using the case study of Beitbridge, Zimbabwe* (Gwaka *et al*., 2018). The purpose of the chapter is to discuss the state of digital infrastructure in the study area, including aspects of connectivity, ICT ownership, access and use among the households. The chapter then shifts to describe the process of implementation of an ICT intervention, the MOSMAC project, which sought to overcome some of the identified challenges. The chapter explores the processes and complexities relating to efforts to undertake digital infrastructure transformation in the study area. The complex socio-political environment is cited as a contributing factor, but transformation of policies was identified as encouraging signs.

Following the discussion on the implementation of the MOSMAC intervention, **Chapter Seven** is a discussion on the intervention's impact assessment. The chapter is developed from a manuscript titled: *A theoretical and empirical investigation on the impacts of digital infrastructure transformation on livestock system's sustainability using a case study of Beitbridge, Zimbabwe*. In exploring the intervention's impacts on the livestock system, the chapter focuses on three dimensions which are: the funder's perspective, a theoretical perspective as well as the empirical perspective. The chapter argues that current metrics (mainly quantitative and Eurocentric) are inappropriate for measuring impact in rural contexts. Also, the chapter argues that impact assessments need to be conducted in real-time opposed to at the end of the project. The chapter applies a critical perspective to the impact assessment but also evaluates digital infrastructure transformation's impact using the theories and frameworks adopted in this study which are: Choice Framework, SES framework and technology affordance theory.

Finally, the study is concluded in **Chapter Eight** which presents the conclusions (answers the main research question) and outlines the impacts of the study on policy and practice. Furthermore, the chapter discusses potential future research avenues.

CHAPTER TWO: CHOICE AND CONTEXT OF STUDY AREA

> *"Realism, as a philosophy of science, insists unearthed in empirical investigation are intelligible only if we understand mechanisms which give rise to them and the contexts which sustain language, this is equivalent to saying that we need to know circumstances programmes affect potential subjects before we can 'work'*." (Pawson & Tilley, 1994:292)

Chapter overview

This chapter focuses on providing a detailed description as well as the key characteristics of the study area which influenced and to some extent, justifies its selection for the study. While the research methodology chapter, Chapter Four, further expands on the study area selection, it is critical to provide key background information necessary for the reader to develop insights about the community in which the study was conducted. This approach of providing context before theory (which follows in Chapter 3) builds on Pawson and Tilley (1994:292) who suggest that context is critical and should drive enquiry rather than theory. To this end, the chapter provides geographic and socio-economic information with a specific focus on the study area location, livelihood options and development challenges faced in the study area. The chapter highlights that there are several development challenges faced in the study area and these challenges are interconnected; thus, interventions implemented in the study area need to be system driven. The chapter consists of five main sections starting with an overview of the Beitbridge area provided in section 2.1. Following this overview, section 2.2 outlines the livelihood options within the community which are, to a larger extent, influenced by the context of the area. The chapter also demonstrates that the geographic (in a natural rainfall region) and physical (at the border of South Africa and Zimbabwe) location of the study area influence the livelihood options of the community households. For instance, the geographic location of the area allows specific activities to be undertaken, e.g. border-related activities, which would not be common in other rural areas not situated close to a border. In section 2.3, the chapter then explores the multiple development challenges faced in the study area. Like many other rural areas, key challenges identified within the study area include drought/climate change, extreme poverty and infrastructure deficit. The interconnectedness of these development challenges is also demonstrated in this chapter using the

findings from the ResilientAfrica Network's study. This analysis shows how collectively the different development challenges are creating a 'poverty trap' for the study area, suggesting the need for holistic approaches to solve the multiple development challenges. Based on the current efforts to overcome the different development challenges, the chapter then shifts to analyse the development trajectory of the study area in section 2.4, showing that the development pathways in the study area continue to be influenced by external parties (donors) and not the communities affected; thus, top-down approaches continue to prevail in the development of the community. Finally, a chapter summary is presented in section 2.5.

2.1 THE CONTEXT OF BEITBRIDGE

Over the past decade, Zimbabwe has experienced a series of socio-economic challenges such as unemployment, poverty, economic crises and political turmoil. While these challenges are endured by Zimbabwe as a country, studies show that often the households in rural areas such as Ward 15 of Beitbridge District face enormous risks (Kinsey *et al*., 1998). Further analysis, however, reveals that contextual differences of these areas such as geographic features, biodiversity, and infrastructure as well as population dynamics of the society, have an impact on the distribution of the problems among the rural areas. Therefore, before focusing on the problems facing the households in the study area, and the specific problem which this study aims to address, it is critical to develop general insights on the specific (contextual) features of the study area which can help create a context for the study. To achieve this task, this section provides descriptions of the study area's geographic features, including its specific location, human population dynamics and biodiversity distribution within the area. These descriptions lead to a discussion on the livelihood options practiced by the households and supported by these specific features.

2.1.1 Geographic features and location

Beitbridge district is located in Matabeleland South Province, one of the eight rural provinces in Zimbabwe (Vogt *et al*., 2015). The district borders Zimbabwe with South Africa and one of the busiest ports of entry in Zimbabwe, the Beitbridge border post, is also located in the district. The Limpopo River divides South Africa and Zimbabwe and some of the households included in this study, specifically in the Dumba village, are situated along the riverbanks of the Limpopo River. Over the years, the Limpopo River has been used for illegal crossing into South Africa and

smuggling of goods between South Africa and Zimbabwe. These illegal activities have since become an integral part of the livelihoods of the households in the study area. For instance, some community members in the study area generate income from facilitating the illegal crossings such as transporting and guaranteeing protection of illegal travellers. However, these illegal crossings have also exposed many people to vulnerability including human rights violations. For instance, existing studies report that during illegal crossings, women are vulnerable to sexual abuse while male counterparts are vulnerable to extortion (Mawadza, 2008).

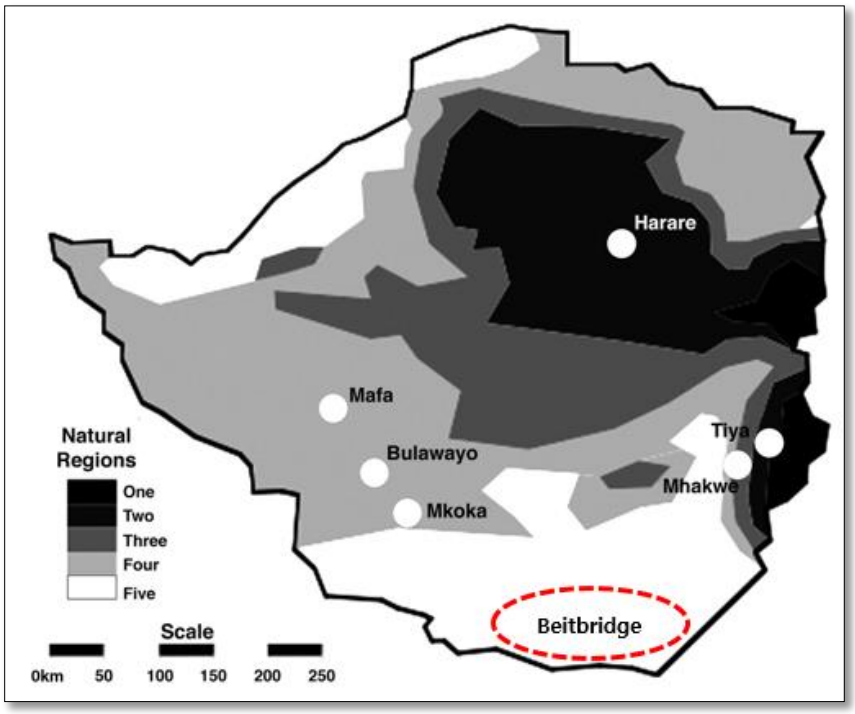


Figure 2.1: Map of Zimbabwe showing natural regions
Source: Patt *et al*. (2005)

Apart from this geographical aspect, Figure 2.1 shows that Zimbabwe is divided into five natural regions which are based on the average annual rainfall received, and Beitbridge district is located in natural region Five which receives below 500mm of rainfall annually (Mugandani *et al*., 2012). These erratic rains contribute to the frequency of droughts in Beitbridge which in turn has several implications on the livelihoods options of the community households. Owing to the little amount of rainfall received annually and the average temperatures experienced in Beitbridge, crop

production, which is one of the main activities on which most rural areas depend on for livelihoods, is limited and uncommon. Against these circumstances, livestock production has been the major livelihood option for most households (Mugandani *et al*., 2012).

In the context of the study, developing an overview of the geographic features of the study area is key in that the geographic location and/or features (e.g. rainfall patterns) are considered to be an individual's or a group's *agency/resource* which ultimately has an impact on the dimensions of choice of the individual or group (Kleine, 2010). On the other hand, within the socio-ecological systems framework, the location of a resource system and the actors is also a key attribute of a system contributing to the fragility and/or sustainability of that particular system (Ostrom, 2009). Therefore, in this study for instance, the geographic proximity of the study area to South Africa offers the community dimensions of choice e.g. individuals in the area can choose to engage in border-related activities which other people staying in different rural areas not located close to borders would not be able to do. On the other hand, the geographic location, i.e. the distance from major towns such as Harare, Masvingo and Bulawayo, disadvantages the local community in relation to the marketing of various local goods including natural resources and livestock. However, while the geographic area is a critical attribute of a socio-ecological system, it is argued that as a single factor, it is insufficient on its own to determine a system's outcomes as other attributes play critical roles. For instance, while the study area is close to South Africa, mobility such as livestock movement between South Africa and Zimbabwe is restricted by the specific governance elements such as *rules-in-use* (cf. Ostrom, 2009).

2.1.2 Human population

According to recent statistics, the Matabeleland South Province in which Beitbridge district is located has the second lowest population density in the country at 12 people per square kilometer. The low population density in the Matabeleland South Province can be attributed to the adverse climatic conditions and to the effects of outmigration of the working population (15-35 age group) to neighboring countries such as Botswana and South Africa. This is further substantiated by claims that "population is very mobile, with a high volume of legal and illegal cross-border movements" (Vogt *et al*., 2015:3).

In addition to this, the Beitbridge district is a multi-ethnic cultural district comprising Suthu, Venda and Shangani ethnic groups (Matsa *et al*., 2017). Due to the proximity of the study area to the South African border, there are families and relatives living across South Africa and Zimbabwe. In some instance, relations have developed over time and these families identify together. Moyo (2016:427) argues that:

> "*Venda-speaking people on both sides of the border post who were "separated" when the border was drawn have always engaged in dynamic and agentive ways that defy the existence of the border. This interaction pre-dated and survived the colonial and apartheid years in the then Southern Rhodesia and South African Republic, respectively*."

Existing studies characterise the human population in rural communities as mainly dominated by the elderly who are often sick and with limited academic education (cf. Mango *et al*., 2014). The lack of economic opportunities in rural areas such as Beitbridge has been identified as a push factor prompting the outmigration of the economically active groups to areas with economic opportunities. In the context of Beitbridge, one of the human population characteristics is the outnumbering of men by women within the households. The proximity of the study area to South Africa and Botswana borders has incentivized the migration of male, especially youths, to neighbouring countries in search of employment opportunities. Consequently, women within the study area have been left to assume traditionally male duties.

In this study, the human population characteristics for the study area are critical in examining the general livelihoods practiced, as well as the impact of the human population characteristics on the livestock systems sustainability. Gladwin *et al*. (2001:180) suggest that "household-level livelihood systems characteristics are in large part determined by gender roles which can change over time." Similarly, in the context of ICT adoption and use, the human population characteristics play a key role. It can be argued that the human population within a specific area impacts the nature of the livelihood activities undertaken. For instance, cultural expectations within African societies are that women would be involved in light house chores while men in heavy duty activities. Thus, with most men migrating to South African in search of economic opportunities, this impacts the extent to which livestock activities are undertaken within the study area.

2.1.3 Biodiversity

In rural communities such as Beitbridge, access to land and natural resources are among the most important issues (Metcalfe, 1996). According to Agnoletti (2014:67), when studying biodiversity, consideration should also be made on the historical importance placed on landscape; thus, suggesting studying "landscapes more as a natural resource than as a cultural phenomenon." Despite the harsh climatic conditions experienced in Beitbridge, studies have acknowledged the richness of the area's biodiversity (Child & Peterson, 1991). Furthermore, the dry conditions experienced in the study area are considered ideal for other seasonal biodiversity species such as mopane worms, morula fruit and baobab from which households derive livelihoods. However, in a recent study, Matsa *et al*. (2017) show that Beitbridge's biodiversity has been severely affected by climate change. For instance, in recent years, the biodiversity in Beitbridge is characterised by silted rivers, extinct plants, animals as well as bird species, and shortages of pastures, firewood and water (*ibid*). Apart from climate change (global environmental changes), there are many other factors which have been linked to the deterioration of the biodiversity; and these include human activities, poor resource governance and population growth leading to overexploitation of resources. While biodiversity loses may be attributed to natural processes, Sundström (2016) argues that corruption and rule violation also frustrate the biodiversity conservation efforts.

Despite the deterioration of the community biodiversity, the rural communities continue to make efforts to manage their natural resources; and Ferraro and Simpson (2005) also demonstrate that apart from the local efforts to conserve biodiversity, international organisations, including donor agencies, have made substantial investments in conserving biodiversity in rural communities. In the district, the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) program has also played a critical role towards biodiversity conservation (Child & Peterson, 1991). In Beitbridge, the conservation efforts are at different levels. For instance, the local council and related government department - *Environmental Management Agency* - (EMA) utilise statutory instruments for the management of biodiversity while at community levels, local rules, taboos and belief systems developed in particular contexts are utilised (Fabricius & Koch, 2013). In the same context, Milfont and Schultz (2016) further demonstrate that cultural beliefs of individuals impact the relations between human and environment.

In the context of the study, the biodiversity has an impact on the livelihoods of the community and affects the sustainability of the livestock system. Studies such as Herrero *et al.* (2009) argue that livestock occupy large spaces of land and may be contributing to the biodiversity losses. It can therefore be argued that the interaction of livestock and biodiversity is bi-directional, and based on the SES framework, it is critical to establish the equilibrium dynamics of resources within a resource system.[8]

2.2 LIVELIHOOD OPTIONS

While the Beitbridge district faces a plethora of challenges, some already pointed out in the preceding section, there are also various livelihood options practiced by the households to generate income needed to access food, pay medical bills and other expenses. The geographic location/features, human population and biodiversity also influence these livelihood options. Since the district's climatic conditions are not ideal for crop production and as a result of the area's proximity to the border (including, the Limpopo River), the livelihood options tend to differ from many other typical rural areas in Zimbabwe. However, one similarity of the study area to most rural communities is that wage employment in the study area is also low. Formal income earning opportunities are extremely limited, thus, most individuals (mostly male) cross the Limpopo river in search of employment in South Africa. Within the study area, women are involved in several trades such as harvesting and selling of natural resources, community gardens initiatives and community saving clubs. On the other hand, male dominated activities include selling of livestock and facilitating border crossing as well as buying and selling of products from South Africa. This section presents further discussion of the selected key livelihood options, livestock, natural resources, donor interventions and interactions with the border.

2.2.1 Livestock

In Zimbabwe, Beitbridge is one of the leading livestock-production districts. Mupangwa *et al*. (2016) show that the Beitbridge area falls in a generally dry area; thus, is suitable for livestock rearing and limited varieties of crops. To this end, families in the study area have practiced livestock production as a primary coping strategy for many years. Chingarande and Ayo-Yusuf

[8] A detailed discussion of the SES framework is provided in Chapter Three.

(2016) found that in Beitbridge, despite the poverty levels, households own significant numbers of livestock including cattle, goats, sheep and donkeys. There are many justifications which the rural households provide for holding these large numbers of livestock which include using livestock as storage of wealth (live banks), for social and cultural practices such as paying lobola, appeasing the ancestors, as a source food (meat, milk) as well as a major source of household income through selling to obtain income to cater for the various household expenses (Scoones, 1990). As indicated in Figure 2.2, livestock contribute to household food production (as draught power), provide food to households (although the contributions of specific livestock species vary) as well as generate cash (income) for the households.

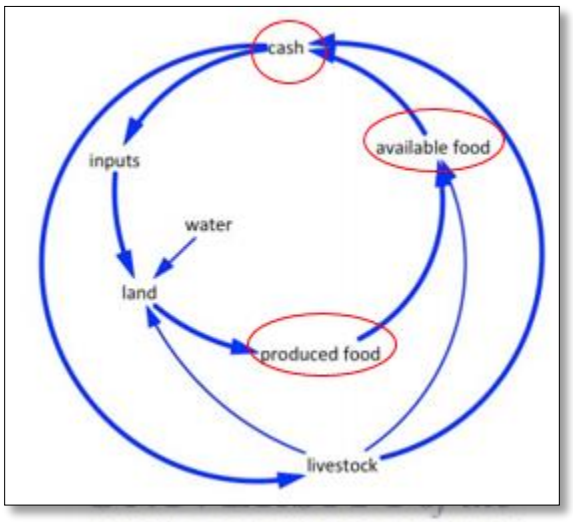


Figure 2.2: Interlink of livestock and human living in the community
Source: Kopainsky *et al*. (2017:103)

While there are several roles played by livestock, producing income for households has been a major function for livestock for many years. However, the patterns relating to livestock production and marketing in rural communities have significantly shifted over the years. Giving historical details on the livestock system in Zimbabwe, Mlambo (1996) shows that during the colonial period, the livestock sector was deemed to be of strategic importance to the colonial government and its development would have failed without the support of the government. Therefore, a parastatal – *the Cold Storage Commission* (CSC) – was formulated to support the livestock sector (*ibid*). However, the formation of the CSC in 1938 was preceded by a series of problems and some of these problems continue to prevail to date (see Mwatwara & Swart, 2017:587). The

establishment of the CSC strengthened the livestock system in Zimbabwe. For instance, Mlambo (1996:62) shows that "the commission had also succeeded in providing cattle farmers with a guaranteed market for their product and restoring the farmers' confidence in the viability of the industry."

However, the adoption of the Economic Structural Adjustment Programme (ESAP) in Zimbabwe recommended the privatization of the CSC (Mavedzenge *et al.,* 2008). Economic and political transformations, particularly land invasion and a failing economy, within the country led to many changes; even the collapse of the once lucrative commission leading to the emergence of multiple livestock marketing agencies. By the year 2000, a new livestock marketing system had emerged characterised by "informal, sometimes illegal, market interactions, involving many more, and very different, actors, connected through diverse and complex interactions" (Mavedzenge *et al*., 2008:619). New market configurations emerged and in some rural communities, livestock auctioning even discontinued with unscrupulous buyers taking advantage of this to offer farmers sub-standard prices for their livestock (Chikwati, 2016).

Therefore, while livestock is important, there are several challenges facing the livestock systems; threatening livestock as a coping strategy. In recent years, studies including my work, *e.g.* Gwaka (2017), demonstrate that farmers in the study area are failing to obtain optimal prices for the livestock; while Descheemaeker *et al*. (2018) show that climate change is further impacting the sustainability of the livestock system. Despite the major transformation, mostly negative, of livestock system dynamics in the study area, the households in Beitbridge, like many other households across sub-Saharan Africa, continue to rely on livestock as a coping strategy and even using livestock as a risk management tool which is critical in ensuring that households have a fallback during times of hardships.

2.2.2 Natural resources

Apart from livestock, the Beitbridge district is also rich in natural resources such as baobab trees, river reeds, and mopane worms. Many studies including Ellis and Allison (2004) as well as Matose (2006) have indicated that households in rural areas such as the study area rely on harvesting and selling these natural resources. Apart from harvesting for selling, the communities also consume some of these natural resources; *e.g.* mopane worms are considered a rich source of micro-nutrients

while baobab also forms part of the daily meals in rural areas. However, households relying on natural resources in the rural areas were noted to sell these natural resources unprocessed (with no value addition) resulting in low income. The lack of value addition in rural areas was also noted in the livestock value chain. In an analysis of a livestock value chain, using the SES framework, Marshall (2015) suggested that there were limited (or no) transformation services in rural areas; thus, these communities often sell their products without adding value (processing/refining) leading to the communities realising less value. There are several value chain actors who buy these unprocessed products for further processing, *e.g.* oil press (baobab) and reselling at high value.

However, from the community engagement activities conducted during this study, it was identified that relying on natural resources was increasingly becoming a risky option considering the climate change's effects on the natural resources. From the discussions with the community and local authorities, it was established that between 2015 and 2016, the study area experienced erratic weather conditions which negatively impacted the natural resources. During this time, the baobab trees did not produce enough baobab fruits while mopane worms did not emerge as normal. Apart from this, there are also other concerns with the community's reliance on natural resources. For instance, during the peak times of the natural resources e.g. mopane worms, school-going children are often forced to miss school to help the family in the harvesting of mopane worms. On the other hand, there were also concerns that during the harvesting of the natural resources, young children are prone to child labour.

2.2.3 Donor interventions in the community

According to Muchadenyika (2016), Zimbabwe is a fragile state faced with a plethora of challenges. The failure of the Zimbabwean state to perform its duties has resulted in an influx of international development agencies such as USAID, CRS and World Vision who continue to play many roles towards the well-being of the state and its citizens (*ibid*). Apart from the international NGOs, Osirim (2001) also identified grassroots NGOs which play different roles towards empowering communities. In Zimbabwe, different NGOs have different activities. For example, the World Food Programme focuses on food assistance – food relief programs – while other programs focus on empowerment of communities (Osirim, 2001). While there are several funding agencies, Muchadenyika (2016) shows there are 5 main donor agencies which played a key role

towards the creation of the Zim-Fund, administered by the African Development Bank. There are often complex relations between the state and donor agencies, and it is prudent to state that these donor agencies are playing a critical role; especially in rural areas which previously relied on agriculture activities which have since become unpredictable.

Given the context of Beitbridge, it is inevitable that many households within the area also depend on donor aid. Since Beitbridge is one of the poorest districts in the country, there has been an influx of donor-funded programs in the area (Chingarande & Ayo-Yusuf, 2016). As indicated in Table 2.1, the study area has received a diversity of donor interventions across different resilience dimensions. NGOs such as World Vision have intervened perennially helping the community with agriculture equipment (garden drip kits), development of infrastructure (livestock market places) and cash transfers, which have been paid via the Ecocash money service (cf. Moyo *et al*., 2006). Interventions such as cash transfers increase access to food and reduce the pressure from smallholder farmers to sell their livestock (Rasch *et al*., 2017).

Table 2.1: Summary of donor interventions in Beitbridge

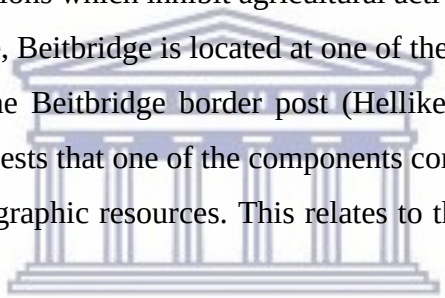
Broad classification	Resilience Dimension	Example of Intervention
World Vision International	Agriculture	• Community Gardens and Garden Irrigation Drip Kits
	Socio-Economic	• Cash Transfer • Fees programs • Food for work
Lutheran Development Services	Institutional development	• School Classroom & furniture
Ruzivo Trust	Natural Resources	• Baobab & Mopane value chain development
MOSMAC	Livestock & ICT	• Community Information Centre & ICT Training
Catholic Relief Service	Agriculture	• ICT Training (Farmbook) • Extension technicians support
USAID - PRIZE Project	Agriculture	• Livestock auction infrastructure development

However, while donor intervention programs have been hailed for helping poor communities, there have also been arguments against these donor programs. One of the major criticisms of donor programs has been the dependency-syndrome which these programs are creating among the communities. Akyeampong (2004) argues that relying on donor funds is not sustainable. Also, in the context of Zimbabwe, donor programs have been viewed as fueling political instability through

support of opposition political parties. Apart from the various reasons provided against donor-led programs, poverty among the rural communities is intensifying despite the existence of these donor interventions. Reflecting on non-governmental organisations' (NGO) contribution towards the well-being of poor communities, Ahsan Ullah and Routray (2007:246) concluded that, "NGOs' role in making significant contribution to the development has remained rhetoric and far from the trumpets they have been making since their emergence." Concurring with these remarks, Mills (2018:2) further elaborates that, "large inflows of foreign aid have almost certainly been a disincentive to reform for many African governments."

2.2.4 Interacting with the border

In Beitbridge, income generating opportunities are extremely limited and the situation is further worsened by the climatic conditions which inhibit agricultural activities. However, unlike several rural communities in Zimbabwe, Beitbridge is located at one of the busiest ports of entry in terms of volume and value goods: the Beitbridge border post (Helliker *et al*., 2018). In the Choice Framework, Kleine (2010) suggests that one of the components comprising agency of individuals or communities pertains to geographic resources. This relates to the geographic positioning of a community or individual.



Beitbridge is located at the border of South Africa and Zimbabwe and this geographic positioning means that there are socioeconomic practices linked to the border. Rutherford (2008) indicated that due to economic crisis in Zimbabwe, many able-bodied individuals within the border-zone opt to work as seasonal or permanent workers on the border zone farms on the South African side. In support of this, Bolt (2012) further indicate that border-dwellers make the most of their location, presenting themselves in certain ways, *e.g.* as farm workers, to legitimise their presence and movement. Furthermore, these border-dwellers manage to secure employment through networks connecting Zimbabwean border villages to South African farms (Bolt, 2012:113).

Apart from farm labour, other studies also show that border zones appear as "lucrative zones of exchange and trade, often illicit and clandestine" (Flynn, 1997:313). While there are many individuals and households making a living from providing services to travellers, several studies such as Helliker *et al*. (2018) also show that due to the border, sex work, including among children, is a common trade in Beitbridge. While abject poverty has been cited as a major push factor

resulting in sex work, Beitbridge attracts sex workers from far away towns such as Mt Darwin in Mashonaland Central Province. In the context of development, sex workers justify the actions by utilising the money for daily expenses, but they are also vulnerable to HIV and the AIDS pandemic. To this end, the border has income generating potential for individuals and households but also has negative impacts on the society as it promotes sex work which in turn contributes to the high prevalence of HIV/AIDS in Beitbridge.

2.3 DEVELOPMENT CHALLENGES

The livelihood options practiced by the community are affected by many developmental challenges. There are diverse causes of these developmental challenges, and Van Berkum *et al*. (2018:24) suggest that the "Root causes [of these developmental challenges] are often location-specific." This section discusses location-specific development challenges: drought and climate change, HIV/AIDS and infrastructure deficit. Then the section addresses the interconnectedness of development challenges.

2.3.1 Drought and climate change

In Zimbabwe, most rural areas practice subsistence farming, both crops and livestock, as a livelihood approach. However, the geographic location of the study area places it in a semi-arid region and as indicated in section 2.1, the region experiences erratic rainfall (<500mm) per season (Patt *et al*., 2005). To this end, crop production is limited, and livestock production (cattle, goats, and donkeys) is the main agricultural activity (cf. Mutsvangwa-Sammie *et al*., 2017). Furthermore, the alternative livelihood option is natural resources. With the study area already experiencing erratic conditions, it is of further concern that Zamasiya *et al*. (2017) suggest that scientific predictions are pointing towards even drier conditions. While there is lingering pessimism on climate change among rural communities, the effects of climate change have already become apparent; for example, through repetitive drought (frequency and intensity), livestock losses and a rise in temperatures (*ibid*).

In recent years, the challenge of climate change has been singled out as a major threat to human livelihoods, and this has triggered global responses to the challenge. However, Zamasiya *et al*. (2017) argue that climate change is a place-specific problem; and thus, needs to be explored from a localised lens. In this vein, Gwaka (2017) argues that climate change is a major threat to the

livelihoods in Beitbridge; particularly the livestock systems. Since the livelihoods of most households in the study area revolve around livestock, climate change therefore is a major threat to the livelihoods. The effects of climate change on livestock production are diverse. For instance, climate change has resulted in livestock deaths as well as poor livestock quality, and in turn low return from livestock. Apart from livestock, climate change (variations in rainfall and temperatures) also affects other natural resources such as mopane worms and baobab fruits which households depend on for cash generation. Furthermore, apart from impacting crop and livestock production, climate change is also contributing towards health challenges in the community. In the context of this study, climate change threatens the sustainability of the livestock system and the study focuses on establishing ways to achieve sustainability. There are two critical processes which households need, and these are adaptation and mitigation.

2.3.2 HIV/AIDS and poverty

Another development challenge facing households in Beitbridge is the problem of HIV/AIDS. Chingarande and Ayo-Yusuf (2016) note that the high HIV/AIDS prevalence in Beitbridge stems from high poverty and contributes to the extension of poverty among the households creating a *poverty trap*. In the study area, other studies have shown that there are limited income-generating opportunities and due to the area's geographic location, as a border area between South Africa and Zimbabwe, the area is a transit place, fueling sex work (Helliker *et al*., 2018). Even though there are many sex workers who come from other areas across Zimbabwe, the proximity of the study area to the border has significantly contributed to high numbers of infections among the households. According to Steinberg (2008), the HIV/AIDS impact households in several ways. Firstly, HIV/AIDS contribute to the loss of human labour (physical) as the sick are weak to engage in productive tasks and often in need of attention. Secondly, the challenge adds to the financial strain within households as individuals attempt to access of medication. Furthermore, there is social stigma associated with HIV/AIDS which often weakens the social capital of the communities.

2.3.3 Infrastructure deficit

Another dimension that is used to assess a community's resilience is the state of infrastructure that people use to function more productively. This includes physical infrastructure such as roads,

bridges, boreholes, markets, railways, and telecommunications. Like most rural areas in Zimbabwe, another developmental challenge facing the study area is infrastructure. While the focus of this study is on digital infrastructure, general infrastructure such as roads, schools, clinics, water sources and roads are also extremely poor in the study area (International Fund for Agricultural Development, IFAD, 2016). In Zimbabwe, the rural district councils are charged with the responsibility of developing infrastructure but due to limited resources and the broader economic challenges facing the country, there are limited efforts to improve infrastructure. Many infrastructure projects often take many years to be completed and in the study area, several roads have been under construction for a very long time. See for example Figure 2.3 showing a road between the main road and the study area that has been under construction for more than 3 years; i.e. it started before the start of the MOSMAC project and remained incomplete when the MOSMAC project was completed.

Figure 2.3: Road under maintenance in the study area

In addition to the traditional infrastructure deficits and in the context of the study, the study area is also characterised by poor digital infrastructure. As everyday life practices become associated with ICTs, digital infrastructure is increasingly becoming more central to human development. As such, the government of Zimbabwe has inscribed ICTs as a key cluster within the nation's development agenda, the Zim-Asset. The lack of ICT infrastructure in rural Beitbridge is a common characteristic of rural communities in developing countries. Addressing this challenge

remains a major target for government but due to limited resources, sit at the bottom of priorities. For instance, during the initial community engagement, it was established that of all six schools in the study area (primary and secondary), only one school had access to computers; and in addition to this, the three of those schools did not even have access to electricity. While there are efforts to address the digital infrastructure deficit in rural communities, it is critical to understand that the process of digital infrastructure transformation is complex; often depending not only on technical factors but also socio-political decisions (Gwaka *et al*., 2018; Takavarasha & Makumbe, 2012). These complex socio-political elements of infrastructure are often hidden as reflected in Bowker and Leigh-Star's (2000:33) words that:

> *"Unless we are electricians or building inspectors, we rarely think about the myriad of database, standards, and inspection manuals subtending our reading lamps, much less about the politics of the electric grid that they tap into.*"

Furthermore, in countries with complex socio-political environments such as Zimbabwe, limited studies exist to confront the socio-political aspects of infrastructure. One of these is a study by Takavarasha and Makumbe (2012) who explore the philosophical underpinnings relating to digital infrastructure transformation using the case study of Econet. With limited context-specific studies available, this study draws upon critical views from canonical studies such as Susan Leigh Star's (1999) "Ethnography of Infrastructure" as well as Langdon Winner's (1980) "Do Artifacts Have Politics?" to develop an understanding of the complexities relating to digital infrastructure transformation.

2.3.4 Interconnectedness of development challenges

The study has outlined the development challenges facing the study area, and these are drought and climate change, HIV/AIDS and poverty, as well as infrastructure deficit. From a systems thinking perspective, there are interconnections between these challenges, and it is critical to establish the underlying causes of these development challenges. The accurate identification of underlying causes of development challenges has the potential to improve the identification and prioritization of an intervention and subsequently overcoming its challenges. In a study conducted in the study area, a ResilientAfrica Network (RAN) report suggests that environmental instability and infrastructure deficits are the major underlying causes of vulnerability in these study

communities (RAN, 2017). To this end, RAN's survey in the study area revealed a strong connection between infrastructure and other development dimensions. It is evident that the study area is characterised by several challenges impacting the livelihood of the community members. In the State of Resilience Report, the RAN established links between the development dimensions. Based on RAN's findings, it was underlined that infrastructure deficit is a major underlying cause of the problems within the study area. The relationships determined by the study are shown in Figure 2.4, where each rectangular box represents a dimension of resilience and the arrows show the pathways to food security. Based on a structural equation model, the strongest pathways (where the numbers approaching 1.0 indicate a stronger correlation) were identified: environment and infrastructure (0.52), infrastructure and psychosocial status (0.36), psychosocial status and health (0.27), wealth and food security (0.24), human capital (skills) and wealth (0.23), and infrastructure and human capital (0.22). The results of the analysis support the presupposition that environmental stability and infrastructure are the underlying causes of vulnerability in these communities (RAN, 2017:37).

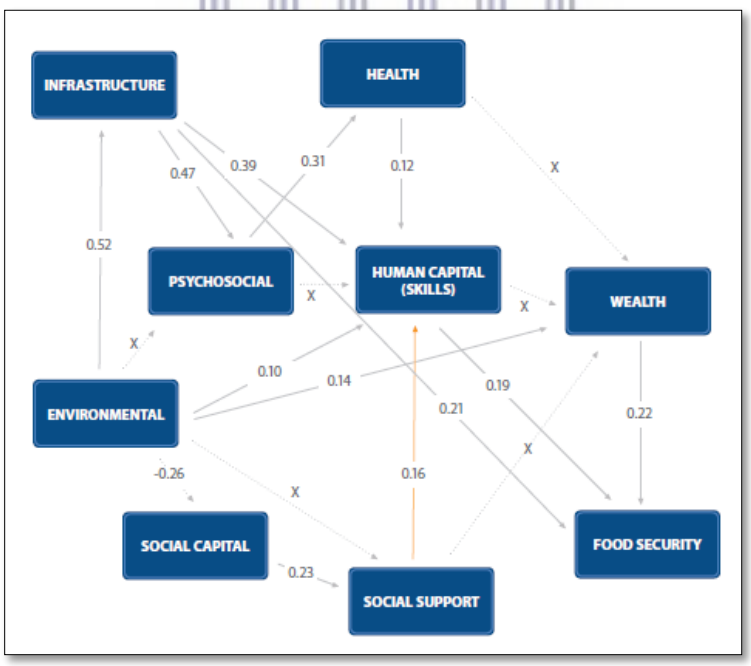


Figure 2.4: A model demonstrating the interconnectedness of resilience dimensions
Source: RAN (2017)

2.4 DEVELOPMENT TRAJECTORY OF THE DISTRICT

So far, the chapter has highlighted the circumstances of the community, available resources and the livelihood options. While the households in the community are evidently poor, there are several development initiatives being implemented (or in the pipeline) by various actors intending to overcome the developmental challenges discussed. The national and local government together with other non-state actors have specific areas which they are targeting to develop based on various timelines; and collectively, these shape the development trajectory of the community. From engagement with the local and central government representatives as well as the non-state actors, it became evident that the development trajectory of the community is also largely influenced by existing blueprints (national, international and local). From a global perspective, development priorities of the community are set in accordance to international blueprints such as the Sustainable Development Goals. Even though existing studies argue that international strategies such as the SDGs are not implemented (translatable) at grassroots levels, these goals still play a role in directing the development trajectory. At national levels, governments often develop national plans which are often in sync with the international development plans. For instance, in the context of Zimbabwe, the national blueprint, Zim-Asset, informs the development priorities of communities. Within the national strategic plan, ZimAsset, there are four key clusters which are Food Security and Nutrition; Social Services and Poverty Eradication; Infrastructure and Utilities; and Value Addition and Beneficiation (Bonga, 2014). It is evident that these key clusters are linked to some of the SDGs (or previously, MDGs). However, studies have criticised various development plans for many reasons including suggestions that these development plans are set without the participation of the local communities thus, may not always accommodate the development priorities of the marginalised communities. To this end, there are several calls for development priorities and trajectory to be influenced by local context.

At local level, there are also numerous factors that affect the process of development and these include demographics, political landscape and economic stability. In the context of the study area, due to the study area's proximity to South Africa and Botswana borders, the local communities experience excessive youth migration; mostly the productive and adult males in search of job opportunities. Apart from this, this chapter has already addressed the human population dynamics, and these collectively contribute towards the development trajectory. For instance, male migration for work has resulted in the area being inhabited mainly by female headed households which means

development programs should tend to align towards women and women start to engage in duties and/or activities previously dedicated for men.

In addition to the above, another factor influencing the development trajectory of the study area includes the political dynamics within the country. Although referring to urban planning, Muchadenyika and Williams (2017) provide a detailed description of politics' interference in the planning profession. They argue that "the role of planners and planning should be mainstreamed in the development agenda through sustained, grassroots-driven contestation and engagement with local authorities" (*ibid*, p.39). However, this has not occurred in Zimbabwe due to autocratic leadership and politics has disproportionately influenced the development trajectory of communities. However, in recent years, the political landscape in Zimbabwe has started transforming. The successful removal of Robert Mugabe and subsequent political changes impact the development trajectory of the country, and our study area is included in that. The political dynamics within a country impact the development trajectory in that it influences the policies adopted and the strategies implemented. In the context of livestock systems, Mavedzenge *et al*. (2008:615) even suggest that a different political context has the potential to "affect the broad policy narratives around livestock production and marketing and the structures influencing market access and governance."

Oliver *et al.* (2018) challenge researchers and practitioners to establish opportunities within existing regimes to usher in new ideas and innovations and develop new alternative approaches to disrupt the status quo of food systems which are largely undesirable. However, considering the lack of resources within government departments charged with the development of rural communities, it is evident that the development trajectory of underdeveloped rural areas such as Beitbridge will continue be shaped by donor organisations.[9] Since donor interventions have been conducted for many years, there is a need to develop a clear understanding on the impacts of the donor interventions as other studies on donor interventions argue that these often lead to dependence syndrome among the poor communities.

[9] In the context of ICT interventions, this study has found that interventions in rural communities of SSA – such as MOSMAC, the one on which this study is based – are mainly led by international partners and donor organisations. Related interventions were also found in rural South Africa and rural Zambia. See for instance, implementation of internet connectivity in rural Zambia (Matthee *et al*., 2007) as well as the Zenzeleni Project in rural Mankosi (Rey-Moreno *et al*., 2013)

2.5 CHAPTER SUMMARY

This chapter has developed a context of the study area, specifically outlining key details about the geographic features, human population, biodiversity, coping strategies as well as the development challenges. The chapter indicated that climatic conditions are not ideal for crop production placing livestock central to the livelihoods of the community. This is also emphasized in the analysis of the livelihood options. In addition, the chapter showed the development challenges among these the ravaging HIV/AIDS challenge stemming from abject poverty as well as the study area's location as a transport corridor. The chapter further demonstrated the interconnectedness of the development challenges prompting a need for a systematic approach to dealing with the challenges. However, infrastructure was also noted as a key development challenge; and its impact of resilience dimensions was demonstrated from RAN's structural equation model. The chapter concluded by suggesting that addressing the different challenges faced in the study area will continue to be spearheaded by non-governmental institutions as government institutions in the study area have limited resources.

CHAPTER THREE: KEY TERMS, THEORETICAL FRAMEWORK AND RELATED RESEARCH

Chapter overview

Having shown the context of the research in the preceding chapter, this chapter moves to discuss the key terms, theoretical framework and existing related studies. In this study, there are selected key terms and/or concepts which will be referred to frequently. However, these terms are also used in different contexts in other studies, thus, attract several different definitions or meanings which necessitate clarifying how these terms are applied within this study. Therefore, the purpose of this chapter is to expand on the key *terminology* and *key concepts* discussed throughout the study to develop a working definition (and context in which the terms are used). Furthermore, the chapter discusses the major theories and frameworks on which the study is anchored. Given the interdisciplinary nature of the study, the chapter discusses theories and frameworks relevant to socio-ecological systems, technology adoption and use as well as ICT for development. For this study, Ostrom's (2009) Socio-Ecological Systems (SES) framework was selected to analyse the study area's livestock system, specifically its attributes; and subsequently, the sustainability of the livestock system. The SES framework is also applicable when examining socio-technical systems such as telecommunication systems; thus, to some extent, is also relevant to understanding the processes of digital infrastructure transformation even though this analytical path was not selected for this study. Since the study focuses on the processes and impacts of digital infrastructure transformation, Kleine's (2010) Choice Framework (CF) was also selected as the analytical lens to explore the impacts of digital infrastructure on the livestock system. Both the SES and CF are premised on interaction of elements (attributes for the SES/ structure and agency for the CF); and thus, allow the analysis to be extended to the interaction of various elements. Kleine's (2010) CF, however, is more definitive in the context of understanding outcomes of the interactions. The rest of the chapter is structured as follows: Section 3.1 provides definitions of the key terms used throughout the study to develop working definitions which are applied to this study. Following this, section 3.2 focuses on the theories and frameworks adopted for the study. Sections 3.3, 3.4 and 3.5 provide literature reviews of related studies on food security, digital infrastructure and impact assessment, respectively.

3.1 KEY TERMS DEFINED

Over the years, many studies have been conducted on food security, livestock systems, sustainability and digital infrastructure. In these studies, these terms have been used in context; thus, carry different meaning and some of these terms remain without a universally agreed upon definition. This section examines selected key terms of the study, particularly to develop working definitions which are adopted throughout this study. Further to this, the terms are examined to clarify how they are applied in the study in relation to other key terms. Defining key terms for a study is central in that it helps to develop a clear understanding of the context in which a term is used since terms are often used in different contexts (cf. Pinstrup-Andersen, 2009). The selected key terms for the study are food security, livestock system, sustainability, digital infrastructure, impact assessment and ICT for both development and sustainability.

3.1.1 Food security

Studies on food security (more correctly, the food insecurity problem) (cf. Ingram, 2011) have increased in recent years with concerns that by 2050, the global population will likely reach 9 billion and the majority will be at danger of failing to access adequate nutritious food (Godfray *et al*., 2010). Ingram (2011) further shows that the crafting of definitions of food security started long back, e.g. by the 1990s many definitions already existed; and definitions of the term will continue to evolve as more studies on food security emerge. Even though many definitions of food security exist, FAO's definition is the commonly used definition (Ingram, 2011; Shepherd, 2012; Leroy *et al*., 2015). According to FAO, food security exists when, "all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 2006:1). From this widely accepted definition, it is inferred that food security has four dimensions: food availability, access, utilisation and stability. While there are debates on how these relate, May (2017) considers these food security dimensions as hierarchical. In this vein, the food security dimensions are considered explicitly interlinked as depicted in Figure 3.1. Thus, one dimension cannot exist without the other (*ibid*). Figure 3.1 suggests that food availability precedes food access and utilisation. Once food is available (produced/available in markets/available in households) then food access (in households/by individuals) can be triggered. The utilization dimension similarly can be explored once food access

has been achieved. However, food stability is considered as a bedrock of the three dimensions; thus, food stability stems from reliable availability, equitable access and proper utilization.

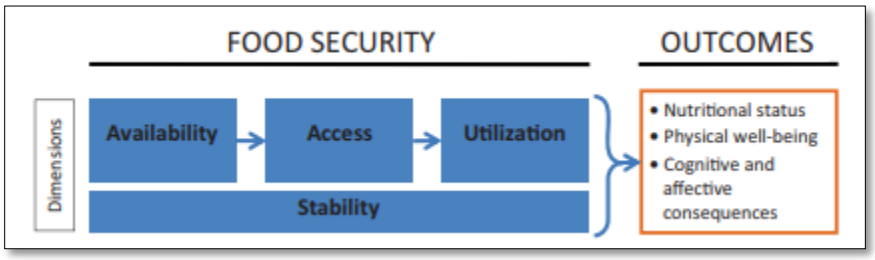


Figure 3.1: Food security dimensions
Source: Leroy *et al.* (2015)

However, while the four dimensions can be inferred from the FAO's definition, there are several open avenues for one's interpretation of these. For instance, Leroy *et al*. (2015) show that the food access dimension can be explored from either social access lens or economic access lens as well as individual or household levels. In this vein, Power (2008:97) suggests that "*conceptualizing an adequate and appropriate understanding of food security … should consider the diversity among people*", which means a dimension may be applied in several ways. The attributes of the food security dimensions and how they are considered in this study are further discussed in Table 3.1.

Table 3.1: Exploring the food security dimensions

Food security dimension	A brief discussion of the food security dimension attributes
Food access includes • Affordability • Allocation • Preference	The food access dimension can be linked to an income-based approach (Burchi & De Muro, 2016) which considers one's ability to afford food; thus, one's resources which can enable access to food. It is affected by socioeconomic matters since one needs income to purchase food; thus, those living in abject poverty are likely to lack access to food. Bellemare (2015) discusses how an increase in food prices may evoke social unrest such as protests, but also shows that policy makers (government) often provide subsidies on certain food items to promote food access. This dimension can also relate to the proximity of households to food supply sources (cf. Burns & Inglis, 2007). It is also discussed in the context of *food deserts* which are areas without a source of healthy food within a given radius (Morton & Blanchard, 2007). This is critical in the context of the study area since it is poor, with limited infrastructure (food markets) and limited crop production. Sharkey *et al*. (2010) suggest that access to food stores (geographic access to retail food resources is construed as a key dimension of food access. Furthermore, the food access dimension can also be explored from an individual basis e.g. intra-household dynamics since there could be different food distributions within households based on age and gender. Furthermore, food access can be considered in relation to reliable Access to traditional/country food (desired food).
Food availability • Production • Distribution • Exchange	Before the modern expansion of the food security definition(s), earlier work on food security equated food security to food availability and to date, "many continue to emphasize availability as their key food security focus" (Kyeyune & Turner, 2016:35). Gross *et al*. (2005) suggest that food availability relates to adequate food being at the disposal of individuals/households at all times. There are various ways of measuring food availability for instance, Burchi and De Muro (2016:11) suggest that "The units of analysis generally used in the food availability approach are the country (and its food balance sheet) or the world and the agricultural sector (its production and productivity)." In the context of the study, livestock provide households/individuals with animal source foods thus, a sustainable livestock system will likely ensure that there is adequate food at

	the disposal of the households at all times. However, consumption patterns of the animal source foods within households may need further examination.
Food utilisation • Nutritional value • Social value • Food safety	Gross *et al*. (2000:25) suggest that food utilisation relates to "… the ability of the human body to ingest and metabolize food. Nutritious and safe diets, an adequate biological and social environment, a proper health care to avoid diseases ensure adequate utilization of food. In most cases, utilization is only discussed from a biological perspective." In the context of livestock and food utilisation, Nabarro and Wannous (2014:475) also suggest that, "poor people depend on animal-source food (especially dairy products) to ensure that their diets deliver the nutrients necessary for cognitive and physical development."
Food stability	Leroy *et al*. (2015:169) suggest that food stability "is a cross-cutting dimension that refers to food being available and accessible and utilization being adequate at all times, so that people do not have to worry about the risk of being food insecure during certain seasons or due to external events." In the context of this study, the focus will be on how livestock contribute towards households' food access and availability. The assumption therefore is that a sustainable livestock system will continue to provide households with animal source foods (food availability) as well as generating income needed to purchase food (food access) thereby enhancing food stability. Inversely, the fragility of the livestock system destabilizes food stability.

However, despite the popularity of FAO's definition of food security, and acceptance by many researchers and organisations, other studies critique the definition citing several concerns. For instance, Shepherd (2012:197) argues that FAO's definition of food security is "absolute" and "frames food security as primarily an economic problem" and yet, there are several non-economic attributes of food security which also need to be discussed. In addition, May (2017) also suggests that FAO's definition pays little, if any, attention to the nature of the food system and this results in "the differences in the terms under which different actors are included into the system, and the impact that this might have on the four dimensions." For example, in the context of intra-household food security dynamics, most discussions of food security assume a household level analysis. Allen and Sachs (2012) claim there is a need to further probe the element of gender in food systems (food security) since studies argue that women spend much time in food but are often the food insecure (Leroy *et al*., 2015).

Based on the discussion above, this study acknowledges the complexities relating to defining food security and as other studies show, it may take many years before a universal definition of food security is achieved. However, cognisant of the different ways in which food security can be approached, the study opts to focus on the dimensions of food security with a specific focus on livestock's contribution to these different food security dimensions. For instance, in related studies adopting this approach show that livestock contribute significantly to the welfare of households through income generation (food access), providing nutritious food (food availability) and converting non-human consumed elements into food (utilisation) (Randolph *et al*., 2007). However, since it is evident that there is no linear causality between livestock and food security, the study broadens the analysis to accommodate the critical perspectives offered in other studies such as May (2017). To this end, the study will adopt a systems approach to address the relationship between livestock and food security.

3.1.2 Livestock system

Over the years, most studies on food security focus on crop production, and livestock's contribution to livelihood issues such as poverty and food security has only started to gain traction in recent times (Alary *et al*., 2011). As a result of adverse climatic conditions, crop production has significantly declined and is expected to continue declining (Dorin *et al*., 2011); thus, livestock

contribution towards household food security, for example, through augmenting cash income, has significantly improved (Zvinorova *et al*., 2016). While crop [food] production will be required to increase by between 70% and 100% to achieve global food security (Godfray *et al*., 2010), the CFS (2016) ratified livestock as critical towards achieving global and household food security. In addition to this, other regions such as the study area have harsh environmental conditions not ideal for crop production and livestock production is one of the major livelihood options. Thus, it is important to understand the dynamics of livestock systems considering livestock's contribution towards global and household food security.

Bernués *et al*. (2005:76) argue that when studying livestock, "a wide variety of disciplines are involved: technical aspects referring to management of animals and grazing resources, animal-pasture interactions and vegetation dynamics, but also [taking into account] social, economic and political considerations." Already, many studies on livestock have been conducted using a value chain approach but it is evident that this is insufficient since livestock interact with many sub-systems, if not all, of a society. For instance, livestock interact with social, economic, environmental, cultural and even political dimensions of societies (Marshall, 2015). To achieve a holistic analysis, Ericksen (2008:234-235) suggests a broader analysis of:

> *"interactions between and within biogeophysical and human environments, which determine a set of activities; the activities themselves (from production through to consumption); outcomes of the activities (contributions to food security, environmental security, and social welfare) and other determinants of food security."*

Based on the complexities of the livestock system, Hammond and Dube (2012) suggest that solving problems within livestock systems will therefore require a systems approach. The systems thinking approach (Checkland, 1981; Ison *et al.,* 1997) is recommended when dealing with complex systems and Ericksen *et al*. (2010) show that in solving food system problems, the systems-based approach is applicable. By adopting the systems approach in this study, the aim is to "reveal the non-linear nature of many cause-effect pathways" since "the systems approach looks in detail at interactions between different systems, to study this kind of tipping point, which occurs outside the food system but which will have a direct impact on food system outcomes" (van Berkum *et al*., 2018:24). It is critical to also indicate that in this study, the term livestock system is interchangeably used with food system as Marshall (2015) (*and in email discussions with Marshall*) suggests that, based on the socio-ecological system framework:

The system is defined as a social-ecological system (comprising the 4 subsystems of resource units, resource systems, products, transformation systems, governance, and actors. The endogenous variables fall within the focal food system, whereas the exogenous variables fall within the external environment of that system. So, a livestock system can be regarded as a food system as the livestock system encompasses Ostrom's original four subsystems.[10]

3.1.3 Sustainability

Another key term used in this study is sustainability. The focus of the study is on exploring the impact of digital infrastructure transformation on the *sustainability* of the livestock system. Admittedly, over the years, and until now, the definition of sustainability has been elusive (Waseem & Kota, 2017). This stems from many factors including the fact that sustainability is measured from different levels; for instance, global or local but in this study, the focus is on the latter. Furthermore, the availability of multiple measures of sustainability further complicates the subject (cf. Lebacq *et al.*, 2013). To overcome these issues, when conducting a sustainability assessment, Lebacq *et al.* (2013:317) suggest "contextualising" the assessment. This involves defining the system and purpose of the assessment.

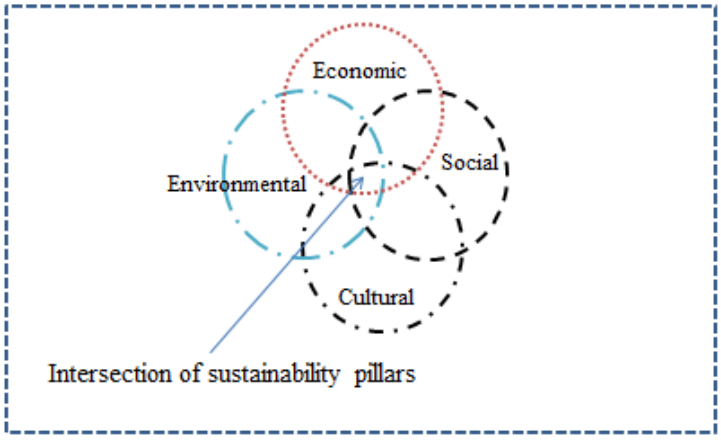


Figure 3.2: Intersection of sustainability pillars

Studies on sustainability have traditionally recognised three pillars of sustainability which are economic, environmental and social. However, as Figure 3.2 depicts, a fourth dimension of sustainability, the cultural dimension, is being advocated in several other studies (Opoku, 2015).

[10] Extracted from an email correspondence with Graham Marshall (June 20, 2016). Also, see Figure 3.3 for a more complete discussion of the Ostrom SES, and a critique.

In line with the advocates for inclusion of culture as a fourth sustainability pillar, Figure 3.2, shows that an ideal sustainable system would achieve a *point of intersection of all the four sustainability dimensions*. However, this is often far from being achieved in many systems with many cases achieving minimal sustainability; that is, intersection of some pillars (mainly important to the system actors) but not all pillars (cf. Marandure *et al*., 2018). The expectation of sustainability as the intersection of all the sustainability pillars is largely theoretical, often overlooking the realistic expectations of the unique system actors. For instance, the sustainability measures expected by an elderly livestock farmer may differ from the sustainability dimensions expected by a livestock agent. However, limited studies focus on these micro-level sustainability dynamics and focus broadly on the system level sustainability. While there are standardized tools to measure sustainability, Marandure *et al.* (2018) suggest that due to the diversity of livestock systems, it is critical to consider system differences; thus, make use of system-specific indicators. In this context, each community may have separate sustainability indicators (*ibid*).

For instance, in the context of livestock, Lebacq *et al*. (2013:311) suggest that sustainable livestock systems are "environmentally friendly, economically viable for farmers, and socially acceptable, notably for animal welfare." However, apart from the predefined metrics such as profit, this study argues that the term sustainability should be expanded to include other elements such as human aspirations, dreams and visions. Thus, the study suggests that sustainable livestock systems, in addition to achieving the common sustainability metrics, contribute towards the achievement of a community's aspirations, dreams and visions. To contextualize this, the study has ventured to explore the community's aspirations, dreams and visions. While opting to do so, the study acknowledges that there are alternative approaches that adopt a similar departure point, such as Sen's Capability approach and the extensions proposed by Appadurai (2004) and others concerning aspiration and agency. Therefore, in this study, sustainable livestock systems are regarded as livestock systems which, in addition to meeting the traditional sustainability measures (see Figure 3.2), enable the community members to "live the life they have reason to value" (Sen, 1999:19). Thus, this study attempts to evaluate sustainability considering the realities of the community being engaged (cf. Marandure *et al*., 2018). In this study, the livestock system attributes are examined using the SES framework and the purpose of this study is to understand how these attributes contribute to the sustainability traits of the system.

3.1.4 Digital infrastructure

To recap, the focus of this study is to explore whether digital infrastructure interventions in rural communities can contribute towards achieving sustainable livestock systems; resulting in improved household food security; and broadly, achieving part of the SDGs. Anadon *et al*. (2015) suggest that technological innovations are central to the achievement of the SDGs. Many studies have been done in recent years to explore the application of technological innovations towards solving societal challenges (Majchrzak *et al*., 2016). In developing countries, technological innovations are synonymous to mobile phones but Anadon *et al.* (2015:4) show that technological innovations encompass a "full range of devices, methods, processes and practices" prompting this study to explore the broader dimensions of technologies; broadly, digital infrastructure. The term digital infrastructure, according to Sorensen (2013:6) refers to:

> "*Equipment; the information itself; the applications and software; the network standards and transmission codes facilitating interconnection and interoperation; and the people who create the information, develop applications and services, construct the facilities etc."*

In this study, the focus is on the impact of a digital infrastructure transformation intervention on the sustainability of the livestock system. While the intervention implemented in the study area is mainly related to the establishment of a community information centre, there are several elements, also classified under digital infrastructure, which are or will be transformed through the setup of the community information centre. As such, the study will examine changes relating to policies (affecting digital infrastructure), human skills, physical artefacts (e.g. new devices) and non-physical elements such as services. The study examines the collective transformation and not only specific elements. Focusing on the broader definition of digital infrastructure also allows the study to adopt the systems thinking approach to analyse and understand the digital infrastructure. While the study focuses on digital infrastructure, the SES framework shows that technologies are identified as one of the secondary attributes of a SES system, such as the livestock system, under the actors' primary attribute. Thus, the digital infrastructure is already positioned within a system. For this reason, digital infrastructure will also be examined in the way in which it interacts with other infrastructure.

3.1.5 Impact assessment

In line with the study's objective of exploring impact of digital transformations in rural communities, it is critical to also focus on the term impact assessment. It is inherent that following the implementation of an intervention in a community, such as digital infrastructure transformation projects, there will be efforts to establish whether the expected (desired) changes or outcomes have been achieved or not (Tilley, 2004). This is achieved through impact assessment. The results of impact assessments are used for various purposes including improvements to projects (learning process) as well as accountability measures (project audits). The purpose of an impact assessment often determines the frequency of assessments, the impact metrics, methodology and individuals who undertake the assessment. To this end, impact assessments are made up of different (and potentially differing) perspectives. Despite these differences, Ravallion (2009:234) argues that "[t]he art of good [impact] evaluation is to ask the right questions at the outset" and Befani (2016) is of the opinion that some of the right questions of central importance when conducting impact assessment include what to evaluate, when to evaluate, and how to evaluate. In the context of ICT4D projects, including digital infrastructure transformation, Pather (2017) has also questioned if the right questions were being asked and evidently, existing impact assessment approaches have been criticized.

In this study, the focus is on conducting impact assessment on a digital infrastructure intervention, the MOSMAC project. Essentially, the study seeks to establish the outcomes of the project. However, the study argues, in line with other studies such as Pather (2017) and Mthoko and Khene (2018), that there is a need for robust and comprehensive impact assessments which can yield results which can be used for policy decisions. To this end, this study adopts a post-positivist approach to conduct impact assessment on the MOSMAC project. To achieve this, the study first presents impact assessment by the funding agent (donor) on the MOSMAC project which is followed by a theoretical impact assessment based on the selected theoretical frameworks discussed in section 3.2 of this chapter which are the SES, Choice Framework and Technology Affordances theory. In addition to this, the study also presents empirical evidence (observed and anticipated) from the study respondents. In all this, the study focuses on extending impact assessment to also include tangible and intangible impacts based on perspectives of users and non-users (Tabassum & Yeo, 2015). Aleixo *et al*. (2019:1446) suggest that there is often a gap "between what a certain [infrastructure] should provide in theory and what it does in practice" and

part of the challenge is that in theory, infrastructure interventions are often examined as singular units when in fact, in practice, they are implemented in context with other existing units. To this end, McFarlane and Anderson (2011:163) suggest that when investigating infrastructure (including their impacts) it is useful to adopt assemblage thinking and focus on "how diverse actants come together and hold together and the form of the resulting unit." In the same vein, Currier (2003:328) argues that an assemblages approach "reorients the relation of the whole to the parts."[11] From an assemblages perspective, the idea of an intervention as an end in itself is refuted; thus, infrastructure is perceived as a means to an end, and as part of the whole (Roelich *et al*., 2015; Knoeri *et al.,* 2016). Brown (2005:763) argues that an intervention can be considered as a means to an end if it "forms part of a larger socioeconomic model and is a critical function in facilitating the development of other basic structures in society such as business, education and health."

3.1.6 From ICT for Development to ICT for Sustainability

Given its focus, this study is multidisciplinary, focusing on the developmental potential of ICTs in rural communities and bringing together literature from the social sciences and from computer science under the umbrella of development studies (Avgerou, 2010). There are several studies which have already examined the application of ICTs to agriculture and even livestock specifically. Generally, studies applying ICTs to 'development' cases are classified under the ICT4D banner (Avgerou, 2010; Walsham *et al*., 2007) but the quest for clarity on the 'D' has led to the emergence of new areas such as ICT for Sustainability (ICT4S) in which the study can be situated. Many studies have been done on the application of ICTs to development cases, *e.g.* in health, education and even agriculture among many others –including studies at local levels (Grimshaw & Gudza, 2010). These studies have been classified as ICT4D studies with Richard Heeks being one of the leading authors in the field of ICT4D (see for example, Heeks, 2002; 2008; 2010). According to Heeks (2014), research on ICTs' application to development cases such as education, health and agriculture has been done to varying degrees. As a result, he mapped the areas where research has been done extensively, moderately and where there is still need for more

[11] Examining algorithms without considering their wider assemblage is, as Geiger (2014) argues, like considering a law without reference to the debate for its introduction, legal institutions, infrastructures such as courts, implementers such as the police, and the operating and business practices of the legal profession.

research. Similarly, Walsham (2017) conducted a study to 'take stock' of the research on ICT4D. Walsham (2017) discusses the key research approaches (methodologies), popular frameworks and like Heeks (2014), the specific areas which need further research. In both studies, Heeks (2014) and Walsham (2017) agree that there is a need for studies on ICTs, Environment and Food. Heeks (2014) positions *e-Agriculture, ICTs and Food* as one area with the highest research gaps. In the same strand, Walsham (2017:27) argues that environment and climate change is a "…crucial issue for many developing countries and ICTs have a part to play." It is against this backdrop that this study focuses on ICTs, food security and livestock systems in rural communities.

Over the past years, there has been a debate within the field on the clarity of the 'D' in ICT4D (Avgerou, 2010). The concept of development has been studied extensively but still; the definition remains elusive. The result has been that researchers and practitioners using the term ICT4D have been forced to clarify in each study what they refer to as development. As the norm, the present study is also expected to clarify the 'D'; and in this study it can refer to either sustainability of livestock systems or household food security. As such, replacing the 'D' with these goals would mean that this study can be situated in the 'ICT for sustainable livestock systems' or 'ICT for food security' through sustainable livestock systems. Fortunately, the concept of sustainability has gained prominence in the past years and there is an emerging branch within the ICT4D studies focusing on ICT for sustainability as well as sustainable ICTs, and this field is known as ICT4S.

The relationship between ICTs and sustainability has evolved over the years. Hilty *et al.* (2013) provide an annotated bibliography which documents the evolution of the studies on the relationship between ICTs and sustainability. It is interesting to note that the *First International Conference on Information Technologies for Sustainability* was hosted in 2013 (Hilty *et al*., 2013). Also, the outcomes of this conference suggest that the relationship between ICTs and sustainability can be viewed from multiple angles, *e.g.* sustainable ICTs (reducing energy consumption by ICTs and reducing e-waste), sustainability by ICTs (using ICTs intelligently) and the use of ICTs to promote sustainable behaviour and support people to live sustainably. In this study, the sustainability by ICTs concept is used to understand whether the ICTs, mainly digital infrastructure, can contribute towards creating and maintaining resilient and sustainable livestock systems in rural communities.

3.2 THEORETICAL FRAMEWORKS

Having clarified the terms used in the thesis, this section examines the theories and frameworks selected for the study. Considering the complexity of the concepts under investigation, the study triangulates three selected theories to provide a holistic analysis of the study constructs: Socio-Ecological Systems framework, the Choice framework and technology affordances theory. Each is described below. The selected theories also influenced the selection of literature reviewed in the related studies section.

Following several studies' recommendations on analysing complex food systems (in the context of this study, livestock systems), *e.g.* Ingram *et al.* (2012), Foran *et al.* (2014), Marshall (2015) and May (2017), the study adopted Ostrom's SES framework (Ostrom, 2009) to characterise the attributes of the study area's livestock system and establish the livestock system dynamics in the study area. With the livestock system comprising various sub-systems, the SES framework offers an opportunity to conduct an integrative analysis since it allows for the livestock system to be studied as units comprising of "multiple first-level and second-level sub-systems" (May, 2017:17). In addition to the level of analysis which the SES framework allows, Marshall (2015:882) further indicates that the SES framework also allows for cross disciplinary diagnosis of problems (or sources of problems) within particular systems, including livestock systems. This critical analysis is needed to accurately understand the attributes of a system and determine the systems' sustainability.

However, there are also limitations to the SES framework especially when there are technological innovations within a specific system. To this end, Foran *et al.* (2014) demonstrate that different theories and framework can be combined to create synergies which can be more useful to analyse a system holistically. In the context of this study, there is a technological intervention within the livestock system and to explore the process of implementing the intervention as well as the impacts of this intervention, the study applies Kleine's (2010) Choice Framework. The Choice Framework focuses on exploring the agency (of the livestock system actors) and structure of the community to understand the dimensions of choices which livestock system actors have in the livestock system.

Additionally, the technology affordances theory (Gaver, 1991) is utilised to consider what the introduction of technologies can do for the actors, *e.g.* changing the attributes of the SES, and changing the agency of the livestock system actors and the structure of the community.

Before discussing the selected theories in detail, it is important to outline an alternative framework also considered for exploring the integration of ICTs in livestock system but not utilised in this study, the Sustainable Livelihoods framework (SLF). The SLF is a prominent international development framework which has been applied extensively to evaluate the impacts of government and non-government interventions on livelihoods. For instance, the United Kingdom's Department for International Development (DFID) has extensively used the SLF approach to assess the impacts of its various interventions (De Haan, 2012). However, despite its popularity, there are potential weaknesses embedded within the framework which makes it less appealing for this study. De Haan (2012:348) for instance argues that the framework has a "concrete and economic take on livelihood" and, the framework appears to overlook critical power dynamics which are inherent within rural livelihoods. Since this study adopts a systems approach, it was considered other there are potentially more appealing framework, including the SES. However, these concerns however do not suggest that the livelihood approach cannot be used in the context of similar studies. Other researchers (Kleine, 2010) recognise the importance of the SLF and have used this framework as a building block to a different framework, the Choice Framework.

3.2.1 Socio-Ecological System framework

A livestock system is complex (Marshall, 2015) and determining the impacts of digital infrastructure transformation on a livestock system will also inherently be complex. Fortunately, Ostrom's (2009) SES framework serves as a diagnostic tool towards understanding complex systems, including livestock systems (McGinnis & Ostrom, 2014; Marshall, 2015). The relationship between livestock and climate change is complex in that it is bi-directional and dynamic (Thornton *et al*., 2009; Herrero *et al*., 2009; O'Reilly, 2016). Thus, livestock species contribute to the problem of climate change and suffer the consequences of climate change (Scholtz *et al*., 2014; McKune *et al*., 2015). The impacts of climate on socio-ecological systems such as the livestock system are broad and complex (Pandey & Bardsley, 2015). However, in most developing regions, smallholder farmers are less aware of the agri-ecological interactions of livestock and climate change compared to wealthier regions, thus making them more vulnerable

(Thornton *et al*., 2009). Even though there are many studies on the contribution of livestock towards climate change, for example through greenhouse gas emission (cf. McMichael, 2007; Thornton *et al*., 2009), Nardone *et al.* (2010) in contradiction, think that the effects of climate change on livestock remain understudied. To understand these complexities, the SES framework can be applied. Accordingly, the SES framework aides to explore the interactions of a system's sub-systems such as actors, governance systems, resources systems and resource units.

Elinor Ostrom's SES framework has emerged as one of the popular frameworks used to investigate dynamics within complex systems, especially in Ecology studies (Marshall, 2015). Ostrom (2009) is credited with developing the SES framework from many discussions and engagements with other colleagues. Until her death, Ostrom (and her peers) continued to work on improving the SES framework to make it a universal tool and/or 'common language' for critical analysis of complex systems (McGinnis & Ostrom, 2014). Ostrom's original SES framework, as shown in Figure 3.3, suggests that a socio-ecological system is made up of four second-level sub-systems which are the Resource System [RS], Resource Units [RU], Governance Systems [GS] and Actors [A] but is also situated within a broader social, economic and political system.

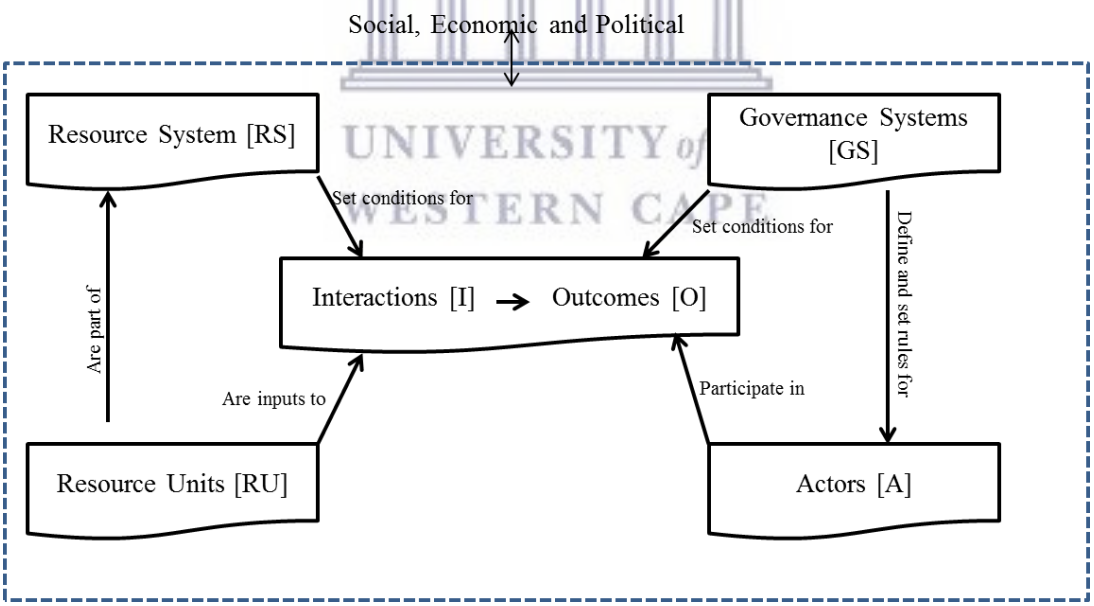


Figure 3.3: Ostrom's Socio-Ecological System framework
Source: Ostrom (2009) and Marshall (2015)

In addition to the four tiers, a socio-ecological system is situated within a broader context shaped by the social, economic and political dynamics. In Figure 3.3, the rectangular elements represent the different sub-systems and arrows show the different interactions and influence between these

sub-systems. In addition to the interactions of subsystems, there is a combined interaction at the centre of the SES which produces outcomes. Also, the SES interacts with external factors (social, economic and political) in a bi-directional way. Hammond and Dube (2012) indicate that food and nutrition security is also strongly shaped by systems outside of the agri-food sector. These second-level sub-systems interact in multidirectional ways, often, shaping each other. When the sub-systems interact they produce outcomes (depending on the system under study); for instance, in this study, the sustainability or fragility of the livestock would be an outcome of the interaction (or not) of the second-level sub-systems, as well as first-level sub-systems. Over the past years, there have been efforts to modify the SES framework and more recently, and linked to this study, Marshall (2015) attempted to modify the framework by adding two addition second-level sub-systems which are Transformation Services [TS] and Products [P]. Further analysis of the modification, however, revealed that [TS] and [P] were less applicable in the context of rural communities; thus, in this study, Ostrom's original framework is adopted.

The SES is applied to examine and characterise the attributes of the livestock system in the study area. The framework is applied to obtain a deeper understanding of the livestock system which is critical when examining sustainability issues such as threats and opportunities within the complex system. Also, by applying the SES framework to understand attributes of the livestock system, the framework provides the chance of establishing the positionality of technologies within the livestock system. Further to this, since SES can be applied to human-constructed systems such as digital infrastructure, the framework can be used to examine the complexities of digital infrastructure in rural communities such as the study area. However, while SES helps to understand the attributes of a complex system, such as the livestock system, it does not further expand on outcomes of the interactions of the primary and secondary tiers; and thus, can be improved by adopting Kleine's approach towards understanding development 'outcomes' using the Choice Framework.

In Figure 3.3, SES identifies actors as one of the sub-systems, and May (2017) suggests that a system's actors can comprise both individuals and institutions. The actions and activities of the actors are defined by the *set of rules* set by governance institutions. However, these actors also contribute to the rules in use, implemented by the governance institutions. Since institutions are also considered as actors within a system, understanding institutions existing to support a specific

system as well as the institutional dynamics will be critical towards assessing a system's sustainability. For instance, during the early 1990s, the existence of the Cold Storage Commission as a parastatal resulted in the establishment of the Zimbabwe beef sector as a competitive sector globally. However, the subsequent privatization of the sector and lack of a controlling institution has substantially contributed to the collapse of the sector. Further analysis of institutions as actors could be achieved through application of the institutional theory lens (cf. Amenta & Ramsey, 2010) to understand how institutional dynamics also impact the sustainability of the livestock system.

In addition to the close examination of the actors' sub-system, another sub-system of a socio-ecological system is the resource system [RS]. The attributes of the resource system include human-constructed facilities, predictability of the system dynamics, as well as clarity of system boundaries and location of the [RS]. In the ResilientAfrica Network's resilience report (Cooke, 2015), the lack of infrastructure (human constructed facilities) is a major contributor to system fragility in rural communities. Adding on to this, Mavedzenge *et al*. (2008) specifically argue that infrastructure relating to livestock in rural communities is poor. Apart from infrastructure deficit, the fragility of the livestock systems in rural areas also stems from the unpredictability of the livestock system dynamics. In the past years, communities have relied on traditional knowledge in the planning processes relating to livestock herd management and decision-making. However, due to environmental changes in recent years, communities are less able to predict the system dynamics with accuracy. Therefore, using the SES, a system's sustainability and/or fragility can be impacted upon by the existence/non-existence of human constructed facilities which in turn can influence the predictability of the system dynamics.

The governance system [GS] is a third sub-system of the SES. The secondary attributes of [GS] include history, network characteristics, rule-making organisations, rules-in-use, and geographic scale of the system and policy area. The historical background of the governance system is critical to understand the governance practices within a specific system. The network characteristics relate to the "connections among the rule-making organizations and the population subject to these rulers" (McGinnis & Ostrom, 2014). The submissions are that strong and sustained connections among the rule making organisations, private and public, are critical to the self-organisation within a system. In addition, the rule making organisation design rules (*rules-in-use*) which regulate a

system's activities. In this context, a rule making organisation may transcend geographic boundaries; for instance, national and international standards may impact how livestock production is done within a local community. However, there is also a need to include cultural rule making groups, as the livestock production is closely linked to sociocultural aspects of a society. Further to this, rules-in-use often determine what can or cannot be done within a system. An example would be the restriction of livestock movement across boundaries. Therefore, [GS] in place plays a key role towards determining the sustainability or fragility of a socio-ecological system.

Finally, the last sub-system in the SES of a livestock system is resource unit [RU]. In the context of this study, livestock mobility is critical in monitoring livestock health and diseases through surveillance. Furthermore, consumers are increasingly requesting information on products they consume (traceability). Thus, it has become a requirement to monitor the mobility of livestock, which farmers in rural areas such as Beitbridge are unable to do. The result is that their products fail to qualify for lucrative markets.

Table 3.2: Applying the SES framework to analyse the study area's livestock system

Primary Attributes	Secondary Attributes	Analysis lens/Focus
Resource System [RS]	System dynamics predictability	Exploring how the system dynamics of the study area's livestock system are predictable and ways in which predictability can be improved including the use of technologies (*e.g.* Enenkel *et al*., 2015).
	Location	Exploring how the system location impacts the sustainability of the livestock system, *e.g.* environmental conditions, proximity to markets.
	Human constructed facilities	Identifying the human constructed facilities available in the community, with a specific focus on the infrastructure supporting the livestock system.
Governance System [GS]	Rulemaking organisations/ Rules-in-use	Determining the rule-making organisations (legislative & cultural); determining the rules applicable within the livestock system; and establish how these rules in use are applied (or not) and the effect thereafter, on the sustainability of the livestock system.
	Network characteristics	Exploring the coordination among the rule making organisations, *e.g.* including public and private sectors.
	History	Exploring the historical trends of the system, as well as changes within the system.
Actors [A]	Number of actors	Identifying the number of actors in the study area's livestock system. These actors will include individuals (key groups) and institutions.
	Socio-economic characteristics	Analysing the socio-economic conditions of the actors (livestock farmers, buyers and related institutions) and understand how these contribute to the sustainability of the livestock system (e.g. decision making, choices).
	Technologies	Exploring the use (or non-use) of technology by the actors in the livestock system.
Resource Units [RU]	Resource mobility	Developing an understanding on the mobility of the resource units (livestock), and the challenges and rules being applied by the governing bodies.
	Economic Value / Marketing characteristics	Determining the economic value attached to livestock by different livestock system actors, as well as establishing the marketing characteristics of livestock in the study area.
	Growth or replacement rate	Determining the growth rate of the livestock species and the rate at which they can be replaced within the prevailing environmental conditions.

3.2.2 Choice Framework

Following the assessment of the livestock system attributes using the SES framework, it was evident that the various sub-systems of the livestock system such as actors, governance systems, resource units and resource system interact to produce outcomes. However, the outcomes of the interaction of these attributes can be broad; and thus, need to be explored further. In development work, many studies intend to create empowered communities, and while many theories exist on empowerment, it is Kleine's Choice Framework (CF) which attempts to clarify the term, building on Sen. In the Choice Framework, Kleine (2010) argues that development must be considered as choice. Therefore, the study turned to the Choice Framework to help explore and understand the impact of a technological intervention within a livestock system.

Kleine (2010) developed the Choice Framework to further Amartya Sen's capabilities approach as an effort towards clarification of the development process (Kleine, 2010; 2013). In developing this framework, Kleine considered provisions of the Sustainable Livelihood framework (SLF) (Duncombe, 2007) as well as Alsop and Heinsohn (2005). The Choice Framework presented in Figure 3.4 suggests that an individual's or group's *agency*[12] interacts with a community's *structure* (in Figure 3.4, the interaction of agency and structure is demonstrated by the bi-directional arrow) resulting in degrees of empowerment which are: the existence of choice, sense of choice, use of choice and achievement of choice. The degrees of empowerment in turn create development outcomes with the primary outcome being choice, and the secondary outcomes will be as chosen by individual. Further to this, the outcomes have a feedback effect on structure and agency.

[12] While Kleine (2010) opts for the term agency, other related studies refer to these elements as resources.

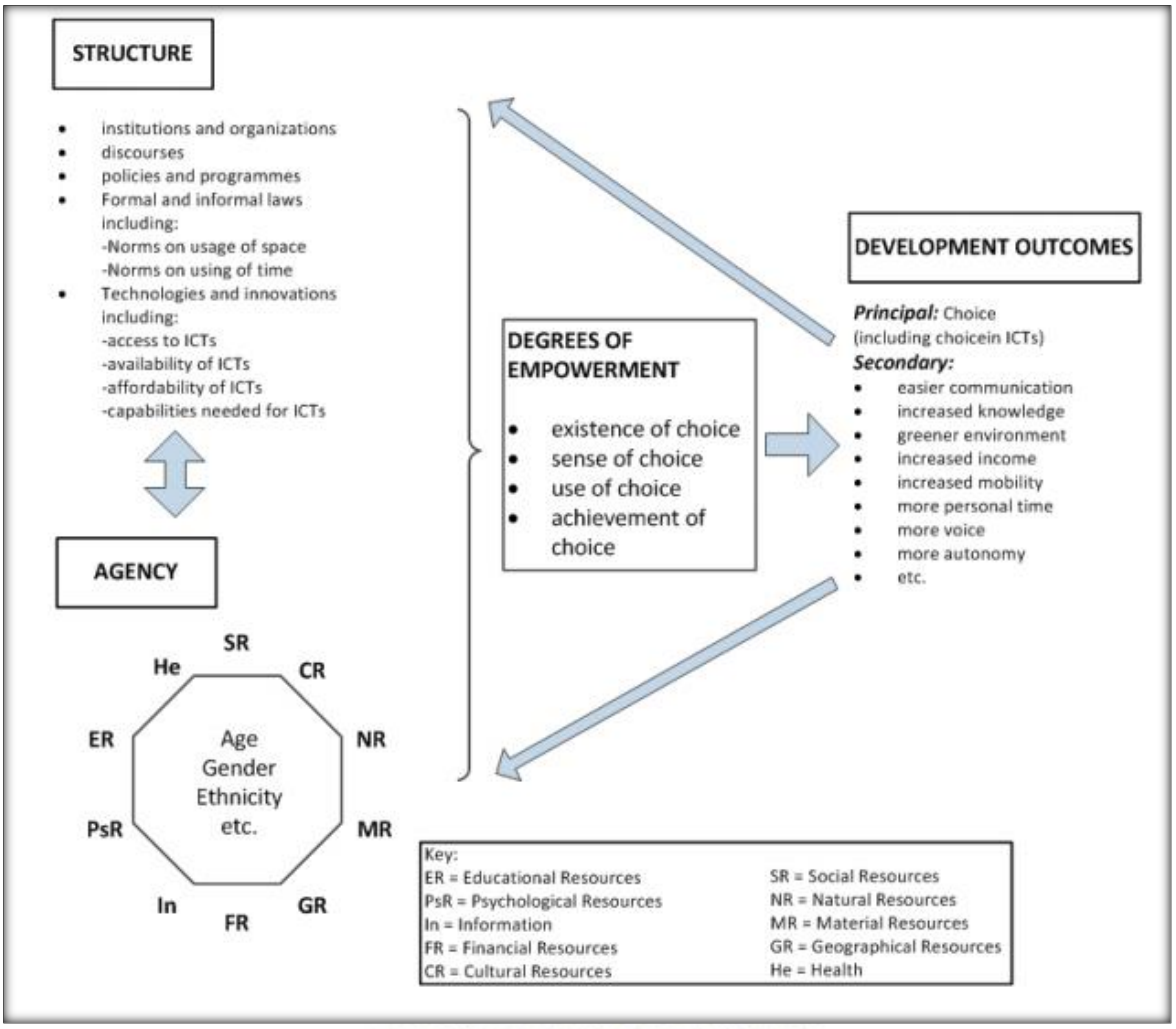


Figure 3.4: The Choice Framework
Source: Kleine (2010)

- **Development outcomes**

The development outcomes result from interactions of other components in the framework. These are the focus and thus, tend to be discussed first (see for example, Kleine, 2010; Marais, 2016). In the Choice Framework, Kleine (2010), building on Sen (2014), has clarified that the primary development outcome in the development process should be choice; thus, when people live the life they have reason to value (Sen, 2014), they are empowered to make choices. In her work, Kleine (2010) exemplifies choice in ICTs as a development outcome while secondary outcomes depend on the activities one chooses to engage in. In the context of this study for example, the MOSMAC intervention may provide individuals or groups within the community with choices in ICTs (primary choice) and subsequently, depending on whether individuals are involved in

livestock, secondary outcomes could be increased communication among the livestock system actors, more voice for the smallholder farmers, as well as increased income from livestock sales. On the other hand, if the intervention is appropriated by school children (schools) then the primary outcome (choice in ICTs) remains the same, but secondary outcomes could change to reflect the lives that individuals or groups value. Thus, the Choice Framework demonstrates that development outcomes within a development process, such as an intervention in a community, cannot be predetermined but rather emerge based on one's preferences.

- **Dimensions of choice**

Before development outcomes can be achieved, the Choice Framework suggests that there are dimensions of choice which are a result of the existence of ICTs (interventions). The choice framework shows that the first dimension is the *existence* of choice. This dimension suggests that choices (alternatives) which individuals or groups can exercise do indeed exist. For example, this can suggest that there are ICTs in place, and that individuals have the appropriate education resources resulting in individuals having the option to exercise choice. The second dimension of choice, which is Kleine's take on Alsop Heinsohn's degree of empowerment, is the *sense* of choice. Essentially, the sense of choice suggests that an individual or group consider an intervention to have perceptible properties which can be appropriated within the life the individual or group have reason to value. The sense of choice is critical in attracting an individual to use or explore an artefact; as when one fails to develop the sense of choice which the intervention can provide, it is likely to be rejected. In the context of the study, it would be critical to consider whether the provision of a community information centre, and potentially a community network, can be perceived to have the capacity of provide alternatives to what currently exist in the community. In addition, the framework then shows that individuals can also make *use* of the choice. This is achieved when choice exists, the individuals have a sense of choice then decides to make use of choice. This results in the *achievement* of choice.

- **Structure**

The dimensions of choice for an individual or group and ultimately the development outcomes *(primary and secondary*) are hinged on the structure of the community and agency. Essentially, the structure of the society can be considered the bedrock of the development process. In the

Choice Framework, the structure includes institutions and organisations; technologies and innovations; policies and programmes; as well as discourses. Pedersen *et al*. (2012) suggest that informal structures include rules or norms inside or outside the company, which are expected to influence outcome. The structure then interacts with an individual's or group's agency/resources (discussed next) to create the dimensions of choice. In relation to ICT, and ICT interventions such as MOSMAC, elements within the structure which are affected include availability, accessibility and affordability of ICTs. Institutions and organisations are central actors which can enable or inhibit the implementation of the intervention (or subsequent adoption) within specific value chains. Also, under the structure node, the Choice Framework provides for technologies and innovations which essentially link to the interventions which the study is based on. The MOSMAC intervention set out to address the technology and innovation as it sought to address the elements of *access to ICT, affordability, availability of ICTs and capabilities.* In addition, policies and programs, as well as formal and informal laws, are also critical elements which can influence the use and/or non-use of the intervention (or the initial deployment, as well as subsequent existence of the intervention).

- **Agency/resources**

The Choice Framework also suggests an individual's agency, also referred to as resources, as another key component in achieving the degrees of empowerment. In developing CF, Kleine improved upon the Sustainable Livelihood Framework and expanded on its resources; how they are defined, as well as adding other dimensions. CF recognises resources instead of capital or assets. The agency/resources can be individual resources while others, *e.g.* geographic resources and cultural resources, can be shared resources. The resources are bulleted and discussed below. RAN recognises some of the agency/resources as dimensions of resilience, and this study expands on the selected resources below showing how these relate to the study. According to Kleine (2010:681) the resources included in CF are defined as follows:

- *Material resources*: These resources refer to all 'objects' owned and/or accessible to the individual or group or community essential in the production process (*e.g.* computer hardware and other equipment).
- *Education resources*: This refers to the education levels of the system actors.

- *Information resources*: This resource is not clearly defined in Kleine's (2010) work but it is argued that information is key in the development process. In this study, information resources are referred to as the potential of, or opportunities available to, individuals to collect, process and disseminate information.
- *Geographic resources*: These resources are elements relating to implications of location (what is available, in terms of natural and non-natural); and, the relative distances to other elements. Kleine suggests that these also include non-tangible aspects of a place.
- *Cultural resources*: Defined from the theory of social capital, cultural resources are identified as rites, norms, values shared by a specific group.
- *Social resources*: Broadly, the social resources are identified as the belonging, relations, networks and interactions within social groups. May (2012:38) suggests that social resources also "encompass the social networks and interactions available to individuals, households, and communities", and these are socially created and less institutionalized.
- *Human resources*: These resources refer to the people attributes; thus, human health, education, and skills (various, not only limited to technical).
- *Natural resources*: These resources refer to the natural environment elements such as landscape, climatic conditions, soil quality and biodiversity.
- *Financial resources*: These resources refer to financial capital (*e.g.* savings and income streams).
- *Health resources*: These resources refer to an individual's physical and mental well-being (free from illness); and in the context of Beitbridge, the high prevalence of HIV/AIDS makes health resources critical to this study.

3.2.2.1 Application of the Choice Framework

Firstly, the Choice Framework suggests that the structure of a community or system includes ICT access, and agency also includes technological (and informational) resources. Therefore, in this study, the Choice Framework is applied to explore how an intervention to transform digital infrastructure (technologies and innovations leading to accessibility, availability and affordability of ICTs) in the context of available resources (agency) impacts the degrees of empowerment of livestock actors, and ultimately the development outcomes; the primary outcome being choice and

secondary choices being, amongst others, easier communication and access to markets. The presupposition attached to the application of the Choice Framework is that intervention indeed transforms the structure of the community and/or the structure of the livestock system.

- **Limitations of the Choice Framework**

While the Choice Framework helps to focus on the development process, further work has been done to 'fine-tune' Kleine's Choice Framework. Attwood and May (2015) applied the Choice Framework to an ICT intervention project and proposed further improvements to the Choice Framework which can help in understanding the development process. The proposed adjustments by Attwood and May (2015) indicate that the Choice Framework is a work in progress but critically, the Choice Framework "eased the process of tracking the many interacting factors and activities that resulted in different development outcomes, influenced by participants' unique personal characteristics and resources" (ibid: np) and this inspired its adoption for this study. In the context of this study, Kleine's Choice Framework falls short in explaining the complex dynamics which occur during the establishment of specific structure. Thus, the Choice Framework becomes applicable within a context in which a specific structure exists. It is argued that the Choice Framework is restricted to post intervention assessments and has limited relevance to the politics of intervention planning (outside of speculative outcome planning). In addition to the above, other studies (Hatakka *et al*., 2016) argue that the Choice Framework fails to interrogate the properties of ICTs which "make possible some action" (Gaver, 1991:80). As such,

> *"[w]e need to look at the material properties and how they, in the interaction with actors in a specific context (defined as agency and structure in the choice framework), affect individuals … by adding the concept of affordances to the analysis, we will be able to better understand why technology may fail in one place but work in another, and … better explain how ICT can improve individuals' capabilities and choices*" (Hatakka *et al*., 2016: np)

To this end, Hatakka *et al*. (2016) argue that the Choice Framework needs to be further expanded by integrating affordances theory.

3.2.3 Technology affordances

Digital infrastructure transformation interventions, such as the MOSMAC project, contribute to the introduction of new technologies in previously disadvantaged communities and these technologies come with specific affordances. However, for one to be able to identify a technological affordance, one needs to possess the skills and knowledge; thus, without appropriate skills development, efforts among rural community members may fail to identify technology affordances of new and existing technologies. As Gaver (1991:80) argues, "[w]hether a handle with particular dimensions will afford grasping depends on the grasper's height, hand size etc." Thus, the expected affordances of technologies resulting from a digital infrastructure transformation intervention like MOSMAC depend on other characteristics of the livestock system, e.g. those identified in the SES framework such as actors' attributes, governance system attributes, resource units' attributes, and the resource system attributes. However, even though system actors are central to the technology affordances theory, Gaver (1991) also argues that technology affordances are independent of perception or appropriation. Thus, digital infrastructure transformation in the study area creates affordances embedded in these technologies but whether actors appropriate the technology affordances or not is a secondary issue. Therefore, from the existing studies, technology affordances emerge as relational since Gaver (1991:80) defines affordances as "properties of the world with respect to people's interaction with it" while Majchrzak and Markus (2012: np) suggest that the theory is premised on "uses and outcomes of information systems and technology are best understood in terms of *relationships* between individuals or organizations and technology features." In addition to this, Leonardi (2012) suggests that technology affordances only bring change when these affordances are appropriated by the wider group. Therefore, the digital infrastructure transformation intervention can only yield desired outcomes when livestock system actors in the study area appropriate the affordances of the digital technologies collectively.

Table 3.3: Technology affordances

	Technology Affordance exists	**Technology Affordance does not exist**
Users have perception information	Perceptible affordance	False Affordance
Users do not have perception information	Hidden Affordance	Correct rejection

Source: Gaver (1991)

In the context of this study, the focus is to understand whether the digital technologies made available to the community through the intervention have the affordances (*hidden or perceptible*) to enable livestock system actors to achieve sustainability of the livestock system, and whether livestock system actors have the perceptual information relating to identifying and knowing ICT affordances. Digital technologies such as mobile phones, internet, and computers are designed with specific affordances regardless of whether one is aware of these affordances or not. Gaver (1991) clarifies that the mere existence of affordances will not result in the artefact changing the situation but rather, it should be accompanied with perceptual information, as indicated in Table 3.3. Further to the above, in a related study on technology affordances, Leonardi (2012) sought to establish when technology affordances enable change within communities. In the same study, Leonardi (2012) explored the concept of group and individual affordances. This is critical to the study considering that the different livestock actors within livestock systems have different agency (including perceptual information, and ICTs) and for ICTs to have an impact on the livestock system, group affordances need to be realised. This means that until all the livestock actors realise and appropriate the ICT affordances, these ICTs may not be able to deliver the needed change.

However, technology artefacts are introduced and used within societies which have specific pre-existing structures (economic, social, political) which can influence the adoption and use of these technologies despite the potential affordances. The study argues that the technology affordances are inadequate when analysing the potential of ICTs within complex systems embedded in other systems which also involve several institutions. Most of the institutions in developing countries have been reported to be inflexible and not open to change, evidenced by the slow progress of features such as e-governance. This is not a result of lack of technologies with perceptible affordances, but rather institutional delays. Therefore, the technology affordances theory connects to other theories and frameworks selected for the thesis in different ways. Firstly, technology affordances can be connected to the SES framework in that the study explores what technology can be used for within the SES (the livestock system). Also, technology affordances are connected to the choices they afford to its users.

3.3 RELATED STUDIES ON LIVESTOCK AND FOOD SECURITY

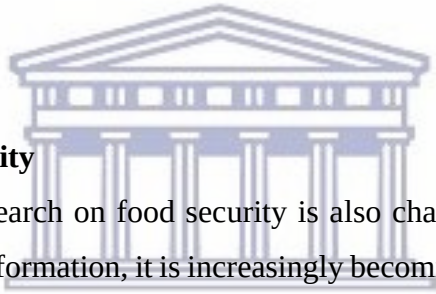
3.3.1 Food security in Zimbabwe

As already noted, food insecurity continues to be a major challenge across the globe dominating the global agenda (Garnett *et al.*, 2013; Swaminathan, 2010). Despite many efforts to address the food insecurity challenge, practical solutions appear far from being realised. As such, the challenge has been redrafted into the SDGs agenda. Even though current research on food security is "*overly characterised by dichotomies"* such as developing and developed, rural and urban, food security is not an issue affecting marginalised communities only (cf. Pereira and Drimie, 2016: np). For instance, despite being some of the most developed countries in the world, the United States of America (USA), Canada and the United Kingdom (UK) are also affected by food insecurity. However, impact does not compare to developing countries, e.g. only 8% of Canadian households are food insecure compared to over 65% in most African countries (Wakefield *et al*., 2015; Wax & Stankorb, 2016:2458).

Further to this, recent studies reveal that countries in sub-Saharan Africa are the most vulnerable to food insecurity across the globe (Godber & Wall, 2014). Grace *et al*. (2015) suggest that most countries in sub-Saharan Africa, including Zimbabwe, are among the most vulnerable to climate change and variability, and are subsequently food insecure. Kuku *et al*. (2011) reported that while the sub-Saharan Africa region faced serious challenges, the situation was dire in Zimbabwe. In the 2017 Global Hunger Index report, Zimbabwe ranked as a low-income food-deficit country with the severity of hunger rated serious (Von Grebmer *et al*., 2017). In the past decade, Zimbabwe has experienced extreme food insecurity with households in the drier areas such as Beitbridge among the worst affected (cf. Mango *et al*., 2014). However, within these households in rural communities, Kuku *et al*. (2011) show that there are different levels of food insecurity, especially between the adults and children. Many households in Zimbabwe continue to rely on donor sponsored programs for food such as World Vision's relief programs, Plan's cash transfer projects and World Food Programme interventions.

In contrast, before the controversial land reform program and economy crisis, Zimbabwe had a progressive agricultural system producing sufficient food (net surplus) for households to an extent it was considered the breadbasket of the African continent (Mavedzenge *et al*., 2006). However,

in recent years, agricultural output contribution towards the national GDP (Gross Domestic Product) has significantly declined. Considering the decline in agriculture (largely crop production), there are suggestions on how food security in rural communities can be enhanced. For instance, Kiptot *et al.* (2014) suggest that in rural communities, agroforestry can contribute towards household food security. Other suggestions include revising and supporting non-farm income generating activities. However, some solutions may need improvements in economic and political sectors; *e.g.* studies show that apart from climate change and variability, economic and political instability has also contributed towards intensification of food insecurity in Zimbabwe. As such, solutions towards the economic and political challenges in the study area may also enhance food security. In all, it is prudent to concur with existing studies that the rural population in Zimbabwe is among the most food insecure, and this is despite most households in rural communities owning livestock, which can potentially play a key role towards household food security.



3.3.2 Livestock and food security

As food systems transform, research on food security is also changing (Djurfeldt, 2015) and as part of the research agenda transformation, it is increasingly becoming evident that researchers and practitioners are interested in understanding livestock's contribution towards household food security, as well as the potential of emerging technologies contributing towards the sustainability of the livestock system (CFS, 2016; HLPE, 2016; Gwaka, 2017; Debsu *et al*., 2016). Jodlowski *et al.* (2016:99) indicate that despite several studies on livestock, "little empirical work actually demonstrates a causal link between livestock ownership and food security." The 43rd convention of the Committee on World Food Security (CFS, 2016) was conducted under the theme "*sustainable agricultural development for food security and nutrition: what roles for livestock?*" specifically to address the link between livestock and food security. However, as indicated in the discussion of key terms, food security, in this study, is explored through the various dimensions of food security (*see Section 3.1.1*). To this end, when considering livestock's contributions towards household food security, the study narrows down these contributions to the different dimensions of food security (cf. Notenbaert *et al*., 2017).

3.3.2.1 Livestock and food availability

Livestock offers numerous products (animal source foods: eggs, milk, meat) and services which contribute towards the different dimensions of food security in rural communities (HLPE, 2016). Further to this, there are many classes of livestock, and their uses within households also vary resulting in varying contributions to household food security (Valdivia, 2001). The wide range of livestock products and services together with the multiple dimensions of food security make the analysis of the intersection of livestock and food security complex. In this review, the focus is restricted to the contribution of livestock towards food availability and food access in rural communities. In harsh agro-environments, livestock play a critical role towards achieving food security (Gerber *et al*., 2013). In such environments, crops often fail, and to ensure continuous food availability, livestock is used to provide multiple products (Alary *et al*., 2011; Smith *et al*., 2013). In the *African Livestock Futures* report, Herrero *et al*. (2014:4) suggest that:

> *"If people can access milk, eggs, meat and other livestock products, they are likely to be able to enjoy food security and to be well-nourished. As people's disposable incomes increase, their demand for (and access to) livestock products tends to increase as well."*

However, over the years, many studies conducted in rural areas have raised questions on whether poor livestock owners consume livestock products. To answer this, Randolph *et al*. (2007) indicate that it is not necessarily the case that when rural households have livestock, they also consume livestock products. An analysis of the intra-household consumption of livestock products demonstrates that rural communities (livestock owners) may not be consuming livestock products. For instance, Bettencourt *et al.* (2015) show that livestock product consumption is often sparse and in some poor communities, the consumption of some products, such as milk and free-range eggs, is restricted; coupled with occasional slaughter of large livestock. Research on livestock in rural communities has reported that small ruminants and small stock are consumed more than large stock (cattle specifically), as large stock is kept for social status, store of value and symbols of wealth. However, the consumption of livestock is an option which households have control over and as such, this study claims that when households have livestock, they have food available to them and whether the households decide to utilise livestock as food is a household option. The difference is that a household without livestock cannot decide to slaughter livestock (and have food); thus, having livestock symbolizes food availability and food choice.

Further to this, food availability can also be considered from the perspective of the nutritious food available to consume. Some researchers approach food insecurity as the *deficiency in the quality of diet rather than quantity of food* (Jodlowski *et al*., 2016:111). In most African communities, livestock provide animal source foods such as meat, milk and eggs, which are critical components of the human diet. Thus, livestock directly contributes towards nutrition status or security of households especially in low-income households (Smith *et al*., 2013). Nabarro and Wannous (2014) further indicate that at least one-third of the protein requirements for humanity is derived from livestock despite livestock using a third of the global grain to do so (Smith *et al*., 2013). Nutrients from livestock products include amino-acids, iron, zinc, vitamin A, vitamin B12 and calcium. In hunter-gatherer societies, animal protein is mainly satisfied through hunting of wildlife (McMichael *et al*., 2007). However, the onset of civilisation and the subsequent decline of hunting activities mean that societies are turning to livestock production for animal protein. Also, Nabarro and Wannous (2014) claim that as people's lifestyle improve, *i.e.* as people get wealthier, their requirements for animal source foods also increase.

Over the years, developing countries have enjoyed relative economic growth and as a result, the demand for animal protein has also grown (Delgado *et al*., 2001). Nabarro and Wannous (2014) forecast that in the African region; demand for animal protein will gradually increase. In most rural communities, individual households possess livestock but there are other households without livestock due to abject poverty. Despite this, these households without livestock still enjoy livestock products. For instance, Jodlowski *et al*. (2016:100) report that in Zambia, livestock distribution to one group even resulted in increased milk consumption by non-recipients. This indicates that food and food consumption practices such as food sharing remain social activities in communities. Therefore, in the context of this study, it is assumed that if a household has livestock, it has food readily available (i.e. they can opt to slaughter and consume) even though livestock alone will not provide the diverse dietary requirements. Households also derive other products such as manure, hides and bonemeal, and the indirect benefit to food security via improved yields without costly inputs. In all this, it can be underlined that livestock contributes towards food availability dimension and thus, contributes towards household food security. Even for those without livestock, they can also access animal source food through social relations.

3.3.2.2 Livestock and food access

As shown earlier in Table 3.1, food security has several dimensions and one of these dimensions is food access (Gartland & Gartland, 2016). In this regard, the food access dimension focuses on elements such as, but not limited to, food marketing, transport, incomes and buying power (ibid). On the other hand, Burchi and De Muro (2016) suggest that the food access dimension is a different way of examining household food security, which they refer to as the *income approach*. In their argument, Burchi and De Muro (2016) indicate that food insecurity is a sub-sector of poverty which is linked to the lack of income to acquire 'necessary goods'; in this case, food (ibid). Therefore, using the income approach, food insecurity is linked to the *lack of income to acquire sufficient food* (Gladwin *et al*., 2001; *see also*, Table 3.1). In all, the realisation of income empowers households to access food. Therefore, if households are to be food secure, the household needs reliable income-generation. However, opportunities for income generating ventures in most rural communities are extremely limited. Thus, most rural households rely on agricultural produce, petty trading, manual labour and sale of natural resources for income. In areas with a harsh agro-environment, livestock present a critical source of income which can be used to 'access' food in most households especially during bad seasons with little or no rainfall. Therefore, in addition to providing animal source food (protein), livestock is also considered a crucial asset which provides households with income necessary for purchasing food (Herrero *et al.*, 2014; HLPE, 2016). Apart from being sold, livestock can be traded in barter trading for food and used as a "savings account" in rural communities (Quinlan *et al*., 2016:77).

Despite the above, there are many challenges to relying on livestock for income generation to supplement food. One of the major challenges which smallholder farmers relying on livestock income for food access is the inconsistency in market prices. In a study done in the Eastern Cape of South Africa, Rasch *et al.* (2017) found that the prices fetched by smallholder farmers on livestock differ according to season. During summer, farmers obtained higher prices due to improved live weight compared to winter. These variations also mean that during the winter period, smallholder farmers have less disposable income and this income would need to be split between the various household needs such as medical bills and school fees and thus, may result in inadequate allocation for food. Therefore, even though livestock is central to livelihoods of rural communities, it is critical to acknowledge that sole reliance on livestock can present risks to

household food security. In other studies, livestock has rather been identified as essential for smoothing of income fluctuations in rural communities; and thus, are used as 'backup' when other sources are unable to sustain the household.

Based on related work as well as the author's experiences of livestock marketing at several auctions in rural communities in Zimbabwe, smallholder farmers are struggling to obtain optimal value for their livestock in rural communities (Gwaka, 2017). In Beitbridge, auctions are the most common way smallholder farmers sell their livestock even though they also conduct farm gate sales. However, irrespective of the option which smallholder farmers use to sell their livestock, the farmers are failing to obtain satisfactory prices. Literature provides many explanations supporting why smallholder farmers are failing to obtain optimal values. Chief among these explanations are smallholder farmers' lack of marketing skills, failure to access market information as well as poor market structures, thin markets with many sellers and few buyers, information asymmetries and high transaction costs (Aker & Ksoll, 2016). Most livestock buyers in rural communities such as Beitbridge are agents and therefore always aim to bargain prices which can allow them to obtain higher profit margins. These agents further re-sell livestock in better markets such as Bulawayo and Masvingo, obtaining considerably higher prices. The major advantage which agents have is organisation between themselves, access to transport and better knowledge on the operation of the markets.

3.3.3 Livestock systems' sustainability

Many studies including Herrero *et al.* (2009) show that despite the contributions of livestock species towards household food security and well-being of households in rural communities, the livestock systems in most rural communities face many challenges. The concept of sustainability, as discussed earlier in the chapter, is broad and complex as it includes multiple dimensions: the three common ones being environmental, economic and social sustainability, with cultural sustainability also being considered as the fourth dimension (cf. Opoku, 2015; see Figure 3.2). While in an ideal scenario all the dimensions of sustainability need to be achieved simultaneously, this is rarely the case and in most instances, the importance of a sustainability dimension is system-based; and thus, varies from one system (*e.g.* type of system actors) to another (Marandure *et al*., 2018). Thus, the selection of indicators is not a prerogative of researchers but should be a collective

exercise of all local stakeholders in the production system including farmers (*ibid*:1086). This study now turns to discuss the dimensions of sustainability since Oliver *et al*. (2018:4) suggest that, "interdisciplinary synthesis, which brings together ecological, cultural, social and economic factors, is a significant starting point."

3.3.3.1 Environmental sustainability

Environmental sustainability of a system refers to a system's ability to function in adverse environmental conditions and the ability to function without impacting the environment (Duru and Therond, 2015). Existing studies show that the relationship between livestock and the environment has negative and positive feedback loops. The livestock system, to some extent, supports the environment (positive) and inversely affects the environment (negative); for example, through exerting pressure on the environment (overgrazing) and emitting greenhouse gasses in addition to many other hidden environmental costs (Braghieri *et al*., 2015). On the other hand, the environment provides livestock with essential services (feed and water) while adverse environmental conditions such as extreme heat also negatively impact livestock.

Climate change has many impacts on the environment and some of these impacts include the depletion of water resources and biodiversity (pasture/livestock natural feed) in most rural communities (Morton, 2007; Misra, 2014). To put this in context, between November 2015 and January 2016, at least 7000 herds of cattle succumbed to drought (lack of water and feed) in the province in which this study was conducted.[13] Livestock deaths threaten household food security in that it reduces the number of livestock available for consumption (food availability) and livestock available for selling (food access). Climate change further results in an increase in diseases affecting the quantity and quality of livestock produced and subsequently, negatively affecting the prices which the livestock farmers can fetch from markets (Verschave *et al*., 2016).[14] In the broader context of food security, climate change will also impact crop production. Foresight studies are predicting that in the future, crop production will continue to be impacted on by climate change (Dorin *et al*., 2011). Al-Amin and Ahmed (2016:52) suggest that due to climate change

[13] 7,000 head of cattle succumb to drought. Retrieved September 26, 2018 from: http://www.chronicle.co.zw/7000-head-of-cattle-succumb-to-drought/

[14] This is further discussed under economic sustainability as distress sales.

and global environmental changes, as much as 30% of African crops could be under threat. Because of this prediction, the role of livestock towards household food security will increase (CFS, 2016).

To this end, climate change has numerous and major impacts on most rural households' livestock and subsequently upon food security (Conceição *et al*., 2016:1; Shetty, 2015:459; Wossen & Berger, 2015). Conversely, the large numbers of livestock held by smallholder farmers in rural communities is a concern in that the increase in livestock directly results in an increase in pressure on natural resources and the environment (Robinson *et al*., 2014). Livestock, especially cattle, occupy large spaces of land in rural communities and the frequent movement of livestock extensively degrades these spaces. Small livestock, on the other hand, do not occupy larger spaces, *e.g.* goats and chickens. Therefore, it is further suggested that efforts to achieve food security in the modern era need to encompass mechanisms to adapt to climate change. In addition to this, there is an urgent need to build capacity and increase awareness on climate change at local levels, contributing to improved adaptive capacity. However, conventional problem-solving approaches used in rural communities which often place problems *at the centre and in the past* are not yielding the desired outcomes. New approaches such as futures visioning can play a key role towards deploying new approaches to solving problems (Chitakira *et al*., 2012).

In sum, related studies show concern on the sustainability of livestock systems in rural communities in the wake of global environmental changes and climate change. Empirical evidence reveals that climate change is affecting livestock systems in various ways and varying degrees. As such, it is critical that communities have the capacity to adapt and mitigate climate change. Adapting to climate change is often determined by the agency (resources) which the communities have, as well as the contributions of the institutions (support/structure of society) within the community (see Kleine, 2010; 2013). Adaptive capacity of the communities, therefore, needs to be enhanced. On the other hand, human activities are also contributing towards climate change. It is essential, therefore, that humans also be aware of their contributions towards climate change and the likely impacts. Innovative approaches such as futures visioning, and scenarios planning can be useful in ensuring that in the wake of climate change, livestock systems' sustainability is enhanced (Sheppard *et al*., 2011).

3.3.3.2 Economic sustainability

Economic sustainability and/or livestock system competitiveness is another dimension of sustainability.[15] Duru and Therond (2015) suggest that economic sustainability of a system can be examined based on a system's profitability, risk, autonomy and transmissibility. If we accept this proposition, there is need to identify the determinants and measures of profitability, risk, autonomy and transmissibility within the livestock systems (Bahta and Malope, 2014). While this would be desirable to closely examine the economic dimension of sustainability, there are several challenges. For instance, the lack of data, *e.g.* on cost of production, inputs and labour complicates calculating profitability while efficiency drivers can easily be ascertained (lack of data makes determination of transmissibility extremely difficult to calculate in the study area). Further to this, there are studies which have examined sustainability at macro levels, that is, livestock systems' contribution to the greater economy (*e.g.* GDP measures, jobs created and exports) but in a distorted economy such as Zimbabwe, it is difficult to accurately ascertain such measures as the macro level measures are influenced by broader issues. In addition to this, Marandure *et al*. (2018) suggest that it is inadequate to focus only on monetary elements. Therefore, in this study, the economic sustainability dimension is measured at household level; and thus, focuses on livestock's contribution to the economic well-being of the household stemming from profitability (during sales).

Studies such as Barrett *et al*. (2017) argue that markets for agricultural produce in rural communities underperform and are unable to generate desired profits for smallholder farmers resulting in the agricultural systems being economically unsustainable (Mavedzenge *et al*., 2008). In previous studies focusing on commodity sales in rural communities, the markets in rural communities are generally thin with limited buyers and a high number of sellers. Further to this, the market participants, normally less educated and elderly, have limited market information, *e.g.* prevailing market prices, compared to the buyers. In the case of livestock markets in Zimbabwe, the dissolution of the Cold Storage Commission in the 1990s resulted in the collapse of the formal livestock auction system with only selected districts continuing with the auction system (Mlambo, 1996; Mavedzenge *et al*., 2008). Other studies have suggested that smallholder farmers in rural

[15] Instead of economic sustainability, Bahta and Malope (2014) use the phrase "livestock systems competitiveness".

areas lack access to market information and this information asymmetry often leads to under-pricing of agricultural produce (Barrett, 2008). While Barret raised this in 2008 (and many other studies did so before), Barrett *et al*. (2017) acknowledged the persistence of structural issues within African agricultural markets that affect the prices which smallholder farmers get. However, there are suggestions that the introduction of new technologies has improved some aspects of the markets, *e.g.* information flows; yet still markets are performing poorly (cf. Debsu *et al*., 2016).

Further to the above, the general macro-economic environment is a major contributor to the fragility and/or sustainability of the livestock system as the economic environment dictates the functioning of the system and many other related systems. Using the case of Zimbabwe, the poor economic environment has affected the performance of the agriculture system in that there are limited financial facilities to assist smallholder farmers, such as loans or export facilities. The economic problems within the Zimbabwe economy also impact the sustainability of the rural livestock system. For instance, cash shortages in Zimbabwe negatively affect the selling patterns in rural communities as buyers are unable to pay farmers immediately during livestock auctions. At the same time, the farmers are forced to make sales, or more accurately, *distress sales*, due to adverse climate conditions. Livestock, in the climate change era, are more prone to diseases and thus, high mortality is a high risk (*high likelihood and high impact*). Furthermore, the decline in feed (biodiversity) means that the livestock quality has also been declining, resulting in livestock being a risky option on which to depend.

From the analysis, the economic sustainability (profitability, risk and autonomy) relates to factors which can be controlled and improved in rural communities; for instance, through training and information dissemination. Empirical evidence suggests that the economic sustainability of livestock systems in rural communities is threatened, but corrective measures can be implemented unlike as for environmental sustainability. There are studies on improving markets using emerging technologies, e.g. technological improvements to improve quality such as biotechnology. However, it is also prudent to accept that while technological innovations have the potential to contribute towards overcoming some of the main challenges within the livestock value chain, there are also limitations.

3.3.3.3 Sociocultural sustainability

In the sustainability framework, social sustainability is one of the three sustainability pillars commonly discussed in most studies; but in this study, the social sustainability pillar is integrated with the cultural sustainability pillar (see again Figure 3.2). Thus, this section focuses on discussing the sociocultural sustainability of the livestock system (cf. Boogaard *et al.*, 2011). In defining the term sustainability, it has already been acknowledged that there are different ways to define it but in the context of sociocultural sustainability, Boogaard *et al.* (2011:1459) suggest that this concept focuses on:

> "*The regeneration of the social system and its continued ability to achieve social objectives such as social cohesion, social mobility, empowerment and equity, institutional development. It also refers to values and norms which are important fundaments of a culture.*"

In addition to this, Allen (2008) argues that the sociocultural sustainability of a food system relates to the achievement and maintenance of social justice. Social justice, according to Basok *et al*. (2006:267) is defined as "an equitable distribution of fundamental resources and respect for human dignity and diversity, such that no minority group's life interests and struggles are undermined and that forms of political interaction enable all groups to voice their concerns for change." However, it is concerning that many studies (*as discussed below*) continue to show that in the current food systems, including livestock systems, women and young people continue to be marginalised; failing to achieve the equitable distribution of fundamental resources within the food system (Allen, 2008). To this end, Sraboni *et al*. (2014:11) show that within the food security challenge, gender-related issues and youth engagement need to be addressed to achieve sustainable food systems.

In sub-Saharan Africa, women constitute a significant portion of the smallholder farmers (Tibesigwa & Visser, 2016). The role of women in rural communities is acknowledged in many studies but Kristjanson *et al*. (2014) postulate that there are still knowledge gaps in understanding the roles of women in the livestock sector. HLPE (2016) suggest that women's roles in livestock systems differ from one region to another. There are limited studies which consider the 'gendered' impacts of complex systems (Tibesigwa *et al*., 2015). However, to improve the understanding of food security in rural communities, it is essential to also understand gender dynamics (Swaminathan, 2010). Gender plays a key role in influencing specific roles in households relating

to food production/sourcing, eating patterns and other responsibilities. Also, the analysis of gender and food security can be extended to examine differences in food security status between female-headed and male-headed families. This is critical since this study area's communities are affected extremely with the proximity of South Africa border to Zimbabwe, as most men opt to migrate to South Africa to look for better opportunities.

With respect to livestock, the role of women has evolved. Nabarro and Wannous (2014) posit that in livestock rearing, women indeed do have a critical role. Traditionally, the household head (usually the male figure) makes decisions relating to livestock but there is evidence suggesting that consultation is made with the female partner. Thus, women can provide support and approval in decision-making (cf. Nyantakyi-Frimpong *et al*., 2016). There are other studies indicating differentiated roles of men and women relating to livestock. For instance, in Valdivia (2001:34) women were found to have control over the management of livestock but not the marketing of the livestock (see also, Aker & Ksoll, 2016). Prior studies indicate that in rural communities, women play a crucial role towards household food security, but they are also the most vulnerable and least food secure (Bishokarma & Amir, 2014:45).

In the African context, culture often dictates the household roles of children, women and men. Traditionally, women are charged with most household chores as well as dealing with household food issues. The ownership and control of household assets such as livestock have also been subject to debate. Even though improving, women's control over assets is considered essential to the sustainability of food security but remains inequitable (Sharaunga *et al*., 2016). Further to the above, when examining gender and livestock, it has emerged that within households there are different types of livestock and women are inclined towards small livestock (*e.g.* poultry & pigs) as well as products of large livestock, while men are associated with large livestock (cf. HLPE, 2016). Most women are charged with the responsibility and/or can make decisions on small livestock. In rural communities, the slaughter of cattle for family consumption is normally reserved only for 'special occasions' as cattle are viewed as a store of value. However, goats and chickens are commonly slaughtered for family consumption.

It is prudent, therefore, to indicate that even though there is no debate on whether women play a role in the livestock systems, it remains evident that within the livestock systems, women continue to face many more challenges as compared to men (Kristjanson *et al*., 2014). There are several

constraints which women face in trying to break men's dominance in the livestock system. Tradition and culture are central factors, often assigning roles and responsibilities in communities. In some contexts, women's ownership of assets in households has been extremely restricted (Bishokarma & Amir, 2014). In the context of areas such as Beitbridge, with high male out-migration, it is inevitable that women will assume control of household assets including livestock; and thus, will also be participating in previously male-dominated activities. In this vein, for a livestock system to be sustainable, it must become acceptable from a sociocultural lens for women to participate alongside traditional activities. Further, even though men may participate more at livestock auctions, decisions to sell *are collectively* made within the household (*ibid*). However, as McKune *et al.* (2015) note, the responsibility or involvement of women in the decision-making process within the livestock system can change over time; for instance, when men are away working other jobs.

The foregoing discussion has outlined the challenges which women continue to face within livestock systems and opportunities for women to be included and empowered. The discussion addressed issues relating to social cohesion, social mobility, empowerment and equity. In addition to these issues, studies also suggest that sociocultural sustainability refers to the regeneration of the social system which is expected to be achieved through passing down of social practices, norms and values to young people. However, the food sector is often intentionally overlooked by many youths who opt not to engage in its activities; labelling it a sector for the 'poor', 'rural' and 'uneducated', and preferring to work in the services sector (Magelah & Ntambirweki-Karugonjo, 2014). There is a great deal of misconception about the agriculture sector by youths resulting in low youth engagement in the sector (Chinsinga & Chasukwa, 2012). However, in some rural communities, youths are absorbed into the agriculture system by 'default'. In most rural communities, there are limited income generation opportunities and families must rely on agriculture. Therefore, as youths develop, they are also allocated their own resources, *e.g.* a piece of land and livestock to transition and be self-sustaining (Chinsinga & Chasukwa, 2012). However, in the context of Beitbridge, the proximity of South Africa to the rural communities has challenged the original society setup (Gwaka, 2018). The migration of youth from rural communities in search of better opportunities is not only affecting border communities but is a major concern for all rural areas.

Further to the above, in the context of Zimbabwe, the agriculture sector has been heavily politicised, starting with the land reform program between 1999 and 2000. The result of the land reform has been the occupation of farms by political figures, neglecting youths who were at the forefront of political activism. Even still, for those who decide to embark on agriculture, the challenges are many. Apart from climate change, the poor performance of the general economy repels youth from engaging in the agriculture sector. The Zimbabwean agriculture sector has not provided any significant incentives which attract youths into the system. It is evident therefore that there is limited empowerment within the agricultural systems in Zimbabwe, which affects the regeneration of the social practices.

However, despite prevailing trends, technological advances are providing new opportunities to improve the participation of women in the livestock system, since ICTs are believed to have ways to promote social and economic inclusion (Deen-Swarray, 2016). However, marginalisation of women also continues to affect women's ownership of technology in rural communities. Therefore, even though technologies may provide opportunities to transform gender imbalances in the livestock system, there are other deeply entrenched cultural caveats which need to be negotiated to enable improved access to technologies by women (Wyche *et al*., 2016). Developing solutions to encourage the involvement of youths remains one of the major priorities for those involved in agriculture; and attempts to incorporate ICTs into the agriculture sector may be a creative pathway to attract youths to participate in the sector (Choi & Graham, 2014). Youths are leading users of ICTs and often find creative ways of using these ICTs to solve problems (Debsu *et al*., 2016). Further to this, the embedding of ICTs needs to be complemented by demystifying the current perceptions of youths about the agriculture sector. Supporting systems, *e.g.* financial systems, also need to be in place to incentivize youth participation.

3.4 RELATED STUDIES ON DIGITAL INFRASTRUCTURE

This section provides a literature review on digital infrastructure, ICTs and their application to development (ICT4D), and finally, in the context of the study, ICT application to livestock systems. The term digital infrastructure has been discussed in Section 3.1.4 and for this study; the term is adopted in its broader context (see, Sorensen, 2013:6). This section begins with a discussion of the ICT4D approach, leaning towards ICT application to livestock systems. Following this, the

section shifts to review literature on the state of digital infrastructure in rural communities as well as efforts relating to addressing the digital infrastructure in rural communities. This leads to a discussion on digital technologies and the sustainability of livestock systems.

3.4.1 Digital infrastructure in rural communities

Steinfield and Wyche (2013) suggest that to explore ICT's impacts within a society or a system, it is critical to first understand the state of ICT within the specific society or system. From the literature reviewed, the state of digital infrastructure in rural communities in Zimbabwe is poor (Grimshaw & Gudza, 2010). One determinant of ICT access in communities is electricity. Even though solar powered initiatives are increasingly becoming common, this remains an expensive alternative. It is no surprise that rural communities' digital infrastructure state is poor given that in a related study, Mugwisi *et al*. (2014) found that with respect to the state of ICT within agriculture education colleges, 64.5% of respondents indicated that it was poor. The 2016 POTRAZ quarterly report further shows that despite rural communities comprising the largest demographics in Zimbabwe, the number of telecommunication base stations allocated for urban communities exceed those allocated for rural communities (POTRAZ, 2016). In relation to connectivity, rural communities also have access to inferior type of networks, *e.g.* 2G and not LTE (Long-Term Evolution) which is only found in urban areas (*ibid*). Most studies on ICT access in rural communities appear not to be concerned with quality of access but rather quantity. The poor state of digital infrastructure in rural communities is also common among Africa countries such as South Africa and Zambia (Van Stam, 2012).

In addition to the above, Mugwisi *et al*. (2014) as well as Takavarasha and Makumbe (2012) show that a lack of policies, coupled with stringent regulations, is contributing to the poor state of digital infrastructure in rural communities. To understand the state of ICT with a focus on e-governance, Ruhode (2016) conducted a thematic analysis of Zimbabwe ICT strategic and policy documents. In the study, Ruhode (2016) shows that while the policy documents reveal government's awareness of the need to focus on developing digital infrastructure in rural communities, there are no signs of the policies being translated into action. Furthermore, no relevant funding models were established in these documents (*ibid*). To combat the poor state of digital infrastructure in rural communities, Wong *et al*. (2013) suggest that there is need to establish alternative models to transform digital infrastructure in the rural communities. To date, there are several efforts by

various players to improve digital infrastructure conditions in rural Zimbabwe, including government efforts. With the realisation that top-down service providers, *e.g.* Econet (Zimbabwe), Vodacom, MTN (South Africa) are failing to address the telecommunication needs of rural communities, community networks are increasingly becoming a viable alternative (Saldana *et al.*, 2017). Rey-Moreno and Graaf (2015) indicate that across Africa, there are several initiatives including just one (Murambinda Works!) in Zimbabwe. Community networks are sometimes heralded as having the potential to overcome the connectivity barrier, but the major challenge remains scalability (Walsham *et al*., 2007) and replicability in different contexts (Gwaka *et al.*, 2018). Heimerl *et al*. (2015:2) show that already, small, local cellular operators are becoming common in some parts of the developed world.

Apart from the networks (connectivity), another aspect to consider is how much digital devices are accessible to rural communities. Many studies on ICTs in rural communities refer to mobile phones, as these are becoming more common in such communities. Further to this, there are also different forms of mobile phones with feature phones (with less functionality) being more popular than smartphones. While feature phones allow SMS (Short Message Service) and voice calls, smartphones can have additional applications, or apps. Another key challenge apart from access, in terms of mobile phones, are the mobile tariffs for voice, data and SMS which are high, specifically for households in rural communities with limited income. While mobile phones represent a viable way to access technology in rural communities, the high costs of operating and lack of connectivity mean that alternative options are needed. Thus, to overcome the access problem, there are efforts by various agencies (government and non-governmental) to set up community information centres with personal computers which are connected to the internet.

Cognisant of the lack of and/or poor state of digital infrastructure in rural communities, many studies exploring options to address these challenges have ensued (Rey-Moreno *et al*., 2016; Gwaka *et al*., 2018). Several studies suggest that the current state of infrastructure in rural communities is an outcome of many factors among these; politics and institutional politics play a key role (Takavarasha and Makumbe, 2012). In addition, there are many studies suggesting how the poor digital infrastructure in rural communities can be addressed. For instance, Rey-Moreno *et al.* (2015) suggest that rural lack of communication infrastructure can be addressed through community-led low-cost community networks such as Zenzeleni in Mankosi. Simo-Reigadas *et*

al. (2015) concur with these suggestions and indicate that there are several successful community network initiatives (including in Africa) which are helping to overcome the lack of digital infrastructure.

However, even though there could be potential solutions and willing investors, infrastructure can be political; thus, context can inhibit the efforts to address infrastructure gaps. For instance, Takavarasha and Makumbe's (2012) study show the hostility of the Zimbabwe government towards Strive Masiiwa at the inception of the now biggest telco company, Econet. Thus, it is inadequate to have technological innovations or capital to invest without understanding the caveats which need to be overcome in certain contexts and/or environments. Against this backdrop, Gwaka *et al.* (2018) have further explored how context impacts the replication of these successful initiatives and argue that it is possible to *transfer*, as opposed to replicate, successful ICT4D initiatives, because context plays such a major role. The study opts for the transfer over replicate because it is concerned with the transfer of models that must change depending on a local context, i.e. models that are not replicable as much as they are transferable.

Based on the studies reviewed, there are infrastructure (including digital) deficits in rural areas and many governments, particularly in developing regions, have limited resources to address these deficits. There are several suggestions to address digital infrastructure gaps in rural communities, but this essentially requires multiple strategies. This means, to address digital infrastructure gaps in rural communities, technological innovations (*e.g.* community networks) must be coupled with policy reforms to attract investors, an appropriate legal framework, as well as community participation. In areas where these initiatives have begun, there are already noticeable improvements such as the establishment of community-owned networks in rural South Africa (Rey-Moreno *et al*., 2015; 2016). However, it is inadequate to transform digital infrastructure if the impact which such transformation has (or can have) cannot be accurately established. For many years, ICT impact assessment has been challenging in developing countries and current efforts are criticised for many reasons, including failure to use context-specific metrics (Guston & Sarewitz, 2002; Pather, 2017).

3.4.2 Information and Communication Technologies for Development approach

For centuries, technologies have been designed to help humankind overcome everyday challenges. More recently, technologies are embedded in everyday life practices (Arts *et al*., 2015) to the extent that the current dependency on these technologies is even worrying. The ubiquity of technological innovations such as mobile phone and internet connectivity in marginalised communities has led to the application (use) of these innovations towards solving several societal challenges (Majchrzak *et al*., 2016). The application of ICTs towards solving societal challenges is classified as ICT for Development. However, among the ICT4D studies, the meaning of the term 'development' is contested (Avgerou, 2010) and the term has attracted different definitions which are often context specific. For instance, this study focuses on livestock systems; thus, it could be argued that the definition of development for this study relates to achieving sustainable livestock systems (cf. Gwaka, 2017). With many existing studies exploring the application of ICTs to development, Heeks (2014) and Walsham (2017) conducted studies to evaluate the status of research studies in ICT4D. According to Heeks' (2014) map of Post-2015 development informatics research priorities, areas with highest research gaps include e-environment and sustainable informatics, ICTs and poverty as well as e-Agriculture, ICTs and food. This study falls within the ambit of e-Agriculture, ICTs and food which Heeks (2014) recognised as one of the areas with the highest research gaps, thus, in need of additional research.

The sustainability of rural communities' livestock systems has already been discussed and literature suggests that the livestock systems are fragile. However, against the challenges faced within the rural livestock systems, there is optimism in the role which ICTs can play towards achieving and maintaining the sustainability of livestock systems (cf. Debsu *et al*., 2016; Gwaka, 2017). In the context of the ICT4D sector, leading researchers in ICT4D, e.g. Walsham (2017), suggest that ICT4D researchers have an important role to play towards combating the societal challenges faced by the majority of those in developing countries (including value chain fragility). In the context of the study, there are several suggestions (Choi & Graham, 2014; Arts *et al*., 2015) that digital technologies (ICTs) can play a key role in the sustainability of environmental and food systems. Despite these suggestions, other studies critique the realistic contribution of ICTs towards improving sustainability, *e.g.* improving prices fetched by farmers (cf. Aker & Ksoll, 2016; Srinivasan and Burrell, 2015). Thus, despite the amount of existing research on ICTs application

to development, Antle *et al.* (2016) support further research contesting that advances in ICTs and their capabilities in societies are yet to be fully exploited.

Foster *et al*. (2018) suggest that in the past years, technologies' application in local value chains, such as livestock value chains in rural communities, has been limited. However, given the importance of these value chains and their fragility, it has become critical to integrate technologies as an effort to improve the sustainability of these local value chains. The opportunity to integrate technologies in local value chains is boosted by advances in ICTs which have resulted in an increase in ICT users, who are expected to reach over half a billion in Africa by 2020 (Kabbiri *et al*., 2017). In the past few years, various technological innovations applicable to agriculture have been developed and Table 3.4 presents a summary of selected innovations accessible in Zimbabwe.

Table 3.4: List of selected digital innovations accessible in Zimbabwe

Platform	Technology	Basic Requirement	Technology Affordance	Potential Use
Remote Livestock Marketing System (RLMS)	Web-based system	PC/Smartphone	Online livestock marketing	Livestock sales
E-Mkambo	Mobile phone/Web/App	PC/Smartphone/Feature Phone	Agric Info System	Market Prices
Eco-Cash, Telecash, Netcash	Unstructured Supplementary Service Data (USSD)	Feature Phone	Cash Transfer Payment system	Payment system
Eco-Farmer	Unstructured Supplementary Service Data (USSD)	Feature Phone	Micro-Insurance for crops against drought	Weather information, farming tips and information on when and where to sell, and the best price for their produce.
Social media i.e. Facebook, WhatsApp, Twitter, Instagram etc.	Web-based / App	Smartphone	Social networking, information sharing	Information dissemination/sharing (e.g. social groups)
Dial-A-Mudhumeni	Call in charged	Smartphone/Feature Phone	Extension services	Best Agricultural Practice
Podcast	Voice	Handheld voice devices	Knowledge transfer and sharing	Information sharing in local voices

Kurima Mari	USSD/Calling	Smart Phones	Digital extension	Best Agricultural Practice.

Source: Author

The agriculture sector is one of the largest economic sectors in Africa and many technological innovations within the sector have emerged in the past decade. Since most individuals have access to mobile phones more than any other form of technology in the rural communities, the integration of digital technologies different sectors, including agriculture, in rural communities has largely occurred through mobile phones, both smartphones and feature phones (Rathod *et al*., 2016). There is a growing ecosystem of digital innovations accessible in Zimbabwe which is relevant to the livestock system. These digital innovations (technologies), listed in Table 3.4, have specific affordances which can be exploited to improve the sustainability of the livestock system. However, users need to have the ability (knowledge and skills) to identify the affordances of the technology (perceptual information) (Gaver, 1991) in order to use them; and as presented earlier in the chapter, most smallholder farmers in the study area have not been able to do so in the context of agriculture.

3.4.3 Digital technologies and livestock environmental sustainability

Section 3.3.3 indicated that livestock systems across the globe are threatened by global environmental changes, including climate change, and economic crisis as well as persistent social injustice. Literature shows that global environmental changes increase the unpredictability of livestock system dynamics, leading to massive losses of livestock (*e.g.* via death). In addition, studies show that some of those most vulnerable to global environmental changes are the smallholder farmers in rural communities who have limited knowledge and capacity to respond to the on-going global environmental changes. It is also challenging for technicians working with such smallholder farmers to suggest solutions, considering the complexity of the challenge.

However, the advent of digital technologies has brought revolutionary approaches to dealing with climate change which can also improve the resilience and sustainability of livestock systems. In relation to environmental sustainability, smallholder farmers and other actors within a livestock system can take advantage of new technologies such as remote sensing, crowdsourcing and mobile connectivity (Enenkel *et al*., 2015; Antle *et al*., 2016). There are new DTs which are being used to make predictions of seasonal and weather forecast and communicate climate change information *e.g.* early warning systems that even deal with the impacts of climate change (Eakin *et al*., 2015;

Hearn *et al*., 2014). Further to this, DTs can be used to help communities adapt to climate change; for instance, through interactions with others through social media (Stevens *et al*., 2016). Further to this, ICTs and recent innovations such as social media have the potential to connect people in real-time providing, platforms for discussions and collaborations (Hearn *et al*., 2014). Often, communities struggle to 'connect' with each, other especially for peer-to-peer advice; and the new DTs can bridge this gap as social networking and sharing ideas can strengthen farmer groups (Grimshaw & Gudza, 2010).

Against the increasing impacts of climate change, smallholder farmers in rural communities also need insurance options. However, like many other financial products, insurance options are inaccessible to most rural communities. There are, however, emerging initiatives to provide financial products to rural communities specifically through mobile technologies. In Zimbabwe, Econet is leading by providing mobile insurance through the EcoFarmer option. EcoFarmer is regarded as "… Zimbabwe's first Micro Insurance product designed to ensure inputs and crops against drought or excessive rainfall … insured farmer will also receive daily weather information, farming tips and information on when and where to sell, and the best price for their produce" (Moyo *et al*., 2017:747). There are similar initiatives across the African region; *e.g.* index-based insurance in Kenya which leverage DTs to assist smallholder farmers to overcome the many risks and threats they are facing. Donner (2009) summarises several other available technology initiatives into five broad categories which are: mediated agricultural extension, market information, virtual marketplaces, financial services, and direct livelihood support.

3.4.4 Digital technologies and livestock economic sustainability

This chapter has already demonstrated that smallholder farmers in developing countries are failing to obtain optimal returns from their agricultural produce. Contributing factors include location of these farmers and their produce, poor marketing strategies and lack of market information. However, studies are suggesting that digital technologies can be used by smallholder farmers to overcome the challenges which they face in marketing their livestock; and thereby achieve profitability, and more broadly, economic sustainability. In the context of economic sustainability, the main challenges faced by smallholder farmers relate to market information and market access. Technological innovations, including even the basic mobile phone, can play a significant role in

overcoming these challenges (Jensen, 2007). In the Zimbabwean context, technological innovations such as RLMS (see Figure 3.5) are offering services to livestock farmers to overcome the various challenges which these farmers have faced over the years. This technological innovation is designed to enable smallholder farmers to market their livestock, solicit buying services and even arrange transport logistics; thereby potentially improving the economic sustainability of the livestock system.

Figure 3.5: Extract of the RLMS website showing the services available[16]

In related studies, Karippacheril *et al*. (2013) report that positive impacts were recorded relating to market efficiencies and market participation because of the introduction of mobile phones in India and Uganda, respectively. Through Geographic Information Systems (GIS) location of additional buyers and selling points is reported to enhance the diversity of selling options for livestock farmers. Furthermore, conducting trade online can be critical in significantly reducing transaction costs which are currently exorbitant for smallholder farmers in most rural communities. However, even though digital technologies are thought to provide smallholder farmers with new approaches to overcome the challenges they face, critiques such as that by Srinivasan and Burrell

[16] Remote Livestock Marketing System (RLMS) services advertised on the website. Retrieved June 22, 2018 from http://www.rlmszw.yolasite.com/

(2015) question the actual role of these digital technologies in bringing about change within specific markets. In their findings, Srinivasan and Burrell (2015:67) argue that, with respect to fishermen using mobile phones in Kerala to access market information, "there is no single practice that prevails as the most significant or universally valued use of the phone"; and yet, there is a universal agreement that mobile phones can be used to obtain better prices for goods. In my view, this type of access could have unforeseen ramifications. For example, the livestock auction in Beitbridge is much more than buying and selling – it is a social event. This has been in existence for decades. During the auction, there are many traders with other wares which they sell to smallholder farmers. The introduction of DTs such as online livestock trading may, in fact, disrupt the social life which the community have reason to value. Therefore, even though DTs, through its offerings such as online trading, can revolutionise the livestock system, it is critical to consider disruptions, caused by the introduction of DTs, which may occur within the system.

3.4.5 Digital technologies and livestock sociocultural sustainability

In addition to environmental and economic sustainability, livestock systems also need to achieve sociocultural sustainability. While most studies only consider social sustainability, the cultural sustainability dimension is also important since livestock carries cultural significance in most rural area. In the context of this study, it has been argued that in terms of sociocultural sustainability, there is need for improved women and youth participation (and empowerment) within the livestock system since livestock systems continue to be dominated by men, while young people are also shunning the agriculture sector. The argument presented for women's empowerment is that sociocultural sustainable systems are characterised by social justice. On the other hand, studies also show that cultural practices relating to livestock systems are slowly disappearing as there is little inter-generational sharing of knowledge nor preservation of such knowledge; thus, involving more young people in the livestock system would ensure that cultural practices relating to livestock are carried over into future generations, and preserve societal values. In this context, studies show that emerging digital technologies can play a role towards improving the empowerment of women as youth within rural communities and these are discussed below.

- *Women participation*

In sub-Saharan Africa, women constitute a significant portion of the smallholder farmers. However, the challenges faced by women in the agriculture sector are many and well-documented (Ogunlela & Mukhtar, 2009). As a result, the concept of gender in agriculture is critical to address (Nagothu *et al*., 2016). DTs have many affordances, and this also includes 'giving voice to the marginalised' (Poveda, 2016). In this regard, studies such as Sharma and Maheshwari (2015) give evidence of women overcoming the fear of ICTs in many African communities. It is encouraging that even illiterate individuals in communities are embracing technology. However, from the observed trends, it is evident that most people in the rural communities have access to feature phones. Access to DTs is providing opportunities to empower women, enabling the ability to make choices and having choices made available to them (Said-Allsopp & Tallontire, 2015). Through ICTs, women can obtain equal information. Therefore, based on improved ICT access by women, it is prudent to indicate that transformation can be expected even in the livestock system. The participation of women in agriculture has always been a major issue in Africa. Key challenges included women's lack of access to information considering women's everyday duties within the household, which means that women are mostly immobile and confined to home. However, DTs can overcome this challenge through instant messaging and even social networking. Even though this is anticipated soon, there is a need for efforts to educate women on the use of ICTs and provide necessary support.

- *Youth participation*

Apart from women's empowerment, another critical role which the integration of ICTs in agricultural activities can play is the attraction of young people. Literature discussed in this chapter has highlighted that over the years, there has been limited participation of young people in the agriculture sector (Magelah & Ntambirweki-Karugonjo, 2014). While many reasons have been provided, agriculture has been negatively perceived by youths who consider it as a practice for the old and uneducated. However, the integration of technologies into agriculture systems, including livestock systems, may play a significant role towards attracting young people to participate. For instance, in recent years, evidence has surfaced of young people engaging in agriculture-related discussions on social media platforms such as Facebook. Furthermore, as young people are more techno-savvy in comparison to the elderly, these young people can play a key role in helping the

elderly access critical information and/or conduct specific activities using technologies. In this way, young people become indirectly involved in agricultural practices. In addition, digital technologies are being used for local knowledge preservation; thus, in the context of livestock, these digital technologies can play a significant role towards preservation of cultural practices. Preservation of traditional knowledge can enable regeneration of the social system.

3.5 RELATED STUDIES ON TECHNOLOGY (INTERVENTION) IMPACT ASSESSMENT

Even though many studies still report lack of infrastructure in many rural communities, digital infrastructure development interventions in rural communities have gathered pace. There are many efforts to address the lack of infrastructure, especially in rural communities, which are driven by governments and non-governmental actors (Matthee *et al*., 2007). In Africa, digital infrastructure investments (ICTs and other technologies, including revision of old and adoption of new regulatory frameworks) have significantly increased over the past few years (Batuo, 2015; Friederici *et al*., 2017). Governments and other actors such as NGOs and international organisations are committing to change the digital infrastructure landscape in developing countries (Batuo, 2015). This has largely been based on the promises of being connected to affordable ICTs. However, despite huge investments in digital infrastructure, evidence is mixed. In some cases, the livelihoods of individuals (or households) in developing countries have not improved much (Qureshi, 2015); in others, poverty has been reduced, albeit marginally (May *et al*., 2014). Justifiably, studies have ensued questioning the significance of transforming digital infrastructure in developing countries. However, the methods of assessing digital infrastructure impact on societies applied across studies (and non-academic evaluations) have been questionable (Gomez & Pather, 2012). The increase in technology investments in developing countries has prompted a need for objective approaches to assess technology impact, and conventional approaches are falling short. Technology assessment (*artefact appropriateness*) and technology impact assessment (*outcome of artefact deployment, adoption and use*) are used interchangeably in this study, which is not commonly done in developing countries. In Africa, most technologies are imported from different contexts and promoted without examining their appropriateness (cf. Pather & Uys, 2010).

Since most rural areas lag in digital infrastructure, technology transfer to these rural communities have mostly been implemented based on the top-down models (Westerveld, 2012). With limited knowledge on digital technologies (to question the technologies and those who brought the technologies), limited, if any, community-based technology assessment occurs.[17] Limited assessment has also been conducted by project instigators, with little community participation. This is despite the adoption of human-centered design principles. Exceptions to this approach include Oosterlaken (2009) and Attwood *et al*. (2013). However, many years later after their introduction, despite digital infrastructure change in rural communities, there is no reciprocal change in livelihoods of communities and concerns on the realistic contribution of ICTs towards development in these developing countries have emerged. Ely *et al*. (2014) show that in developing countries, technology assessment has been much less common than in developed countries. Contrastingly, in developed countries, technology assessment has existed for many years and Schot and Rip (1997:251) posit that this was prompted by the need to "reduce the human costs of trial and error … of new technologies … by anticipating potential impacts and feeding these insights back into decision making, and into actors' strategies." The late (or in some cases, the non-existence of) technology assessment in marginalised communities stimulates critical questions on whether there are concerns around human costs of trial and error of technologies in marginalised communities or not. This is critical considering the number of technological innovations which have failed in marginalised communities.

Apart from limited technology assessment initiatives, there are also concerns with the different technology assessment approaches which have been developed and implemented in developing regions. Ely *et al*. (2014:509) show concern that, in addition to technology assessment being less common in developing countries, "technology assessment in developing countries tends to have been largely technical in nature, carried out within centralized institutions or by external consultants." Furthermore, technology assessment fails to appraise advances in the wider social, environmental and economic implications of digital infrastructure transformations (Ely *et al*., 2014:506). In supporting this, Gomez and Pather (2012:11) also show that attempts to conduct

[17] This study does not distinguish between technology assessment (e.g. product appropriateness) and technology impact assessment (outcomes based on the technology product). Therefore, technology assessment and technology impact assessment are interchangeably used.

ICT evaluations in developing countries have focused much more "on measuring quantifiable, tangible outputs and outcomes of the ICTD interventions." Based on these observations, it is critical that technology impact assessment metrics be revisited to ensure that context-appropriate metrics are applied. Furthermore, in marginalised communities, there are many ways technological innovations are used and one of the most common approaches is *repurposing*. Thus, technological innovations may be more important for other activities other than those initially intended. Therefore, evaluations must also consider such appropriations, as failure to do so may lead to termination of initiatives which have considerable impact on societies which are not noticed if evaluations are only focused on expected, or intended, project outcomes.

Further to this, critical studies on technology assessment such as Guston and Sarewitz (2002) as well as Pather (2017) also suggest that the timing of technology impact assessment needs to be shifted to ensure that technology assessments are not only done at the end of the projects but are also done across the spectrum, *e.g.* at planning, during and post-implementation. It is argued that the practice of real-time technology assessment results in maximizing articulation of the potential benefits by the society, minimizing risks associated and promoting community responsiveness to the ICT project (cf. Guston & Sarewitz, 2002:95). In addition, another critical element to consider in impact assessment is the focus of the evaluation. Successes of ICT intervention differ based on the intended goal of the project. For instance, Pather (2017:256) suggests that success of an information system can be defined by the system's achievement of the goal for which it is designed. On the other hand, Toyama (2017) suggests that an information system's success can be judged by how it helps communities achieve aspirations, hopes and dreams.

Subsequently, impact analysis of these technologies is conducted using the technologies deployed as a unit of analysis and this implies assessments of technology adoption and diffusion. However, "evaluating the implementation of complex interventions requires attention to more the measurement of outcomes and effectiveness, but also to the social relations and processes related to the work that leads to those outcomes" (May *et al*., 2007:148) which would differ from one social setting to another. Against this, it is evident that within a given context, the technology impact assessment must be framed within the social and political structures of a community. To achieve this, the unit of analysis in the technology impact assessment needs to shift from the technology deployed to the relations between people, objects and contexts enabled by the

technology (cf. May *et al.,* 2007). Such a shift then feeds into the prevailing technology impact assessment critique suggesting that impact assessment must be transformed from measures using tangible metrics in favor of critical non-tangible impacts, whether positive or negative (Pather, 2017). Furthermore, there are also many issues within the impact assessment processes which require urgent attention. For example, the issues of authority *vis-à-vis* expertise in technology assessment as well as the selective enrolment of actors. For instance, in most donor funded technology projects, impact assessment is conducted by external experts whose understanding of local context (socio-political processes and structures) is limited.

3.6 CHAPTER SUMMARY

In this chapter, I have outlined the key terms for the study and discussed how these terms are defined from various contexts, which was followed by a contextualization of these key terms to explain how the terms are used in the context of this study. The key terms discussed are food security, livestock system, sustainability, digital infrastructure and impact assessment. In essence, the chapter argued that each term be viewed from a system perspective (broader perspective). The chapter then shifted to discuss the theories and frameworks on which the study is grounded. The theories discussed are the socio-ecological systems framework, Choice Framework and technology affordances. The chapter outlined the proponents of each theory and/or framework before closely examining the application of these theories and frameworks in the study. The chapter outlined the significance of each theory and framework but showed that to achieve a holistic analysis, each theory and framework can be complemented by using constructs of other theories and frameworks. In doing so, I indicated that combining the theories and frameworks in this study provides a holistic approach to understand the concepts investigated. In the related studies, section 3.3 showed that rural areas are food insecure and livestock play a significant role towards household food security. However, the section also indicated that the livestock systems in rural areas such as the study area are fragile, which emanates from several factors including lack of appropriate and adequate infrastructure. In addition, the chapter indicated that there are existing and emerging technological innovations which can be appropriated by livestock system actors to overcome the various challenges contributing to the fragility of the livestock system However, as section 3.4 revealed, there is perennial lack of digital infrastructure in rural communities (specifically in the context of fragility of livelihood options). The section revealed efforts to

address lack of digital infrastructure. Finally, section 3.5 focused on related studies on impact assessment arguing that the conventional approaches to impact assessment are failing and there is need for non-conventional approaches.

CHAPTER FOUR: RESEARCH METHODOLOGY

Chapter overview

This chapter presents and discusses the research design and methodology for this study. The chapter reflects on the selection and application of the research techniques during the fieldwork, the nature and type of data collected, data analysis and presentation. This study focuses on the intersection of two complex systems which are the livestock system and the digital infrastructure system in a rural community. Broadly, the interdisciplinary nature of the study required a post-positivist approach which was achieved by using multiple multidisciplinary theories and frameworks, as well as mixed research methods. The research was action-oriented in that the researcher was involved in the various stages of the infrastructure transformation intervention which included the setup of a community information centre. The chapter starts by briefly revisiting the research questions guiding the study which is followed by a discussion on doing research in the ICT4D field. The chapter then shifts to explore the research design, explaining the methods adopted in data collection. Each method is examined to show its relevance to the study and outline how it was conducted during the study. Subsequently, data analysis is examined before a further discussion on ethical considerations and study limitations. While a brief introduction to the study area is provided in Section 4.3, a thick description of the study area, based on empirical evidence, is presented in the Chapter Five.

4.1 RESEARCH QUESTIONS

This chapter presents the research design and methodology applied to collect and analyse data used to develop answers to the primary research question which reads as: *Do digital infrastructure transformations in the rural communities in Zimbabwe impact the sustainability of livestock systems, and if so, how and in what ways?* This primary research question is further supported by the following sub-questions:

i. What roles do livestock species play towards household food security in rural communities and how sustainable are the livestock systems in rural communities?
ii. How does the adoption and use of digital technologies in rural communities contribute towards the sustainability of the livestock systems?

iii. How does context impact the process of digital infrastructure transformation and in what ways can the impact of a digital infrastructure intervention in rural communities be assessed?

iv. Do the impacts of digital infrastructure interventions on livestock systems warrant their prioritization as interventions to improve food security in rural areas?

In collecting data to answer these research questions, reference was also made to the theories and frameworks guiding this study, which were discussed in Chapter Three. For instance, based on the SES framework, some of the attributes used to characterise the livestock system require numerical data thus influencing the decision of the data collection instruments used. Also, specific questions in the questionnaire such as number of livestock (Resource Units_number), actors involved in the livestock systems and the challenges smallholder farmers face were prompted by the need to obtain data on specific attributes as described in the SES framework. In addition to this, the Choice Framework was critical in influencing the activities to observe, for instance, the livestock auction process. In the study, the qualitative data collection activities were mainly centred on understanding individual choices within the livestock system. Thus, the data collection activities had to allow for choice (decision making), reflection on agency and structure of the community. For instance, during the visioning workshops, individuals reflected on what they would love to achieve, what resources they had, as well as structure-related elements available within the community. Therefore, it is prudent to indicate that the data collection activities were influenced by the theories and frameworks on which the study is anchored, in addition to the context in which the research questions were being studied.

4.2 DOING ICT4D RESEARCH – CRITICAL PERSPECTIVES

In Chapter Three, Section 3.1.6, the study provided a brief discussion on the positioning of the study within the ICT4D and ICT4S disciplines. While ICT4S is relatively new, Walsham (2017) highlights that ICT4D research has a rich history extending over 30 years. Considering the rich history of the ICT4D research, it is prudent to argue that reflecting on the past and future trends suggested by canonical thinkers in the discipline helps to shape the research approach in a particular study such as this one; thereby playing a key role in answering the question: *Which*

methodologies are appropriate in answering our research questions, given a particular take on development? (Hatakka *et al*., 2016). In this vein, Walsham (2017) and Heeks (2014) have provided snapshots of the current state of the ICT4D research, focusing on changes over time, methodological issues, as well as the general approach to research in ICT4D. Apart from these concerns, many other studies such as Qureshi (2015) undertake critical reflection on whether the ICT4D research is actually "making a better world" (Qureshi, 2015:511). In this context, this study argues that by reflecting on the critical perspectives, addressing the key concerns and adopting the suggestions raised in several studies on ICT4D research, it is possible to improve the research approach for this study. In this regard, Donner and Toyama (2009:8) suggest that, "If we listen first and use qualitative-quantitative bridging exercises to move beyond the 'common' aggregates of users and divides, we can better assess the impact of [ICTs] on communities." In this thesis, the issues relating to theories on ICT4D are discussed in other sections (see Chapter 3) and the methodological issues are the major focus for this chapter. Thus, this section will discuss suggestions from prior studies on how to undertake research in ICT4D, noting common approaches as well as limitations cited in other studies. This discussion will then be linked to the approaches used by the researcher in conducting this study.

4.3 STUDY AREA SELECTION AND ACCESS

This study was conducted in the communal areas of Beitbridge District in Matebeleland South, Zimbabwe. In Zimbabwe, districts are administrative areas under the government of a local Rural District Council (RDC) and District Administrator (DA). These districts are further sub-divided into Wards which are also further sub-divided into villages. There are many areas in Zimbabwe which meet the selection criteria described in Table 4.1, and the selection of the study area (Beitbridge, Ward 15) was further influenced by the established relations between the researcher and the community during the implementation of the MOSMAC project in the community. This study was conducted in Ward 15 in Beitbridge District which consists of 4 villages. The selection of the study area was influenced by factors explained in Table 4.1 such as accessibility, community attitude towards the study, community participation and livelihood system (cf. Mutandi, 1998).

Table 4.1: Factors influencing the selection of the study area

Selection Factor	Selection criteria (definition of selection factor)
Community accessibility	The extent to which the researcher can access the community, including obtaining permission to enter community from local and traditional authorities
Community attitude and participation	Community interests in taking part in the research activities and responsiveness to initiatives
Community status	Community status in relation to vulnerability as reported in literature and official reports, e.g. the Zimbabwe Vulnerability Assessment Report.
Livelihood System	The livelihood option of the community, in this case, dependence on livestock was a critical factor
Community Location	The study area should be classified as rural and in Zimbabwe

Since 2015, I was involved in the MOSMAC project within the community focusing on improving farmers' access to ICTs in Beitbridge (see Gwaka, 2017). Therefore, the researcher had developed knowledge about the community, its culture, livelihood strategies and the leadership structures. From the onset of the study, I was aware of the leadership protocols within the community such as the local authorities (District Administrators and Rural District Council) as well as the traditional leaders (Headman, Senior Village Heads, Village Heads and community committees). Krauss (2012) identified these individuals (sometimes as collective groups) as community gatekeepers who play a key role in a researcher's continuous engagement with a community. Since I was already working in the community on the MOSMAC project, it was critical to explicitly explain to the gatekeepers about the study to secure permission to conduct study activities. Formal written submissions were made to the local authorities requesting permission to conduct academic research. Since these local authorities are mandated with community development, they were helpful in the process and facilitated community access clearances (see Appendix D). The local authorities and the communities are connected through a local councillor who is elected by the community. In this study, the councillor also played a pivotal role in linking me to the local leaders and the community. As shown in Figure 4.1, I made a formal presentation to the community leaders (including the Headman, see, *yellow star*) explaining the study which subsequently led to the granting of clearance to engage the community.

Figure 4.1: Engaging community leaders[18]

Apart from the local authorities and the traditional leaders, the livestock system and ICT system involve several government departments. As such, in addition to clearances from the local authorities and traditional leaders, the researcher further engaged various departments such as the Ministry of State, District Police, Ministry of ICT and Broadcasting Services, as well as the Livestock Production and Development Department as part of community entry.

4.4 RESEARCH DESIGN

A research design refers to a 'plan' or 'roadmap' followed when conducting research. De Vaus and De Vaus (2001:9) suggest that the research design's function is to "… ensure that the evidence obtained enables us to answer the initial question as unambiguously as possible." Furthermore, a research design is different from research methods in that a research design determines the work plan flow; *i.e.* a plan, layout or guide which explains how the research process will take place or how the researcher will conduct the research study (Du Toit & Mouton, 2013). On the other hand, research methods relate to the methods and procedures that the researcher will apply in order to collect data that will be used to analyse and answer a research question (Struwig & Stead, 2013). This study focuses on understanding the intersection of two complex systems, and to achieve this, the study adopts both descriptive research (description of the livestock and digital infrastructure systems) and explanatory research (focusing on why). With the study assuming broad research, both qualitative and quantitative processes are adopted. In addition to the above, the study also adheres to Action Research as it provides an intervention in the community through the development of the community information centre and community network. The research

[18] Permission to use images has been secured for all images used in this thesis, and this was noted in the ethics application to the University of Pretoria (Appendix C1) reference: 468/2015.

questions outlined for the study exhibit several characteristics about the study which include; *social change, past and future orientation*, and based on these characteristics Baskerville and Myers (2014) suggest, a combination of the Action Research and Ethnographic approaches. In line with this, Tacchi *et al*. (2003) show that studies using a combination of ethnography [research methods] and action research can be situated within the Ethnographic Action Research paradigm.

4.4.1 Data collection processes

4.4.1.1 Mixed methods approach

To achieve the objectives of this study, and considering the complexity of the systems under investigation, *e.g.* the political nature of the systems, a mixed methods approach was deemed appropriate for data collection.[19] Clark and Creswell (2008) suggest that a mixed methods approach uses a combination of qualitative and quantitative data collection and analysis techniques to achieve the objective of a single study. Thus, the mixed methods approach views qualitative and quantitative techniques as complementary, enabling researchers to integrate these in a single study to complement the strengths of each approach (Newman & Benz, 1998). In this study, the researcher sought to characterise the livestock system and digital infrastructure (*e.g.* system dynamics) and community demographics, as well as relationships between systems; and these required both quantitative and qualitative techniques. During the fieldwork, quantitative data were obtained using a household survey questionnaire, but the questionnaire could not provide data relating to intrinsic aspects of the livestock system and digital infrastructure (qualitative data). Thus, to obtain data relating to these intrinsic aspects, qualitative ethnographic techniques such as participant observation, key informant interviews, visioning workshops and focus group discussions were used. While the use of mixed methods is common among complex studies, the use of these mixed methods in a single study is not without its challenges. Among the different challenges of using mixed methods, Mudombi (2014) argues that the use of different data collection techniques can produce diverging results. Also, the usefulness of mixed methods within a specific study depends much more on how well each individual method is conducted. Further to

[19] Donor interventions especially relating to ICTs are perceived to have an influence on the political dimensions of societies, *e.g*. Takavarasha and Makumbe (2012) discuss the conviviality of ICTs and the subsequent use of the fear-defense-fear mechanism to thwart the establishment of a mobile network in Zimbabwe

this, the balance between the different research methods needs to be outlined since studies tend to be either predominantly qualitative or quantitative. In this regard, this study can be classified as predominantly qualitative. A further discussion of both qualitative and quantitative data collection and analysis process conducted for this study will be provided in subsequent sections of the chapter. In the next section, the chapter focuses on the sampling for both the qualitative and quantitative approaches.

4.4.1.2 Study sample size and sample selection

Carrying out research with human subjects can be costly and time consuming, as well as challenging to engage the entire population, especially when dealing with large communities (Lunsford & Lunsford, 1995). While data generated from an entire population would give a more accurate answer to the research question(s), there are constraints which restrict research studies to collecting data only from population samples. A study sample is defined as a subset of subjects which are representative of a given population (Lunsford & Lunsford, 1995), from which the study findings obtained from a representative sample can be generalised to a given population. The sample size requirements for qualitative and quantitative methods differ as the focus of these research methods also differ. In this study, qualitative data were generated from purposively selected samples while quantitative data were generated from a systematically determined sample. Systematic determination of the sample size included the application of a du Plooy (2009:113) formula to calculate a recommended sample size when dealing with a specific population size. While there are concerns of whether size really matters in qualitative research, Cleary *et al.* (2014) suggest additional elements to consider on the sample and these include participant selection, participant engagement and redundancy.

- **Quantitative sampling**

As indicated already, the study area was selected based on certain preconditions including the existence of the MOSMAC project. The respondents to the questionnaires were subsequently drawn from all the four villages of Ward 15 using non-probability sampling approaches. In each village, the village head was tasked to convene a meeting, and only the households represented at the community meetings had the chance of being included in responding to questionnaires. During the meetings, household representatives were then asked to complete a questionnaire (a household

could discuss their responses) but each household only completed one questionnaire. There were households which opted not to participate in the process. During the completion of the questionnaires, trained local enumerators were available to assist the respondents who needed assistance; for instance, translation of questions and clarification of questions. Following the completion of questionnaires at the village meetings in all the four villages, the enumerators further conducted household visits to cater for other households which were not able to participate in the meetings for various reasons, including timing of the meetings, distance to meeting points as well as households with only the elderly or sick individuals. Following these activities, the total questionnaires collected in all the villages were 270 and the distribution per village is presented in Table 4.2.

Table 4.2: Summary of household survey sample selection

Village	Completed Questionnaires	Included in final Analysis
Dumba	93	74
Old Nuli	64	59
Mapai	59	42
Shabwe	54	49
Total	**270**	**224**

As indicated in Table 4.2, from the 270 completed questionnaires, only 224 were included in the final analysis. The 46 omitted questionnaires were deemed to have numerous problems which would affect the quality of data analysis. In most of these cases, the variables had no values as a result of people not answering a question.

- **Qualitative sampling**

Cleary *et al*. (2014) suggest that there are no hard-line rules when conducting focus group discussions but provide critical elements to consider. For instance, too few participants may fail to generate deeper insights; while too many participants may also provide misleading insights. Therefore, the selection of participants (for qualitative data) in this study was systematically planned. For instance, the study started by observing the whole community engaging in the livestock auction, then narrowed down to community visioning workshops. The participants

engaged in the community visioning workshops were drawn from all four villages. Furthermore, from those who participated in the community visioning workshops, participants for the focus group discussions and key informant interviews were identified. The richness of engagement increased as participants were narrowed.

4.4.2 Qualitative data collection

Qualitative data for the study were collected using multiple methods, predominantly classified under the ethnographic methods banner. A brief ethnographic account of the researcher during the study is presented before detailing each of the methods used to collect data.

4.4.2.1 Ethnographic methods and researcher's account

Ethnography is one of the most controversial qualitative data collection methodologies and yet, one of the most common in research on complex social phenomena. The methodology's armory (Russell & Barley, 2016), which includes being multi-methodological, was critical in its selection for this study. While Amit (2003:5) suggests that the practice of ethnography involves researchers "thorough immersion in the daily practices and face-to-face relationships of a particular set of people", Watson (2011:202) argues that ethnography is "not a research method" but a "way of writing about and analysing social life." The ethnographic approach has been appropriated in different disciplines even though its roots are in humanities and anthropology (Watson, 2011). Over the years, the practices of ethnography have transformed and its adoption for many studies in different contexts meant that several internal variations developed along the way. One of these variations which Fine (2003) outlines is that ethnographic work is increasingly becoming short, with brief stays in the study field in comparison to longitudinal approaches. In addition, there are also structural inconsistencies between studies applying ethnography. In responding to Fine's (2003) suggestions, there are studies which counter the idea of ethnography as lengthy stays in a research field; such as Falzon's (2016) argument that ethnography can be multi-sited ethnography which does not require lengthy field stays.

For this study, community engagement started in November 2015 and qualitative data collection was concluded in June 2018 during which community feedback meetings were held. Meetings with officials from local authorities and various government departments preceded other data

collection activities. Following a series of meetings in November and December 2015, supporting letters were received from the different departments paving the way for community engagement. During this period, I developed multiple relationships with various stakeholders which were critical in developing insights on the livestock system, digital infrastructure and the community at large. In carrying out field work, I engaged in multi-method ethnography which entailed using various methods to obtain data. The multiple methods, however, generate different data and there was need for systematic engagement which directed the sequence of the activities. In this regard, the study drew from Fine's (2003) suggestion that the process of ethnographic work should move from descriptive (how) to analytical (why). As such, in this study, the first activities I engaged in were participant observations in community gatherings such as livestock auctions, as well as other community events. These activities allowed me to develop deeper insights on how the systems function (descriptive). Following this, I engaged the communities in community visioning workshops, through interviews as well as focus group discussions. The data collection techniques increasingly became intense and intimate, allowing me to develop deeper insights on various aspects of the society.

Participating at livestock auctions was one of the key activities for this study and between 2015 and 2018. I took part in fourteen livestock auctions, including nearby auction sites not in the study area. At the first auction within the study area, the researcher was formally introduced to the livestock auction participants and subsequently allowed to take photographic evidence. While I needed the photographic evidence, it was evident that many participants showed discomfort. In the subsequent auctions, the researcher only observed (without taking pictures or videos) and engaged the participants in a simple way. Consistent participation at various other community gatherings such as Ward meetings helped me integrate into the community to an extent that I always received updates and feedback from meetings or gatherings that I failed to attend.

Further to the above, one main challenge in carrying out the study was defining the boundaries of the ethnographic work. The livestock systems in the rural communities across Zimbabwe are similar in many ways but my study was in Ward 15, Beitbridge. I often made occasional visits to Buhera, Murambinda and Rushinga; even observing livestock auctions, discussing digital infrastructure in the study areas as well as making notes about these areas. Amit (2003) suggests that the 'field' in which ethnography is conducted could comprise "sets of relationships" within a

system. As such, I quickly learnt that my research was about the processes and the people (not entirely about the geographic). Therefore, the aim was to understand the relationships of actors within a livestock system as a factor towards the system's sustainability.

In all, this brief ethnographic account may be critiqued in several ways and like many other researchers (see Fine, 2003), there is a lingering question on whether indeed this was ethnographic work or not. I believe that I accomplished what others have done and collected sufficiently thick data to achieve the aims of the study. Further to this, I remain engaged with the community, conducting several activities with and within the community, such as setting up a community cooperative for a community network. The process of immersing myself in the community allowed me to learn more and understand comprehensively the livestock system. Since multiple methods were used in the ethnographic work, it is critical to further explore these methods in detail.

4.4.2.2 Participant observation

As indicated in earlier sections of the chapter, between 2015 and 2018, I participated in fourteen livestock auctions at designated auction places (see Figure 4.2 and Table 4.3), several community meetings and other social events.[20] My participation in these activities (direct observation) allowed me to develop deep insights about the community which otherwise are difficult, if not impossible, to generate using other research methods such as interviews, focus group discussions or survey questionnaires (cf. Quinlan *et al*. 2016). These insights include power relations, process dynamics (physical and emotional) during livestock auctions, and how the livestock system works. Attending these activities allowed me to collect data, analyse situations and experience the dynamics in a social setting.

[20] Auctions are done per ward but the study area (Ward 15) combines with Ward 5 for the auction at Lutumba Business Centre. Some of the auction sites visited during the study are presented in Table 4.3 and these are: Dite, Chitulipasi, Chaswingo, Penemene, Makakavule, Shashi, Toporo, Zezani and Msane.

Figure 4.2: Participant observation at a livestock auction in Ward 15

Even though the livestock auction is a public event, permission to take videos and photographic evidence had to be requested in writing from the local authorities. Further permission at the auctions was sought using oral approaches which usually were an announcement at the beginning of the auction process. In addition to videos and photographic evidence, I also collected random auction prices for livestock (see Gwaka, 2017). Participant observation allowed data collection at a community level in that the entire community participates at the livestock auction. Following the first set of observations, the researcher engaged the community using a community visioning workshop.

Table 4.3: Participant observation activities

Location	Average Herd [21]	Key Individuals Stakeholder Engaged
Dite	30	Council/Police/buyers
Chitulipasi	10	Council/LPD Police
Chaswingo	40	Council, Traders Veterinary, Police
Lutumba	90	Council Auctioneer Veterinary
Penemene	40	Council/Police/LPD
Makakavhule	60	Smallholder farmers
Shashi	50	Informal traders/buyers
Toporo	40	Smallholder farmers
Zezani	30	Smallholder farmers
Msane	40	Smallholder farmers

[21] Number provided is not exact, and it is rounded to the nearest 10.

4.4.2.3 Community visioning workshops

Data for the study were also collected during community visioning workshops. Development initiatives across the globe often follow blueprints such as the Sustainable Development Goals (SDGs) which are developed by experts, scientists and academia but often without community contribution. Chitakira *et al*. (2012:1230) suggest that communities can be involved in the development planning through a community vision process, which is defined as "a process involving a group of people coming together to develop common ideas about what they would like their community ideally to be like and to plan how to achieve it." In this study, the focus was on engaging the participants to develop common ideas about the livestock system they would like to achieve. The participants for the community visioning workshops were drawn from the four villages in Ward 15. Due to geographical locations and resource scarcity, the first two community visioning workshops combined villages closer to each other; thus, Shabwe and Old Nuli combined as well as Mapayi and Dumba. A third community visioning workshop combined all the villages. Generally, in conducting the visioning workshops, any individual who could provide a different perspective on digital infrastructure, livestock system and other community issues was considered. Community based local government officers such as agricultural extension workers also participated at the visioning workshops.

Figure 4.3: Community visioning exercises in Ward 15

While I facilitated the community visioning sessions, as shown in Figure 4.3, participants were given the autonomy to develop and present their ideas. The process of community visioning started with the facilitator explaining the purpose of the workshop. The participants were then tasked to develop sketches (maps, diagrams, words) of their current community and the livestock system (as

they are). This involved identifying actors, resources, opportunities and challenges within the livestock system and the community at large. Subsequently, the task changed to developing sketches (maps, diagrams, words) of the desired future (what they wish for, what they imagine and what they desire). From these activities, the researcher generated notes (anonymised notes – on community resource mapping, challenges and desires), diagrammatic representations and recordings for further analysis. The community visioning workshop also involved open discussions of suggested ideas. The process of community visioning allowed exploration of community creativity. Also, participants for the focus group discussions were also identified.

4.4.2.4 Focus group discussions

In addition to the participant observation sessions and the community visioning workshops, focus group discussions were also conducted to collect data. The purpose of the focus group discussions was to discuss common subjects (livestock and digital infrastructure) and establish agreements to and differing points on the subject among the participants. In these focus groups discussions, my role was to facilitate and ensure dynamism within the discussions and providing guidance on subject of discussion.

Figure 4.4: Focus group discussion with male respondents

Participants in the focus groups discussions were drawn from the four villages (see Table 4.4) and were mainly those involved in and/or with interests in the livestock system. Firstly, focus group discussions were done in each of the four villages; and then further focus groups discussions combined the villages. The study then segregated the focus groups discussions by gender (see

Figure 4.4), age and interests (livelihood options). In total, nine focus group discussions were conducted, averaging eleven participants per focus group discussion. A focus group discussion guide was used to guide the discussions. Responses from the focus group discussion were audio-tapped using a digital voice recorder and noted down in a notebook. Within focus group discussions, ethical issues are complex. However, before the focus group discussions, informed consent was secured from the participants (see appendix F). In addition, the participants were assured of confidentiality, and participants themselves were also tasked to maintain confidentiality about the opinions of other participants beyond the focus group discussions.

Table 4.4: Summary of focus group discussions

Area	Activities	Gender		Total
		Women	Men	
Dumba	Meeting Notifications	1	2	3
	Focus Group Discussion	4	10	14
	Community meetings	21	16	37
Mapayi	Meeting Notifications	1	4	5
	Focus Group Discussion	2	7	9
	Community meetings	15	9	24
Shabwe	Meetings Notifications	1	2	3
	Focus Group Discussion	2	7	9
	Community meetings	17	14	31
Old Nuli	Meeting Notifications	2	2	4
	Focus Group Discussion	2	6	8

4.4.2.5 Key informant interviews

Key informant interviews were conducted with purposively selected smallholder farmers, traditional leaders and representatives of farmer groups, as well as representatives of the relevant government institutions and departments involved in livestock systems and digital infrastructure. The main purpose of the key informant interviews was to generate insights from knowledgeable individuals on livestock and digital infrastructure systems. Key informant interviews help obtain a thorough understanding of not only how but also why people do certain things which are mainly of interest to the researcher. Furthermore, key informant interviews are conducted with carefully selected individuals who are identified through various processes including but not limited to snowball techniques. Within societies, it is common for community members to know individuals who are more knowledgeable about specific issues and thus, this was used as a key technique to

identify participants. The researcher developed interview guides (see Appendix B) which were used to conduct the interviews. Interview guides were developed to provide guidance to the researcher on issues to discuss and to provide flow for the interview. During the interview process, the researcher systematically recorded the responses provided by interviewees through taking notes and using a digital recorder (after participants agreed to the recording). Even though in key informant interviews the researcher engages research participants with specific knowledge, consideration of participants' backgrounds is essential. This was critical in this study since there are different actors within the system. Representativeness and sample size are often issues not considered relevant within qualitative data methods. However, there are varying suggestions on the number of key informant interviews one should conduct in a study. Marshall *et al*. (2013) collated different studies which suggested different numbers of interviewees but point out that the key to qualitative data collection, including interviews, is saturation. However, considering that key informant interviews are used to obtain qualitative data, it can also be argued that a purposive number can be used. Therefore, based on these arguments, available resources and the use of complementary methods (quantitative and other qualitative approaches), the researcher conducted 15 key informant interviews for the study. The summary of the interviewees is presented in Table 4.5.

Table 4.5: Summary of key informant interviewees and justification for selection

Group	n	Reason for selection
Smallholder farmers	8	Primary actors involved in the livestock system
Government departments e.g. education, Department of livestock production and development, ministry of information	5	These are the Regulators/Policy makers/Advisory ensuring that Regulation and support need in the livestock system are in place
Associations Representative	1	Play a key role in mediating between farmers and other stakeholders
Traditional leader	1	To obtain leadership perspective on the livestock systems
Total	**15**	

4.4.3 Quantitative data collection: household survey questionnaire

Quantitative data for the study were collected using a household survey questionnaire (see Appendix A). In designing the questionnaire, recommendations (*e.g.* types of questions) from several guidelines were adopted. The household survey questionnaire was also prepared after

extensive literature studies and preliminary community engagements which helped to generate appropriate questions. To improve the nature of data collected for the study, the question types were diversified to include lists, closed questions, quantities, category questions and ranking questions (cf. Marshall, 2005). However, despite the variations of question types, these questions were developed to support the primary research question and related sub-questions. In social research, questionnaires are a common tool for data collection (Bowling, 2005; Marshall, 2005) with advantages and disadvantages when used for data collection. For instance, Marshall (2005:131) suggests that using a questionnaire for data collection is cost effective and enhances the anonymity of participants. However, questionnaires may be a challenge for illiterate participants (self-completion) and in this study, this challenge was overcome by recruiting enumerators to assist with administering the questionnaires. Enumerators received training on the questionnaire to improve data collection accuracy. As indicated in Table 4.6, the final questionnaire administered in the study area comprised 67 questions (some as sub-questions) allocated into various sections.

Table 4.6: Categorization of the questions in the household survey questionnaire

Household survey questionnaire sections	No of Questions
1. General household information	5
2. Household demographics	7
3. Household assets (with sub-questions)	9
4. Household livelihood activities	10
5. Household food system (with sub-questions)	10
6. Digital infrastructure and ICTs	26
Total	**67**

In this study, the face-to-face administration of questionnaires was critical to increase the response rate and admittedly, impacted the anonymity of respondents (some respondents were not comfortable to respond to questions they considered too personal). The questionnaires were pilot tested to adjust obscure and ambiguous questions which improved the questionnaire's reliability and validity. To handle dialect issues, local research assistants were identified and recruited. These research assistants were trained on completing the questionnaire before they collected final data

for the study. However, during the study, some respondents opted to complete the questionnaire themselves and consulted assistants when they were unsure.

4.5 DATA ANALYSIS

In a mixed methods study, data analysis, like data collection is also conducted using mixed approaches. In this study, since both qualitative and quantitative data were collected, data analysis was also completed using qualitative and quantitative data analysis techniques. For the former, the desired precision was 95% with the desired confidence interval of 5 which means the significance threshold was set at 0.05 with p-values < 0.05 considered significant.

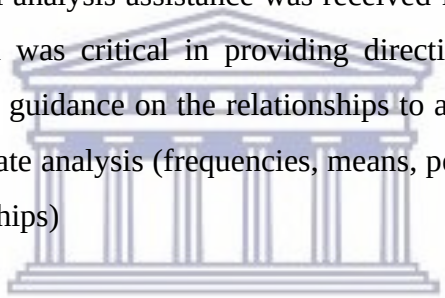
4.5.1 Qualitative data analysis

The study employed different ethnographic methods which yielded different types of qualitative data sets including field notes, recordings, photographic evidence, diagrams and maps. The process of data analysis started immediately when I had gathered data from the field. This allowed the processes of data collection and analysis to be completed concurrently. The advantage gained from this approach was that I could identify the gaps within the data and dedicate more effort towards the missing data. The process of qualitative data analysis started with data cleaning. During the data collection, it is likely that incomplete data would have been captured and then, not useful for analysis. In this study, it was noted that from the data gathered, other data sets had issues including incompleteness (*e.g.* incomplete notes not making sense), community notes (poorly written), incomplete recordings (less than 60 seconds) and even hazy photographs. There were various options of treating these data sets. These options included going back to the community to clarify (on incomplete data), reconstruction and exclusion. Once data sets were cleaned, the development of the themes started. The process of developing themes was cyclical but consisted of four major phases (Vaismoradi *et al.,* 2016). The process started with initialisation to capture participants' accounts. The processes included transcribing recorded sessions such as focus group discussions and key informant interviews. At this stage, I carefully listened, in most cases, repeatedly, to the audio recordings collating data notes in Word documents. At this stage also, the notes on different charts made during the various sessions (*e.g.* community visioning workshops) were also transcribed. Based on literature, reflections on the field activities and thematic analysis of data, themes were identified relating to the research focus. The process of developing themes included

defining, labelling, classifying and comparing the data. Further to this, established themes were related and the story presented in the results section was developed. To ensure the validity of the findings, the researcher conducted a findings confirmation (feedback) session with the respondents.

4.5.2 Quantitative data analysis

Quantitative data generated from the questionnaire were analysed using the SPSS statistical package version 25. From the 270 questionnaires distributed, 46 were discarded from the analysis for various reasons mainly that the quality was deemed too poor to use; and in some cases, were there were suspicions of fabrication of data. Of the remaining 224, data were captured using Kobo toolbox, cleaned and organised before subsequently being converted to CSV format for analysis using SPSS software. Statistical analysis assistance was received from a qualified statistician. A discussion with the statistician was critical in providing direction for the data analysis. For instance, the statistician needed guidance on the relationships to analyse. From the analysis, the data generated included univariate analysis (frequencies, means, percentages, graphs, charts) and multi-variate analysis (relationships)



4.6 ETHICAL CONSIDERATIONS

Ethical approval for the study was sought and granted from the University of the Western Cape Research Ethic Committee (*Ethics Reference Number: HS17/3/2* – Appendix C). Since this study also emerged from the large on-going MOSMAC project, another ethical approval was obtained from the University of Pretoria, Faculty of Health Sciences Research Ethics Committee (*Ethics Reference No. 468/2015*). Furthermore, the permission to engage communities was also granted by local authorities (Appendix D) and traditional leaders within the study area. In addition to the clearances, the following ethical issues were also considered: informed consent, voluntary participation and participant confidentiality.

4.6.1 Informed consent and voluntary participation

To ensure that the information on which participants based their decision to participate in study (or not) on were accurate and precise enough, the researcher research sought voluntary and informed consent from the research participants. During data collection, the researcher and data

collection enumerators informed (verbal and written) the research participants that participation in the study was based on an individual willingness with no material benefits expected in return. The research participants were further informed of their right to withdraw from participating in the research project when they perceived that the research was not keeping up to the ethical expectations. As ethnographic action research, the researcher recognises that there are 'power' relations within the research creating possibilities of 'exploitation' (either of the researcher or the research participants) throughout the research which need to be managed. To avoid this, Löfman *et al.* (2004) recommend that the researcher conduct research by involving participants, thus avoiding perceiving participants as 'objects' within the study. However, being 'the researcher', there is unavoidable potential of power conflicts, especially when conducting research in resource constrained areas. This could be mitigated by the researcher adapting to the local dynamics and continuously getting involved in local activities.

4.6.2 Participant confidentiality

Following on informed and voluntary consent, research participants were also assured that the researcher would exercise respect for the community and any information obtained during the study. Khanlou and Peter (2005:2337) highlight that respect in research is exercised through "protection of confidentiality and privacy." Information obtained from the research was neither used for non-academic commercial activities nor for any purposes not specified in the agreement between the researcher and the research participants. The data obtained during the study (*e.g.* recordings and transcripts) are kept under the conditions outlined in the ethical application (passwords, lock and key). Disposition of these will also follow the procedures outlined in the ethics application.

4.7 RESEARCH PROCESS LIMITATIONS

There are some limitations to this study and, in conducting this study, many challenges were encountered; some were overcome and others not. The use of a single case study – the MOSMAC project – represents a potential limitation which needs to be considered when reading the conclusions of this study. However, the use of a single case study was considered appropriate for developing deeper insights within the time constraints (Dyer & Wilkins, 1991; Gerring, 2004). Furthermore, given the location of a household, it was difficult to access all the households as

much as the researcher would have desired. The researcher initially wanted to engage respondents within natural settings; thus, at their places of stay, as engaging the respondents at public gatherings (meetings) could trigger respondents to respond in different ways. For the questionnaire administration, the easiest option was to convene the community at the local school, given the dispersion of the households in the study area. This was a major challenge in Dumba village given the spatial distribution of the households and poor roads which made accessibility of these households problematic. However, to overcome this challenge, a local research assistant based in Dumba conducted additional household visits during different times to administer the questionnaires in households which failed to participate at the community meetings. Because of this, it could be that other households within an area (in the Dumba village) failed to participate resulting in non-generalizable findings but this was also extremely difficult to determine considering the anonymity nature of questionnaires. Secondly, this study, as an action research study, entailed the development of the community through establishment of community information centre. The challenge with infrastructure transformation in the study area was found to be aligned to politics (Gwaka *et al*., 2018) and delays were experienced in receiving institutional clearances in some instances.

4.8 CHAPTER SUMMARY

This chapter has presented the research methodology applied to gather and analyse data used to answer the research questions. Section 4.3 has demonstrated that the study area was selected based on specific characteristics including the researcher's engagement with the community in the MOSMAC project. Following this discussion, section 4.4 focused on the research design indicating how the different data collection activities such as focus group discussions and participant observation among others were conducted. This section provided detailed explanations on the appropriateness, selection and application of the research methods to gather data. Since the study gathered mixed methods, section 4.5 details the analysis processes of both qualitative and quantitative data. However, different data sets answer different research questions and a summary of the matching of research question to the data collection methods and theoretical lens is presented in Table 4.7.

Table 4.7: Summary of the research questions, methods and theory

Research Questions	Methods	Theoretical lens
What roles do livestock species play towards household food security in rural communities and how sustainable are the livestock systems in rural communities?	Quantitative data obtained from the household survey questionnaire as well as qualitative data obtained from focus group discussions, participant observation and community visioning.	Socio-ecological systems framework (Choice Framework)
Does the adoption and use of digital technologies in rural communities contribute towards the sustainability of the livestock systems?	A balanced use of quantitative data obtained from the household survey questionnaire and qualitative data obtained from participant observation, focus group discussions and interviews.	Technology affordances and Choice Framework
How does context impact the process of digital infrastructure transformation and in what ways can the impact of the digital infrastructure intervention in rural communities be assessed?	Qualitative data obtained from document analysis, email exchange, interviews and focus group Discussions; the question had limited data from the household survey questionnaire.	Choice Framework
Do the impacts of digital infrastructure interventions on livestock systems warrant their prioritization as interventions to improve food security in rural areas?	Qualitative data obtained from document analysis, email exchange, interviews and focus group discussions.	Choice Framework and Socio-ecological systems lens

CHAPTER FIVE: A THICK DESCRIPTION OF THE BEITBRIDGE RURAL COMMUNITIES AND THE LIVESTOCK SYSTEM[22]

Chapter overview

In Zimbabwe, the Beitbridge district has been a leading community in livestock production and households in this community rely extensively on livestock for many purposes. The study area's climatic conditions are not ideal for extensive crop production, and inherently, livestock production is the most practiced form of agriculture. However, despite the large numbers of livestock which the households maintain, the well-being of the households has been poor, with the district being characterised as one of the poorest in the country. In an economic sense, the smallholder farmers in Beitbridge have not been able to realise optimal value from their livestock. On the other hand, environmental factors are also affecting the production (quality and quantity) of livestock in the area. In all, it is prudent to argue that the livestock system in the study area is fragile. The fragility of the livestock system and other local value chains stem from a set of complexly interlinked factors which can best be examined using a systems thinking approach. To this end, this empirical chapter is framed with the Socio-Ecological Systems framework to provide a thick description of the study area's livestock system. Specifically, the chapter attempts to answer the questions: *What roles do livestock species play towards household food security in rural communities and how sustainable are livestock systems in rural communities such as Beitbridge*? Following the characterisation of the study area's livestock system, the chapter further applies the foresight technique of futures visioning to develop the livestock system which the community desires and the approaches which can be taken to ensure that such a desired livestock system can be achieved. As discussed in chapter four, data used to answer the research questions set for the chapter were obtained using household survey questionnaires, key informant interviews, community visioning workshops and participant observation. The rest of the chapter is structured accordingly. Starting with section 5.1 an overview of the study area's socio-economic system is presented. The chapter then shifts to discuss the study area's livestock system in section 5.2 focusing on livestock ownership and livestock contribution towards household food security. Section 5.3 then provides a characterisation of the livestock system based on Ostrom's SES

[22] Some sections of this chapter were presented at the *3rd International Conference on Global Food Security, 3-6 December 2017, Cape Town International Convention Centre, Cape Town, South Africa.*

framework before shifting to analyse the livestock system's sustainability in section 5.4. Then, using foresight technique, section 5.5 focuses on the community's desired livestock system.

5.1 THE SOCIO-ECONOMIC SYSTEM OF BEITBRIDGE

5.1.1 Demographics

This study was conducted in Ward 15 of Beitbridge Rural District, Zimbabwe. The study area comprises of four villages: Dumba, Mapayi, Old Nuli and Shabwe. Official statistics from the ZimStat (2016:77) presented in Table 5.1 show that the four villages have 932 households (HH), with a total population of 4166 resulting in an average household size of 4.5 people per household. Of the total enumerated people in the Ward, about 54% are female and 46% are male.

Table 5.1: Official population statistics in the study area

Number of Households	Male	Female	Total Population	Average HH Size
932	1930	2236	4166	4.5

Source: ZimStat (2016)

The respondents for the study were drawn from these 932 households with 270 households responding to a survey questionnaire (Appendix A) and other selected respondents (based on research methods detailed in Chapter Four) participating in the different data collection activities such as the focus group discussions, community visioning workshops and key informant interviews. Also, during the participant observation of livestock auctions, I observed activities linked to the entire community rather than households.

However, the respondents per household and their demographics were relatively easier to determine in the household survey, which was administered by trained enumerators, as one of the main data collection tools in the study. When the respondents to the survey questionnaire were asked their position within the household, the results presented in Table 5.2 show that 59% responded that they were the household head (HHH) while 41% were not the HHH. Of the latter, 29% were the partner (spouse) and 8% were a child of the HHH and the remainders were relatives.

Table 5.2: Survey respondents' classification by village and age

		Household Head		Other adult		Total (n=224)
Village	Dumba	59	26%	15	7%	74
	Mapayi	22	10%	20	9%	42
	Old Nuli	25	11%	34	15%	59
	Shabwe	27	12%	22	10%	49
	Total	**133**	**59%**	**91**	**41%**	**224**
Age						
	18-25	10	4%	23	11%	33
	26-35	22	10%	29	12%	51
	36-45	24	11%	21	10%	45
	46+	77	34%	18	8%	95
	Total	**133**	**59%**	**91**	**41%**	**224**

In addition, the respondents were also asked to indicate their age groups. The results in Table 5.2 show that most of the respondents, 42%, were in the 46+ age group followed by 23% of the respondents aged between 26-35 years. The third largest group of the respondents was the 36-45 age group with 20% and only 15% of the respondents were aged 18-25. The chi square test ($p < 0.001$) further suggests that there is a significant difference between the age group of household head respondents and non-household heads. In the study, most respondents (79%) were female and male respondents were only 21%. This trend is common with respondents suggesting that men often have 'other' tasks to attend to.

5.1.2 Education levels

Another key aspect which the study explored was education level within households. Most studies only consider the education of the household head, but this study also explored the education levels of other household members in comparison to the household heads. As shown in Table 5.3, among the household heads in the study area, less than 1% attained a tertiary education qualification while 24% have no formal education. Furthermore, 50% among the household heads attained primary education qualification, and 25% have a secondary education qualification. However, within these households, highest education levels of any other household members are distributed as follows; only 4% with no formal education, 36% achieved primary education, 58% with a secondary education qualification and at least 2% with tertiary education. A chi square test ($p < 0.001$)

indicate that there is a highly significant difference between the education levels between household heads and other adult household members.

Table 5.3: Comparison of education levels of HH head and other HH members

Level of Education	HH Head (n=224)		Other adult (n=224)	
No formal Education	55	24%	8	4%
Primary Education	112	50%	80	36%
Secondary Education	56	25%	130	58%
Tertiary Education	1	<1%	6	2%
Total	**224**		**224**	

In relation to the education levels of household members within the study area, it was also found that there are inadequate education facilities within the community. Both primary and secondary school children walk long distances and there are no technical training facilities within the study area. Donor programs are playing a key role in addressing the challenge, *e.g.* through provision of bicycles, as depicted in Figure 5.1, to improve mobility of school children and reduce school dropout rates.

Figure 5.1: Bicycles donated to school children to improve mobility

5.1.3 ICT ownership and access

In recent years, ICT has become a key factor of a society's socio-economic system. These ICTs are being integrated in different sectors including agriculture (livestock), health and education among others. However, ICT ownership and accessibility in rural areas such as the study area have been concerns for development agencies. Thus, this section explores ICT access and ownership in

the study area. In terms of household ICT ownership, the findings presented in Table 5.4 show that in 83% of the households, at least one or more household members own a mobile phone. Mobile phone ownership surpasses ownership of any other ICT with only 4% of the households owning a television, 2% owning a DVD player and less than 1% (only 1 household) owning a computer.

Table 5.4: ICT access, ownership and use within the study area

Technological artefact	Ownership (n=224)		Access (n=224)		Use with no help (n=224)	
Mobile Phone	185	83%	188	84%	140	63%
Television	8	4%	12	5%	7	3%
DVD Player	5	2%	5	2%	5	2%
Computer/Internet	1	<1%	1	<1%	1	<1%

The study findings are consistent with related studies on the distribution of ICTs in rural communities (cf. Mudombi, 2014; Rey-Moreno *et al.*, 2016). From the engagement with the community, it also emerged that households make use of radios but there was poor radio connectivity; thus, households used these radios to access foreign channels. In addition to ICT ownership, the study also explored access to ICTs within the study area. In terms of ICT access, the study found that 84% of the households had access to mobile phones. This finding shows that the number of households with access to a mobile phone is more than the number of households owning a mobile phone. The finding reflects suggestions in other studies that individuals in rural communities often share mobile phones. Similarly, households with access to television also is higher than the number of households owning a television set which further demonstrates sharing of resources among households. However, the study did not find any sharing of the DVD player and computer as there were no changes between number of households owning and accessing the DVD player and computer. However, while this study has focused on ICT access at household level, it is also key to note that there are efforts to improve ICT access, especially to children, through various ICT school programmes.

5.1.4 Sources of income

In rural communities such as Beitbridge, formal income generating activities are limited. Also, some of the income generating activities are seasonal in nature and are therefore short term. During focus group discussions and workshops, respondents indicated that household income sources in the study area are mostly informal and there are many determinants of the specific income

generating activities pursued by an individual or by a household. Key determinants identified are age, education levels and time of the year. In terms of the different economic activities pursued in the study area and the different timelines for these activities, study findings obtained during a community workshop in Table 5.5 show that only three activities: livestock sales, border related activities and remittances, provide households with perennial income.

Table 5.5: Timing of income generating activities practiced in the study area

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Livestock auctioning	x	x	x	x	x	x	x	x	x	x	x	x
Mopane worms		x	x	x							x	x
Baobab selling					x	x	x	x	x			
Gardening				x	x	x						
Border related activities	x	x	x	x	x	x	x	x	x	x	x	x
Farming		x	x							x	x	x
Remittances	x	x	x	x	x	x	x	x	x	x	x	x

Key: x – time for activity and workshop participants, n=55.

It was also established that natural resources-related activities such as mopane worms/baobab harvesting and selling (see Figure 5.2), as well as farm-related activities such as gardening and farming, are seasonal. However, the seasonal nature and the spread of the income generating activities help households have income generating activities throughout the year.

Figure 5.2: Women selling baobab

Since different social groups pursue different income generating activities, the study further sought to segregate the economic activities by age. The Pearson chi-square test showed that there was a significant difference (p = 0.009) between the household head's age and the main economic activity pursued within the household. The study findings in Table 5.6 show that households with household heads in the age groups 18-25 and 26-35 were less likely to engage in natural resources related income activities while household with household heads in the age group 46+ were more inclined towards these natural resources related income activities, which include harvesting and selling of baobab, mopane worms and *ilala* (palm tree species native to the eastern Afrotropics).

Table 5.6: Household income generating activities by household head age

			Natural Resources	Petty trading	Community Gardens	Total (n=206)
Age	18 - 25	N	2	15	15	32
		%	6%	47%	47%	100%
	26 - 35	N	4	29	15	48
		%	8%	61%	31%	100%
	36 - 45	N	7	19	16	42
		%	17%	45%	38%	100%
	46+	N	25	29	30	84
		%	29%	34%	37%	100%
Total		N	38	92	76	206
		%	18%	45%	37%	100%

Chi-square = 17.110, df = 6, p = 0.009

5.1.5 Household assets, water and energy sources

Respondents were also asked to indicate the assets which the household owned. The assets identified for the study were considered critical assets to the livelihood of the households. Study findings show that only one household (<1%) owns a tractor, 4% of the households own a motor car, 26% own a bicycle, 46% own a scotch cart and 51% own a plough. In addition to these household assets, water and energy sources are also critical for households' livelihood in rural communities as the availability of water and energy impacts household food security. As such, the study asked respondents about the household water and energy sources. Study results showed that about 82% of the households use community-shared water sources and 18% had their own private water sources. Further to this, a total of 32% households have access to energy sources comprising 28% using solar, 4% having a generator and only one household (<1%) with access to electricity. The study found that there was no significant difference between household average income and

the household water source, as well as the energy source. However, in all this, it was concerning that households using community-shared water sources complained that the water sources are located at distant places, open and not protected. In relation to energy sources, most households use firewood as a source of energy. The non-discriminatory cutting down of trees is an environmental concern and if environmental regulations on the cutting down of trees are not enforced, this can result in an environmental disaster.

5.1.6 Household food security status

Respondents to the household survey questionnaire were asked about the average number of meals the household members have per day. Findings presented in Table 5.7 suggest that 17% had an average of 1 meal a day. Most respondents, 46% suggested that they had an average of 2 meals per day while 37% indicated they had an average of 3 or more meals per day. When a chi square test was performed between the household average income and the average number of meals, the study found significant differences ($p = 0.034$) between the household average income and the average number of meals. Thus, the study findings suggest that household average income has an impact on the average number of meals consumed within a household.

Table 5.7: Household average number of meals by average household income

		HH average number of meals			Total
		Up to 1	2	3 or more	
HH average monthly Income	0 - 300	35	96	68	199
	%	18%	48%	34%	100%
	301 +	2	8	15	25
	%	8%	32%	60%	100%
Total		37	104	83	224
		17%	46%	37%	100%

Chi-square = 6.497, df = 2, p = 0.034

In the vein of household food security, the study also explored the inclusion of wild fruits, vegetables and insects in household diets. Respondents showed that 99% included wild fruits within their diets, almost all the households; 99% included wild vegetables in their diets; and 71% consume wild insects. The study found a significant difference ($p < 0.001$) between household income and the inclusion of wild fruits, vegetables and insects in the household diet. Households with higher income were found to be less likely to consume wild fruits, vegetables and insects; while those with limited income consumed these more frequently. The nutritional status of the

meals was not asked but the study asked respondents whether within their respective households any member had suffered from a malnutrition related disease in the past 6 months. The responses show that 13% of the households had a member who suffered from a malnutrition related disease in the past 6 months. Further findings show that of the 13% households with a member who had suffered malnutrition related disease, most of these households were female-headed households. Further to this, respondents were asked about the sources of household food.

Furthermore, respondents were asked the extent to which livestock species contribute towards household food. From the responses obtained, 45% selected "to a greater extent" while 45% opted for "moderate extent" and only 11% indicated "lesser extent". The study findings ratify the importance of livestock species towards household food security as suggested by the Committee on World Food Security (CFS, 2016). However, for the livestock species to continue contributing towards household food, livestock systems must be sustainable. Therefore, the next section focuses on exploring the livestock system within the study area to examine the sustainability attributes of the system. From the responses obtained, which are presented in Table 5.8, about 26% of the households had received food aid in the past 6 months. As indicated in the context chapter, the study area is replete with donors, including those providing food aid. When the study explored the relationship between household head gender and whether the household had received food aid in last 6 months, the study findings ($p = 0.0118$) show a significant difference. Thus, the gender of a household head is likely to influence a household's reliance on food aid, with female headed households more likely to receive food aid.

Table 5.8: Household food aid by household head gender

Has HH Received food Aid in last 6months?	Male	Female	Total (n=224)
Yes	22	93	115
No	37	72	109
Total	59	165	224

(p = 0.012)

5.2 THE LIVESTOCK SYSTEM OF BEITBRIDGE

In this section, findings on the study area's livestock system are presented. These findings relate to household livestock ownership, use (with specific focus on contribution to household food security) and characterizing the study area's livestock system. To capture the social, economic and environmental elements within the livestock system, and achieve an in-depth analysis of the livestock system, a systems approach was adopted (cf. Tendall *et al*., 2015; Marshall, 2015; Ericksen, 2008).

5.2.1 Household livestock ownership and use

Beitbridge is one of the leading livestock production districts in Zimbabwe. The study findings from the household survey show that households in the study area hold large herds of livestock but there are also large variations between households' herds, *e.g.* cattle, $X_{(n)} = 59$ with SD = 6.4. The study findings in Table 5.9 indicate that there was no significant difference between gender and the number of livestock owned by the household for cattle (p = 0.260), sheep (p= 0.176) and goats (p = 0.063)[23] However, there were significant differences between gender and livestock ownership for donkeys (p = 0.015) and chickens (p = 0.006).

Table 5.9: Livestock ownership by gender (based on averages)

	HH Head Gender	N	Mean	Std. Deviation	p-value
Number of Cattle	Male	115	3.53	5.552	0.260
	Female	109	2.56	7.237	
Number of Donkeys	Male	115	3.03	3.033	0.015*
	Female	109	2.09	2.662	
Number of Goats	Male	115	8.36	9.034	0.063
	Female	109	6.21	8.063	
Number of Sheep	Male	115	1.31	4.463	0.176
	Female	108	.63	2.820	
Number of Chicken	Male	115	8.38	7.142	0.006**
	Female	109	5.81	6.816	

[23] Not significant but notable

Further analysis of livestock ownership based on income groups show no significant difference ($p = 0.653$) between the average livestock owned and the average household income. There are many motivations for holding large herds of livestock which include economic and socio-cultural. During focus group discussions most respondents suggested that livestock species provide a wide range of products and services to the households as one respondent indicated that:

> *In our area, livestock rearing is an inherited culture from our forefathers and livestock has many crucial functions. We keep livestock for selling to cater for household expenses. We also slaughter cattle on special occasions such as weddings and use livestock for cultural activities. Having large herd of livestock also gives social status (prestige)*[24]

Intra-household livestock ownership dynamics are critical to understand, mainly due to the gender perspective on livestock ownership and control. The study findings, like other studies (Valdivia, 2001; 2004; Smith *et al*., 2013) show that women remain relatively marginalised within the livestock system. Women have control over small stock such as goats, chicken and sheep, while men control the larger cattle and donkeys. However, the proximity of Beitbridge to South Africa has led many men to migrate in search of better economic opportunities. This migration was found to increase the involvement of women in the management of large livestock such as cattle. In the study, it was observed that women participate at the livestock auction but further discussions with women participating at the auction revealed that some women participating at the livestock auction still do so at the instruction of men. On the uses of livestock, discussions with the respondents indicated that within the study area, holding large livestock was motivated by culture and the need to attain social status and economic well-being, as an investment and risk management strategy (cf. Quinlan *et al*., 2016). While cattle are used for draught in most rural communities, this was not the case in the study area, as donkeys are more commonly used for draught power compared to cattle. The major reason for this practice is to improve the quality of cattle to ensure higher returns when selling. In the study, it was found that while the four villages have similar characteristics, the use of livestock within these villages varies. The study found significant differences between livestock use per village, *e.g.* selling: $p = 0.007$; investments: $p = 0.01$ and food: $p = 0.01$.

[24] Focus Group Discussion, 56-year old male, Mapayi

5.2.2 Livestock and household food security

Livestock contribute to household food security in multiple ways (Smith *et al*., 2013) even though other studies (Alary *et al*., 2011) question the availability of empirical evidence to support these claims. In the study, during community engagement, it was established that households use livestock in farming activities (*e.g.* food production to a lesser extent since limited crop production is practiced) and transportation of food commodities. Donkey-drawn carts are common in the study area since there are limited transport options which emanate from the poor road networks. In addition to this, livestock contribute to household food availability in the study area since it is a source of nutritious food to the household providing eggs, milk and meat. The consumption of the various livestock species in presented in Table 5.10.

Table 5.10: Livestock use for food by households in Ward 15

	Animal	n=195	Yes
Does the household use [animal] for food?	Cattle	48	25%
	Donkeys	19	10%
	Goats	163	84%
	Sheep	29	15%
	Chickens	175	90%

The study findings, like Quinlan *et al*. (2016), show that despite the rural households owning large numbers and diverse species of livestock, small livestock such as goats are more frequently used to meet household food requirements than large livestock. As revealed in Table 5.10, 90% of the households use chicken for food and 84% also use goats for food. However, only 25% households use cattle for food. Sheep is also used by only 15% while 10% of the households included donkeys as part of their food. Furthermore, it was revealed that the households slaughter large livestock (cattle) for consumption at major social and cultural events. Other responses obtained during community engagement also suggested that large livestock would be slaughtered when deemed to be ill and during times of distress. However, this practice may negatively impact the food utilisation dimension.

Apart from food availability, livestock also play a major role towards household food access. During the workshops and interviews, respondents indicated that livestock species, mainly cattle,

are used to generate household income; some of which is channelled to purchasing household food and some to other household expenses such as school fees, medical bills and transport. However, evidence obtained from the community engagement exercises show that realising optimal returns (income) from livestock sales is difficult, as the rural markets perform poorly. These markets are characterised by high transaction costs, high information asymmetries and farmers struggle to obtain optimal returns (cf. Mavedzenge *et al*., 2008). Further to this, due to the socio-economic status of the smallholder farmers (most respondents), the income obtained from livestock sales is distributed across many household expenses and as such, if livestock species are to play a key role towards household food security, attributes of the livestock system need to be understood.

5.3 CHARACTERIZING THE BEITBRIDGE LIVESTOCK SYSTEM

One of the major contributions of this study is characterising the study area's livestock system. Since the livestock system is complex, the study, like Marshall (2015), relies on Ostrom's SES framework. While Marshall suggested adding two primary tiers which are: Transformation systems [TS] and Products [P], further analysis suggested that these additional tiers were not applicable to rural livestock systems; thus, in this study the analysis was based on Ostrom's original framework.

5.3.1 System Actors [A]

One of the key determinants of a systems' sustainability comprises the *actors* involved in the system. In recent years, studies in systems thinking have moved away from identifying participants of a system as 'users' in favour of the term 'actors', with the latter representing "both individuals and institutions that possess and exercise social agency in the system" (May, 2017:19). In this study, from several discussions and participant observation sessions, it was established that the number of actors, *both individuals and institutions*, within the livestock system in Beitbridge are unbalanced. In the context of individuals, the study noted that while the number of producers (smallholder farmers) was high, livestock buyers were extremely limited. During the livestock auctions attended, it was observed that the *same set of buyers* participated at all the auction markets with rare cases of new buyers. The limited number of buyers meant that these buyers wielded power during negotiations, resulting in farmers selling their livestock for sub-optimal prices; affecting the economic sustainability of the livestock business in the context of smallholder farmers. These remarks further revealed another attribute of the SES framework which help

explain the limited number of actors within the livestock system: location of the resource system. In the context of this study, the resource system (livestock system) is in a rural location; and furthermore, a lack of human constructed facilities (roads) mean that there are limited buyers coming from outside the community to buy livestock. Following this observation, the study sought to explore the *socio-economic attributes* of the buyers in comparison to the smallholder farmers. Discussions with both the farmers and buyers showed that the buyers (agencies) can self-organise and transport livestock for resale in larger towns such as Masvingo and Bulawayo. One farmer indicated that:

> *These agents come and buy here for lower prices and transport the livestock to town where they fetch higher prices. While we are happy that at least we have buyers, they are taking advantage of us and are making more money than us. It's such a shame that we as farmers are not able to come together to make similar arrangements.*[25]

While there are many factors contributing to the selling patterns of smallholder farmers, the SES framework also suggests that the socio-economic characteristics in the context of the study area, *e.g.* abject poverty and poor educational background, may explain the selling decisions. From the empirical evidence obtained in the study area, the livestock market in the study area is a thin market with limited buyers and more sellers (Gwaka, 2017). Furthermore, the livestock system actors (focusing on smallholder farmers) are poor and survive on less than US$2 per day. Also, with most smallholder farmers located in the rural areas (location), there is limited, if any, use of technologies within the livestock system. Apart from individuals, actors of a system can also be institutions. In the study, it was found that there were extremely few institutions focusing on livestock within the study area. Apart from government departments, there are few development agencies undertaking work on livestock. In this regard, one participant voiced that they wish they could be involved in the decisions on what donor-funded programs get implemented so that they could influence or convince donors on the need for projects addressing livestock issues. Mlambo (1996) and Mavedzenge *et al*. (2008) argue that in the pre-2000, the Zimbabwe livestock system was performing outstandingly and this in turn attracted several actors (individuals and institutions). In their studies, Mlambo as well as Mavedzenge *et al*. argue that the presence of the Cold Storage Commission was critical to the success of the livestock system but since the collapse of the Cold

[25] Community workshop, 42-year female, Mapayi

Storage Commission in Zimbabwe, there has been a sharp decline in formalised auction sales (as one farmer in particular indicated). However, the limited number of institutional actors can be linked to the governance system in place, *e.g.* type of regime. Mlambo (1996) shows that government's adoption of the ESAP program was the beginning of the end of the Cold Storage Commission, and as relations deteriorated between Zimbabwe and the global players, accessing international institutions (markets) became difficult.

In addition to the above, another sub-system of the actor attributes is the technology used by the actors. From the observations made during the field activities, it was evident that among the smallholder farmers, there was extremely limited use of technologies, including basic ICTs such as mobile phones. For instance, during the cash crisis in Zimbabwe, buyers were prepared to pay using Ecocash (mobile money) but the farmers rejected this option. The buyers and livestock technicians suggested that they were making use of technologies (*e.g.* social media) to improve self-organisation while carrying out livestock-related activities. However, at institutional level, it was also evident that there was limited uptake of technologies signified by the manual nature of the activities. One of the extension workers even acknowledged government's delays in digitising processes within the livestock system which could result in improved services. He indicated that:

> *Government digitisation process will take long since it must be implemented at national level, then move to provincial level before it gets to district level. We will just find our means of using ICTs within the system, where and when we can.*[26]

5.3.2 Governance System [GS]

In the SES framework, another attribute is the governance system [GS] and the sub-attributes include rule making organisations, rules-in-use, network characteristics, regime type history, and location. However, in this section, the study focuses on exploring selected governance system attributes to understand how they impact the sustainability of the study area's livestock system. McGinnis and Ostrom (2014:30) suggest that another attribute of the [GS] is the history of the [GS], which they suggest is an attribute included to "distinguish between systems of governance that have been in place for long periods of time and those that are more recent in form." In the

[26] Agriculture extension worker, Beitbridge

context of the study, the focus was on the establishing governance within the livestock system in the study area. During community engagements (with focus group discussions), the community suggested that in the early 1990s, the local government provided the community with the appropriate assistance, for example chemicals needed for cattle dip, technical education and support during crisis periods. To this end participants argued that:

> *Things have changed, mostly for the worst, in the past years. Our government can no longer supply us with the chemicals for the dip and even the water. We must contribute as a community to buy water and chemicals for the dip and animal health services from the government have declined.*[27]

Furthermore, during the colonial and post-colonial era, livestock activities were mainly regulated through the Cold Storage Commission, which was a government parastatal. However, since the adoption of the ESAP which resulted in the dissolution of the Cold Storage Commission, there has been poor governance of the livestock value chain. Evidence of poor governance is marked by several elements including the failure of smallholder farmers to integrate into profitable markets, particularly the export market. Apart from the parastatal's role, livestock systems are also regulated by local level governance systems which are mainly influenced by culture and tradition. For many years, livestock systems in Africa have been linked to culture and tradition, and it follows that there were also traditional governance systems in place. However, the study findings concur with prior studies such as Byers *et al*. (2001) that the infiltration of religion, immigration (which resulted in cultural infusion) and modernity have led people to disrespect the traditional rules critical to governance of biodiversity (resource systems) and ultimately, livestock systems (cf. Byers *et al*., 2001). Demonstrating this claim, one participant indicated that:

> *Livestock systems are gradually losing the sociocultural significance in our community. There are even households without livestock, bride prices are being paid in cash and not cows, and all this is because of the modernity which has infiltrated our society.*[28]

Another [GS] attribute includes the rule-making organisations which are identified as the "different types of organizations responsible for crafting and/or implementing different kinds of

[27] Male, Focus Group Discussion (male participants), Dumba
[28] Elderly female, informal discussion (post workshop), Old Nuli.

rules" McGinnis and Ostrom (2014:30). In the study, it was observed that there are many organisations responsible for different aspects relating to livestock system. The veterinary organisations develop and implement rules relating to livestock healthy. The police were identified as key in implementing rules relating to ownership of livestock. However, it was the absence of solid rules or provisions relating to selling of livestock (pricing) that stood out in this study. In the historical context, the CSC provided guidance on pricing but since the dissolution, there has been a void. During community engagements, smallholder farmers also indicated that one of the main challenges they faced was cattle theft. The farmers indicated that there were syndicates which committed organised theft, and this affected the farmers severely. However, the major concern among the farmers was that the *rules-in-use*, specifically the terms, were not effective enough to deter livestock theft.[29] Considering that the some households in the study hold large numbers of livestock (*number of units*), livestock theft is only discovered after several days, making the recovery process extremely difficult. This situation is further complicated by the non-use of *technologies* by the livestock farmers (actors), *e.g.* tracking devices.

Therefore, this study submits that within the governance system [GS] of the study area's livestock system, there are fundamental transformations which need to be implemented in order to achieve sustainable livestock system. Firstly, coordination between public and private sectors (network characteristics) need to be improved. Currently, programs and/or interventions within the livestock system conducted by private and public sector are misaligned. Secondly, smallholder farmers engaged in the study suggested that revitalizing a government parastatal like the CSC could play a significant role towards improving the sustainability of the livestock system. Furthermore, considering the unpredictability of the livestock system dynamics, rule-making organisations need to embrace adaptive management (*rules-in-use*) to accommodate the sudden unexpected changes occurring within the system, *e.g.* controlled movement of livestock during bad seasons as opposed to a total ban.

[29] See for example, Cattle rustlers given long jail terms. Retrieved September 2, 2018 from https://www.newsday.co.zw/2018/02/cattle-rustlers-given-long-jail-terms/ and in this article, the Beitbridge community was complaining that the police were handling the livestock cases "with kid gloves" despite the long jail term sentences sanctioned to the convicted cattle rustlers.

5.3.3 Resource System [RS]

Another tier of the SES framework is the resource system [RS] and the sub-systems under this tier include clarity of boundaries, size of resource system, human constructed facilities, productivity of the system, predictability of system and location. While all the sub-systems of the resource system are critical, the study focuses on discussing a few selected sub-systems which are closely related to the MOSMAC intervention. In the literature reviewed, many problems affecting the livestock system were identified but one of the major issues raised is the lack of human-constructed facilities to support the livestock system (Mavedzenge *et al*., 2008; Barrett, 2008). In the study, through participant observation (transect walk in the study area), it was observed that there are limited human-constructed facilities to support livestock systems in the study area. While visiting the communities for research engagement, I experienced that road networks were poor and other roads have been under construction for many years. While there are plans to improve the road network, the processes often took extremely long as one resident complained during a community visioning workshop that:

> *The council comes for a few weeks and they peg a portion they want to work on. After that, people are forced to use a detour but unfortunately, we end up using the detour for a very long time. I don't think that the council is serious about developing roads. However, close to election times, they will come again trying to work on the roads*.[30]

This finding was corroborated by observations of a road refurbishment which commenced at the same time as field work for this study but at the conclusion of this study, the road remained incomplete, with extremely limited progress. This is like many other facilities which could be usefully adopted to improve community resilience. In the context of the study, other human-constructed facilities lacking from the study area include electricity, mobile networks, and cattle holding facilities, as well as auction sites. Respondents from Dumba, the furthest village in ward 15 argued that "*In Dumba, we don't have the auction place and in addition, the roads are extremely poor to drive the cattle to the auction it's such as challenge*"[31]

The study findings of limited human constructed facilities are also similar to RAN's findings in which they identified broad infrastructure as extremely poor. There are several possible

[30] Elderly male, community visioning workshop, Dumba
[31] Young female, focus group discussion, Dumba

contributors to the state of human constructed facilities. When the community members were asked for their opinion on the possible causes of the lack of human constructed facilities, one respondent suggested that the limited human-constructed facilities reflected the governance system [GS] in place. In this regard, one participant during a focus group discussion elaborated that the development of infrastructure "*really depends on the councillor of the ward and general leadership from the government departments as well as council and DA*"[32]

In previous work on digital infrastructure in the study area, it was established that the development of infrastructure (or lack of it thereof) was to some extent an outcome of political decisions. For instance, stringent regulations inhibit the private sector from investing in human-constructed facilities which could be beneficial to the communities. In the context of the livestock system's sustainability, limited human constructed facilities have negative impacts to the different dimensions of sustainability. In addition to this and similar to findings of this study, RAN argues that lack of infrastructure is an underlying cause of poverty and community vulnerability. Therefore, the government, through the various departments, as well as donor-funded projects such as MOSMAC, are focusing on the improvement of infrastructure in rural communities.

Further to the above, another key aspect of the resource system is the predictability of system dynamics. In the analysis, it was also noted that the limited use of technologies by the system actors contributed to the system's unpredictability. For instance, Enenkel *et al*. (2015) noted that there are emerging technologies which can be adopted, and these can help improve system predictability. However, the interconnectedness of the problems manifest in that the failure of the community and/or smallholder farmers to adopt technology could be emanating from the lack of human constructed facilities such as community information centres.

5.3.4 Resource Units [RU]

As discussed in earlier sections of the thesis, in the study area, livestock play many roles towards household welfare, and chief among these is the provision of income to the household and also acting as a form of wealth storage (live banks). In the context of the SES framework, this function can be analysed in terms of the economic value of resource units (livestock). From the participant

[32]Young male, community visioning workshop, Dumba

observations of the livestock auction, it was observed that the smallholder livestock farmers received sub-optimal value for their livestock. In this regard, it was evident that there were discrepancies on the economic value placed by the auction participants. The buyers valued the livestock in terms of profitability (how much they could resell, after considering other costs) while the livestock farmers valued livestock as their primary source of income. As reported in prior results (Gwaka, 2017), farmers are not satisfied by the economic value placed on their livestock. A further analysis on the potential causes of the discrepancies on the economic value points to several aspects. In discussions with the community members, it was evident that the location of the resource units within a rural remote place disadvantaged them and this meant they received poor offers. Secondly, the lack of infrastructure also contributed significantly to the low economic value placed on the resources (cf. Marshall, 2015).

In addition to the above, another attribute under resource units is the growth or replacement rate. In discussions with the veterinary officers together with the farmers, the study found that the number of livestock was decreasing, with many deaths as a result of various factors including climate change, water shortages and diseases. Incidentally, these factors also impact the growth and replacement rate. For instance, climate change has been reported to contribute to drought, heat stress and diseases which affect the growth of livestock. However, since it has been suggested that the study area's households often overstock, it can be argued that the slowing in the growth and replacement contributes towards achieving equilibrium of resources (cf. Samuels *et al*., 2008)

As a result of the harsh climatic conditions, herd mobility is used to manage resource variability. However, over the years, there has been a significant reduction in the mobility of livestock, and Samuels *et al*. (2008:124) cite "inadequate supply of infrastructure, the breakdown of customary hierarchies, famine and wars" as contributing factors to the decrease in mobility. Historically, farmers were known to use livestock mobility to rest certain parts of their rangeland and for many years, this solution was marginalized by agricultural extension services. However, the subsequent changes in land ownership and imposition of rules-in-use (statutory instruments) has led to the restriction of livestock mobility. While this impacts livestock during times of drought (limited availability of resources like grazing areas), the restriction of livestock mobility has also been sanctioned by the need to control livestock diseases. To this end, traceability systems have become common instruments to explore livestock movements which further determine its acceptability

within specific markets (Prinsloo & De Villiers, 2017). In the context of the study, it was established that livestock movement (resource unit mobility) was restricted and these restrictions were imposed by the livestock department, as well as the police. For one to facilitate livestock movement, they required clearances (permits) issued after an onerous process. This was imposed to restrict movement which could result in the spread of diseases, as well as reduce livestock theft.

Another attribute of resource units is marketing characteristics. This attribute considers the features of the resources units which attract buyers. Marshall (2015) suggested that within SES, key transformations could be adding the transformation systems [T] and products [P] attributes. This suggestion assumed that rural areas could transform resource units and create a new product. However, subsequent analysis reveals that the [T] and [P] sub-systems do not apply to rural communities as in these areas, there is extremely limited, if any, value addition (Alarcon *et al*. 2017). In the context of livestock, any efforts to slaughter livestock for resale are likely to be hampered by the strict health regulations (rules-in-use) as well as lack of facilities such as cold storage facilities. In terms of live livestock, it has been established that among the smallholder farmers, there is lack of marketing strategies and technological/management constraints (Alarcon *et al*. 2017).

5.3.5 Social, economic and political settings [S]

Apart from the four sub-systems addressed in Table 5.8, the SES framework also acknowledges that a SES is situated in and interacts with broader external sub-systems which are the social, economic and political settings of a community. These sub-systems can be explored at local levels, national levels or even global levels. Therefore, in this context, a livestock system's sustainability is also affected by other sub-systems which include economic development of the community (or country at large), political stability and demographics as well as social and cultural settings.

Over the past two decades, in terms of economic development, Zimbabwe as a country has experienced extensive economic challenges which have affected the function of different sectors. Furthermore, as Mlambo (1996) argues, the economic problems faced by Zimbabwe led to the adoption of the ESAP which subsequently contributed to the dissolution of the CSC. Furthermore, apart from the local economic problems, the global economic crisis of 2008/9 also resulted in many problems which include shortage of basic goods, including vaccinations for livestock; price fluctuations; and currency crisis; and all these have had a negative effect on the livestock system.

Zimbabwe has continued to face poor economic development, and this has had a major impact on the sustainability of local value chains, including the livestock system.

The country has also endured other challenges such as political stability and social problems (corruption); and these have contributed to the further marginalisation of rural communities. In the context of the study, most rural areas such as Beitbridge are extremely under-resourced to support the livelihoods of the communities such as livestock systems. Furthermore, the social structure of the country has led to communities living in extreme poverty. Therefore, it is the study's submission that the broader social, economic and political settings [S] is also contributing to the fragility of the livestock system. In Table 5.1, a summary of the Beitbridge livestock system based on the Ostrom's SES framework is presented. Following this section, the chapter shifts to explore the sustainability of the study area's livestock system against the attributes of the livestock system highlighted.

Table 5.11: Analysis of the study area livestock system using Ostrom's SES framework

Primary Attributes	Secondary Attributes	Empirical Evidence on how these attributes contribute to system fragility
Resource System [RS]	Predictability of system dynamics	The study found that the livestock system dynamics in Beitbridge are unpredictable. The complexity of the livestock system and other elements affecting the livestock system (climate change, economic trends) require sophisticated approaches to predict system dynamics; and traditionally, smallholder farmers have relied on extension workers, who themselves are finding it challenging to predict system dynamics. Also, indigenous knowledge can no longer suffice to predict system dynamics; thus, new technologies and methodologies are needed and are being developed (modelling & scenario planning) to improve the predictability of system dynamics. During a key informant interview, a livestock technician indicated that "we need new technologies and methods to assess and predict the seasonal forecast."
	Human-constructed facilities	From the study, the lack of human-constructed facilities in the study area was evident. Apart from the observations made during the community visits and engagements, participants in the visioning workshops suggested that developing supporting infrastructure, *e.g.* police station, mobile network, road networks, education and skills centres was a major need within the community (see Appendix G). Corroborating evidence on the lack of infrastructure is also presented in the RAN unpublished work, as well as our previous work (Gwaka, 2017; Gwaka *et al*., 2018).
	Location	This study examined a livestock located in Beitbridge District, a typical rural community in Zimbabwe. The community is located at the border with South Africa, and the livestock farmers are in four villages. The location of the [RS] in the agro-ecological region (V) which means there are ecological challenges that affect the productivity of the livestock system, *e.g.* limited rainfall and poor biodiversity. The location of the [RS] in rural communities, coupled with poor infrastructure and transport facilities, makes it difficult for farmers to participate in other competitive markets in the closest larger towns such as Bulawayo and Masvingo.
Governance System [GS]	Network characteristics	Drimie and McLachlan (2013:219) suggest that "food system challenges cannot be understood and addressed using mono-disciplinary approaches only." Firstly, in the study area, it was observed that tackling problems within the livestock system was largely mono-disciplinary, *e.g.* the veterinary technicians were expected to have solutions to diverse challenges, including lack of infrastructure (beyond their purview). Secondly, it was observed that there was lack of coordination among the rule-making organisations, both public and private sector; *e.g.* some interventions can benefit other

		value chains but once it is brought to the community targeting one value chain, it was difficult to repurpose the intervention.
	History	Before the adoption of ESAP, CSC, a parastatal which was established during colonial Zimbabwe and later adopted by the post-colonial government, had dominance of the livestock marketing system. However, subsequent privatization of CSC and the entrance of the private players in the livestock system transformed the marketing system resulting in the collapse of formal livestock auction in most rural communities. There have also been changes in the structure of the government departments responsible for livestock.
	Rule-making organisations/Rules-in-use	Rules-in-use (*e.g.* veterinary) restrict the mobility of livestock and/or livestock products. These restrictions often mean that during the times of drought, smallholder farmers are unable to transfer their livestock to other regions. However, the restrictions are also important as a way of restricting the spread of livestock diseases. Furthermore, restricting movements may enhance the traceability of livestock products.
Actors [A]	Number of actors	The study findings reflect an imbalance of livestock actors. The study area's livestock system has a thin market, with many sellers (farmers) and fewer buyers. The location of the study area (approximately 265km from the nearest major town) may also be playing a role towards the poor participation of buyers. The study further revealed that apart from the various government departments responsible for various duties, there is no parastatal involved since the collapse of the Cold Storage Commission
	Technologies	In Beitbridge, it was found that the livestock actors were making limited, if any, use of technologies within the livestock system. While the buyers indicated that they make use of mobile phones to communicate among themselves as well as with livestock technicians, most smallholder farmers did not make use of technologies. While there is lack of human-constructed facilities to promote ICT access, the socio-economic characteristics of the smallholder farmers could also be a contributing factor to the non-use of technologies.
	Socio-economic characteristics	The socio-economic characteristics of the livestock actors also extensively impact the sustainability of the livestock system. From the study, it was established that most households in the study area were economically poor (limited income generating opportunities less than the poverty datum line but had considerable resources (livestock) which represented the social status or wealth of a household, and source of income.

Resource Units [RU]	Resource mobility	The mobility of livestock allows farmers to drive the livestock to auction places. Farmers expressed that they drive the livestock, in some cases, for longer than 20km and this may affect the livestock. However, there are also [rules-in-use] which prohibit the mobility of livestock from one area to another without necessary clearance and this may restrict efforts to sell in other markets. There are no traceability systems in place which are needed for products to qualify for certain markets, *e.g.* export markets.
	Economic value	There are discrepancies on the economic value placed on livestock by different actors. Smallholder farmers expressed concern that they failed to receive the optimal value from the sale of their livestock. Since there are poor human-constructed facilities and farmers have limited technologies, there is no value addition (transformation/processing) done by the smallholder farmers; thus, it results in farmers failing to obtain higher value.
	Marketing characteristics	In comparison to other rural semi-dry areas, the livestock from the study area is considered as 'good quality' which can fetch higher prices. This is a measurement of the marketing characteristics of the livestock. The livestock farmers also do not document management practices; and thus, are unable to target certain markets. However, as reported in related studies (Gwaka, 2017), livestock selling is often based on 'eye-balling'.

5.4 LIVESTOCK SES SUSTAINABILITY

In the preceding section, empirical evidence relating to the attributes of the study area's livestock system has been presented. The practices of livestock production are handed down from one generation to another. Already, there is an increase in demand for livestock product as the number of middle-class earners increase. There is a need therefore to examine sustainability of a livestock system which is considered as a system's ability to "meet the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987). Duru and Therond (2015) think that sustainability is about meeting pre-determined outcomes embedded in three pillars which are: environment, economic and social. On the other hand, Herrero and Thornton (2013) suggest that on livestock systems sustainability, much focus has been given to environmental sustainability. However, while this is critical, social and economic impacts also require similar attention. Thus, in the next section, the study provides the environmental sustainability overview of the study area's livestock system which is then followed by sections focusing on the economic and social sustainability of the livestock system.

5.4.1 Environmental sustainability

The relationship between livestock and the environment is complex. The livestock system's environmental sustainability pillar considers how environmental elements (*e.g.* biodiversity and weather) impact the livestock system, as well as the impacts of livestock on the environmental elements (*e.g.* land degradation). In this study, it has already been established that households in the study area hold large numbers of livestock. These large numbers of livestock (see Figure 5.3) impact the environment in many ways including overgrazing and increased pressure on natural resources such as water and land. Further to this, livestock also contribute towards greenhouse gas emissions even though there are limited studies if any, which measure the contribution of livestock in the study area to greenhouse gas emissions.

Figure 5.3: A household's cattle in a kraal
Source**: Author**

While livestock contribute to general environmental changes (*e.g.* climate change and biodiversity losses), livestock species are also affected extensively by environmental degradation and general environmental changes. In the study area, the impacts of general environmental changes and climate change are visible. Increased biodiversity losses (see Figure 5.4) result in poor pastures and livestock in the study area depend on mopane leaves and acacia leaves.

Figure 5.4: Goats grazing the *acacia* and evidence of sparse grass
Source**: Author**

When respondents to the questionnaires were asked for their perception on whether the changes in weather patterns (general environmental changes) over the years have impacted livestock production in the study area, about 89% of the respondents acknowledged that weather patterns (general environmental changes) over the years have impacted livestock production. However, 8%

suggested there were no impacts of changes in weather patterns on livestock production. Also, 3% of the respondents did not answer this question.[33] The impacts of climate change on livestock are diverse and Table 5.12 shows the collation of climate change impacts on the livestock system supported by empirical evidence gathered from the study area.

Table 5.12: Empirical evidence of climate change impacts on the livestock system

Element	Impact on livestock system	Empirical Evidence
Water	Changes in water availability - Limited drinking water - Limited rainwater resulting in limited grasslands	Extremely limited water sources in Beitbridge Ward 15 were reported by focus group discussions and in community workshops; *e.g.* boreholes have not been repaired in ages and a newspaper report headline: *16 000 cattle succumb to drought* (Chikwati, 2016).
Biodiversity	Rangeland productivity - Alterations of fodder quality and quantity	In the study area, livestock species depend on mopane tree leaves and there are no more grasslands in the study area. Goats rely on *acacia* leaves (see Figure 5.4).
Livestock health & diseases	Disease epidemics - Emerging diseases - Poor quality reproduction	High livestock deaths Evidenced by poor prices fetched at livestock auction markets (by observation).

Developed based on Thornton *et al*. (2009)

Further to this, corroborative evidence was obtained from the Department of Livestock Production and Development's (DLPD) official records of reported livestock deaths within the study area. As depicted in Figure 5.5, the official records for the last quarter of 2016 show that livestock deaths reached over 800 in the district. Within the quarter, the cattle death tally exceeded 450 and at an average price of US$350 per herd, total losses reached an average of US$157,500 which is a significant amount when considering that the average household income per day in the study area is less than US$2 (Gwaka, 2017).

[33] Interpreted as lack of awareness on the term/concept of climate change

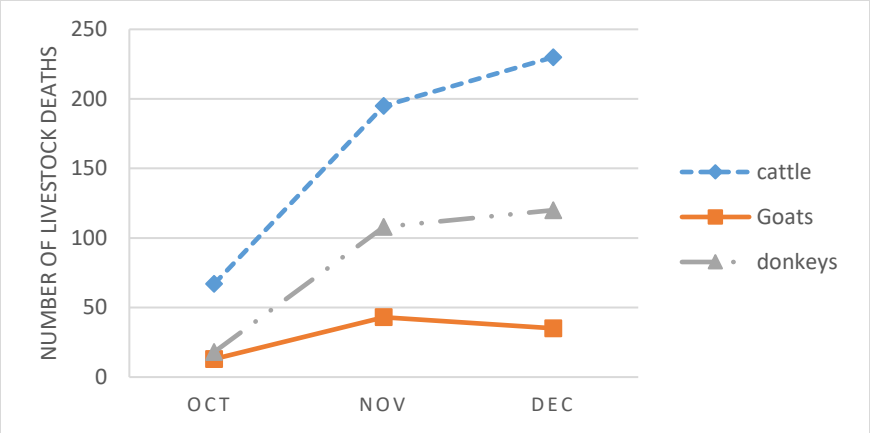


Figure 5.5: The 2016 4th quarter livestock deaths count in Beitbridge
Source: Livestock Production Department in Beitbridge (2016)

Concerned with the large losses facing the smallholder farmers, extension workers were asked of the efforts in place to help the smallholder farmers. One extension worker responded that:

> *Against the intensifying climate change, extension workers are continually engaging with communities to develop mechanisms to adapt, cope and mitigate climate change effects on livestock. Best practices being promoted within the community include paddocking – to mitigate diseases and control grazing and destocking – resource planning.*[34]

However, these suggestions were often met with challenges, for instance, one technician indicated that:

> *The uptake of best practices by smallholders is extremely poor thus, they continue to face same challenges year in year out. Key among contributors towards resistance by farmers is lack of knowledge, lack of resources and unjustified resistance to change. More must be done since climate change is really affecting the farmers.*[35]

Chikwati (2016), reporting in the Zimbabwe national newspaper The Herald, added that some interventions include programs led by NGOs such as FAO which facilitated $US1 million worth of stock feed for supplementary feeding. With the relationship between climate change and livestock still unclear to many smallholder farmers, it is prudent to suggest that environmental sustainability of the livestock system is endangered. Current general environmental challenges

[34] Extension worker, key informant interview, Old Nuli Village
[35] Livestock technician, key informant interview, Shabwe Village

challenge both scientific and traditional knowledge. However, with evidence of the impacts of climate change, farmers may be persuaded to adopt climate-smart livestock approaches.

5.4.2 Economic sustainability

Economic sustainability of a socio-ecological system refers to "economically viable production with the farmer and other chain stakeholders able to prosper and to sustain investment while consumers access quality food that is affordable" (Buckwell *et al*., 2015:11). This entails:

- Ensuring that farm operations obtain a fair share of the profits achieved in the food chain;
- Supporting the ability of livestock producers to invest in sustainability improvements; and
- Adopting innovation and approaches that help farmers deal with market volatility and hence the prices of products and inputs.

Most smallholder farmers in rural communities do not maintain records of costs of production for livestock; and thus, are unable to determine profitability of their operations. In any case, the lack of record management, while a concern, has not been identified by smallholder farmers as major a concern as it should be. From the field study, it was established that one major concern for the smallholder farmers in the study area was the functioning of the livestock markets, particularly the livestock auctioning system. Therefore, for economic sustainability, this study focuses on the livestock auction system in the study area.

Another major finding of this study shows that smallholder farmers in the study area receive sub-optimal prices for their livestock (and other agricultural products, as well as natural resources) (Gwaka, 2017). This is also reported in several other studies (Mavedzenge *et al*., 2008; Dube *et al.*, 2014; and Chikwati, 2016). With the current state of the livestock auctioning system, it may be critical to explore the history of the system. Between 1990 and 1991, the Zimbabwean beef sector experienced a boom with readily available export markets and attractive prices; and was well-regulated (Mavedzenge *et al.*, 2008). During this period, livestock auctioning system was controlled by the Cold Storage Commission parastatal. A detailed account on the establishment, first years and collapse of the CSC is outlined in Mlambo (1996). In this study, Mlambo (1996) shows that the CSC played a key role developing the Zimbabwean beef value chain. The CSC had control to an extent that over 90% of the beef sales in the country went through the commission.

In Beitbridge, livestock marketing is conducted mostly through formalised market auctions, locally known as *showa*. The auction process observations made in Beitbridge resemble those made in Ethiopian markets (Kocho *et al*., 2011). During the auction days, smallholder farmers *drive* their cattle to the auction place. There is limited (and costly) transport to ferry livestock to auction; thus, some farmers travel long distances to reach the auction place. The study found that about 42.4% of the respondents travel more than 20km to reach the nearest auction place. Further to this, it was observed that due to limited infrastructure; different Wards share auction facilities. During the auction, as shown in Figure 5.6, animals are driven onto a central scale where buyers make bids for livestock until a price is agreed upon. Payments at the auction are handled by the local authority (Rural District Council) officers. The auctioneers represent an independent third party only facilitating negotiations between the buyer and the seller. The process also involves several governmental departments, e.g. police to verify livestock ownership (considering high livestock theft cases) and maintain peace during the auction, veterinary to inspect the animal health, as well as traditional leadership who vouch for the ownership of livestock. Therefore, livestock without proper details or supporting documents, and those suspected of diseases, are left unsold like those for which buyers and sellers fail to agree prices.

Figure 5.6: Observation of the livestock auction in progress
Source/Credit: Paradzai Munyede

During the auction, as depicted in Table 5.13, price discrepancies were observed between prices offered by buyers and prices expected by farmers. The smallholder farmers felt that they were receiving sub-optimal prices for their livestock, while buyers justified prices offered based on their perception of livestock quality as well as market dynamics. Smallholder farmers in the study area

were found to be vulnerable to exploitation at auctions for several reasons. On the prices offered by buyers at the auction, smallholder farmers indicated that they were not satisfied but at the same time felt they had no option other than selling. The lack of alternative markets hindered farmers from declining low prices, for instance, one farmer indicated that:

> *If you come with your livestock, you will be hoping for a fair price. We understand the cash shortages and other economic challenges, but these buyers connive to pay very low prices. Also, we don't have an option, if you don't sell the livestock, a large herd is a risk since they can also die from lack of adequate feeds, water or general diseases - and you remain in desperate need of money to solve other household problems. This has been going on for years.*[36]

Table 5.13: Livestock auction prices at participant observation data collection session

Lot number	Live Mass	Farmer Asking Price	Highest Bid	Other	Gender of seller
1	240kg	$300	$260	N/A	M
2	300kg	N/A	N/A	No proper details	F
3	465kg	$600	$570	N/A	F
4	250kg	$310	$240	N/A	M
5	315kg	$350	$370	N/A	F
6	400kg	N/A	N/A	No proper details	M
7	420kg	$420	$380	N/A	M
8	220kg	$300	$250	N/A	M
9	400kg	$480	$390	N/A	M
10	310kg	N/A	N/A	No proper details	M

Most smallholder farmers engaged indicated that they lacked access to market information, *e.g.* prevailing prices, and as a result, buyers dictated the price range during the livestock auction. Also, it was observed that at all eleven auctions attended by the researcher, the same buyers participated. These buyers also have an association and engage in discussions relating to buying strategy. On the contrary, smallholder farmers are not united. Furthermore, there are no readily available alternative markets. Buyers are aware of the farmers' desperation and take advantage offering sub-optimal prices (Chikwati, 2016). In addition to the Beitbridge livestock market being a thin market, environmental extremes, *e.g.* drought and socio-economic conditions (poverty), push farmers to

[36] Elderly male, informal discussion, Lutumba auction.

sell livestock at poor prices. The overall impact is that farmers end up with less disposable income for household needs; impacting on household food security. During the participant observation exercises, it was observed that of the total livestock brought to the auction; at least 40% remained unsold by the end of the auction; apparently for several reasons; chiefly among these, a shortage of buyers.

Apart from the failure to agree on prices with buyers, lack of proper documentation for livestock is another challenge which farmers face. Record keeping, including ownership records among livestock farmers is poor. During the auction, livestock details, *e.g.* ownership and transfer history are verified and any livestock without proper details will remain unsold. This is critical to avoid buying and selling of stolen livestock. Due to poverty and subsequently desperate need for income, smallholder farmers who fail to sell during a livestock auction become easy targets for unscrupulous buyers who take advantage of the financial desperation of these farmers. Also, apart from the formal auction, smallholder farmers also sell their livestock in informal markets. Often, smallholder farmers are forced to negotiate with buyers using 'eye-ball' pricing to ensure that they secure a sell.

Further to the above challenges, the cash crisis in Zimbabwe was another challenge faced by smallholder farmers during the time this research was conducted. The normal practice during livestock auction is that farmers are paid in cash for their livestock. While this is a risky practice, it has come a long way and has become the norm. However, the Zimbabwe economic crisis has resulted in the use of multiple currencies, normally the South African Rand (ZAR) and United States of America dollars (USD). During the time of the field work, the country was experiencing cash shortages, and this also impacted smallholder farmers. The auction continued as normal; thus, once a month. However, during the auction, buyers often expressed cash shortages and therefore payments to smallholder farmers were delayed. The local authority, Beitbridge Rural District Council (BBRDC) is responsible for facilitating payments and it ensured that smallholder farmers would receive their cash whenever buyers managed to access the cash, and this averaged between one and two weeks. This challenge, therefore, meant that even when farmers needed to solve household problems using proceeds from livestock sales, the national cash crisis delayed the process. Given these challenges, it is prudent to suggest that the introduction of electronic markets (technologies) could assist to overcome some of the challenges as Zimmerman *et al*. (2012:129)

suggest that, "[e]lectronic marketing reduces travel costs, increases access to potential bidders, offers a no-sale option for sellers, and may reduce commissions, animal shrinkage, animal stress, and health concerns from co-mingling."

5.4.3 Sociocultural sustainability

Further to the economic and environmental sustainability pillars, the study also explored the socio-cultural sustainability of the livestock systems. Even though many studies focus on the social dimension, this study focuses on both social and cultural sustainability dimensions. Boogaard *et al*. (2011) suggest that sociocultural sustainability should be studied in context as livestock may carry different meaning among different people. Context is critical when considering Crane's (2010: np) suggestion that sociocultural sustainability of livestock contributes to the maintenance of "livelihoods that satisfy both material and moral (normative) needs." Therefore, this section focuses on the sociocultural sustainability of the livestock system within the study area by exploring the place for social dynamics and culture in the sustainability debate (Crane, 2010: 2014). Boogaard *et al.* (2011:1464) suggest that "sociocultural sustainability is about people's perceptions of livestock farming." During the study it was established, through participant observation at the livestock auctions, that fewer youths were taking part in the livestock system. With livestock practices (traditional knowledge) handed down from one generation to another, the modern generation is showing little interest in livestock farming as they opt for other trades. For instance, further investigation revealed that most youths (mainly male youths) were migrating to neighbouring countries in search of economic opportunities, as one parent indicated:

> *The proximity of South Africa and relaxed border control (on the Limpopo River) has resulted in a massive migration of youth (especially male) into SA. These youths are less interested in taking agriculture as a profession, but they cannot be blamed since the livestock does not always provide attractive incomes*.[37]

In the same vein of sociocultural sustainability, little has improved in the marginalisation of women in the livestock system (Patel *et al*., 2016). In the earlier sections of the chapter (section 5.2.1), it was highlighted that in terms of livestock ownership within households, males retain much control over large livestock (mainly cattle) and women have control over small livestock.

[37] Elderly female, community workshop, Shabwe Village.

However, during the auctions, women were also observed participating; yet it is prudent to argue that men dominate, as can be seen from Table 5.13. Quinlan *et al.* (2016), using a cultural lens, suggest that livestock carry 'proximate value' which can also be considered the cultural significance of livestock. In the study area, livestock carries cultural significance such as linking households to the supernatural realm. Also, households use livestock as exchange of medium for specific cultural activities such as appeasing avenging spirits. However, from the study, it emerged that the cultural significance of livestock may be disappearing as communities absorb new cultural beliefs. For instance, one elderly respondent indicated that:

> *Our culture is increasingly becoming diluted. Some of the processes are adopting foreign cultures, e.g. in lobola cases, families are accepting cash* ***in lieu*** *of livestock. Also, our children are never there to learn the cultural uses of livestock. Religion is also affecting us– some of these traditional practices are perceived to be backward practices.*[38]

5.5 DESIRED LIVESTOCK SYSTEM

To this point, the chapter has characterised the study area's livestock system and explored the sustainability dimensions of the livestock system using the SES framework. While empirical evidence indicates that the livestock system in the study area is fragile, this section of the chapter reports on outcomes of participatory foresight activities; specifically, community visioning conducted to map out the livestock system desired by the livestock system actors in the study area (cf. Sheppard *et al*., 2011). Wiek and Iwaniec (2014:497) argue that:

> *"[t]he discourse on sustainability and sustainable development has recognized that positive visions about our societies' future are an influential, if not indispensable, stimulus for change."*

In the context of this study, while the livestock system in the study area is fragile, conventional approaches to solve this problem (and other community problems) focus much on 'problem-solving', failing to capitalise on foresight techniques. Rural communities such as the study area are vulnerable to multiple threats and are perceived to 'need' help and yet, these communities aspire, dream and have desires for the future they want (cf.; Chitakira *et al*., 2012). However, these aspirations, dreams and desires are often neglected in the process of development. To this end, the

[38] Focus Group Discussion, young female, community member, Shabwe Village

study participants were engaged using participatory processes to develop the livestock system they desired and "speculate how they might be attained" (Chen & Kates, 1994:199).[39] While other studies might critique that creating desired futures may be based on "unfounded optimism" (Chen & Kates, 1994:208), the approach was deemed appropriate as it can encourage creative thinking about overcoming livestock system fragility.

5.5.1 A common vision

Following several engagements focusing on the common problems faced in the study area, the study participants were tasked to develop images of the future communities (livestock system) they would love to have and in doing so, identify the key resources within the community which could be appropriated. Given the diversity of individuals (age and gender) and households (socio-economic status) in the study area, it was impossible to establish a single common vision. Furthermore, it is prudent to acknowledge that the desired livestock system suggested by study participants very much depended on personal circumstances, but when participants were tasked to develop a desired livestock system in groups, power dynamics played a major role in the activity. However, despite these challenges, key words generated from the various futures visioning exercises include profitable, modernized, and culture oriented. In sum, the overall desired livestock extracted from the community diagrams, notes and discussions would be:

> *An economically viable livestock system supported by the natural environment that would retain socio-cultural values to be handed down to other generations.*

Without any doubt, the suggested community vision may contrast other community members' perspectives (cf. Graef *et al*., 2014); but most elderly respondents suggested that during the early 1990s when the CSC was still in operation, the community had achieved such a desired livestock system. In the desired livestock system, all the pillars of sustainability were more pronounced. However, as Marandure *et al.* (2018) argue, in-depth analysis could further reveal the different actors and the sustainability pillars important to the different actors. The achievement of the community desired livestock system depends on several factors such as community cohesion

[39] In supporting Toyama's (2017) call for design for aspirations, Sein *et al*. (2018:15) make a critical contribution by suggesting that, "*Needs-based design gets rooted on 'what we need now' or what we may need in the future'. By contrast, aspiration-based design makes us think on 'what do we aspire to'. Aspirations have a long-term perspective while needs have a much shorter perspective.*

(pulling in the same direction) as well as the availability of key resources. Wilkinson (2013:161) also indicate that, "Investment in foresight production – whether derived from models, scenarios, visioning or a combination of methods – needs to be matched by investment in consumption, *i.e.* using the insights developed in such studies to inform policy and decision making." Thus, the community was further challenged to identify the key resources needed to achieve the desired livestock system, and the practical steps which needed to be take place for the achievement of the outlined vision.

5.5.2 Key resources to achieve the desired vision

From the common vision, the community identified key resources which need to be in place to achieve the common vision and these include human resources, infrastructure and natural environment stability, as well as socio-political stability. In related studies, *e.g.* RAN's vulnerability assessment report, Chitakira *et al*. (2012) and Mavedzenge *et al*. (2008), the resource identified as critical to achieve a sustainable and/or desired livestock system in rural areas is infrastructure. The major concerns raised in the community visioning exercises are listed in Table 5.14.

Table 5.14: Major community concerns identified during community visioning

Concern		Possible Solution
Livestock sustainability	Poor returns from markets, livestock theft	New marketing approaches
	Limited market options (few buyers)	
	Inadequate pastures & effects of drought	Government subsidies
General Infrastructure	Poor roads, no health facilities (hospitals), few water sources	Comprehensive infrastructure development by government and non-state actors
	No electricity, poor mobile network connectivity	
Sickness, HIV/AIDS	Disabled community members – food insecure	Food aid/cash transfer programs
	High HIV/AIDS burden	Education, health facilities
	Outside invaders competing for natural resources	Regulations (by-laws), constitution

Source: Transcribed from community visioning workshop notes (see Appendix G)

As demonstrated earlier in the study, achieving a sustainable and/or desired livestock system within the study area may be hindered if the inter-connectedness of problems facing the

community is not fully comprehended. From engagement with the community, it was noted that other common problems encountered in the community include lack of health facilities, lack of electricity, poor roads, poor networks, theft and general poverty. These various challenges also contribute to the fragility of the livestock system directly and indirectly. For instance, poor roads contribute to the lack of transport for ferrying livestock to the markets and contribute towards higher transport costs reducing the profits realised by smallholder farmers. Also, in terms of the lack of health facilities, sick people are not able to be productive, and it is costly for them to access the health service. As a result, smallholder farmers are forced to sell livestock for very low prices to pay for health services. Overall, this study argues that in order to achieve a sustainable and desired livestock system within the study area, key transformations within the infrastructure dimensions are critical. These study findings were similar to findings by Chitakira *et al*. (2012) who also identified infrastructure to be at the centre of the achievement of a community's desired future. However, the specific infrastructure suggested from the engagement refers to traditional infrastructure such as roads, water sources and electricity. For many years, efforts were directed towards improving such infrastructure (Thimm, 1993) but with technologies increasingly becoming relevant in nearly all aspects of life (Arts *et al*., 2015), it is also essential to explore the digital infrastructure dimension. Evidence from the study (see Appendix G) show that now, digital infrastructure transformation is among the least desired changes and only those with a certain level of education showed appreciation of technologies in achieving the desired livestock system.

5.6 CHAPTER SUMMARY

This chapter, using empirical evidence from the study area, obtained using mixed methods, has provided a detailed description of the study area. The chapter outlined an overview of the demographics of the study area, the household coping strategies and an assessment of the household food security status. The chapter demonstrated that the socio-economic attributes of the community such as lack of diversity of income generating options coupled with limited crop production in the study area contributed to food insecurity among the households in the study area. This chapter also examined livestock contributions to household food security and the study area's livestock system sustainability. The chapter has shown that livestock play many roles towards household food security; for instance, through income generation as well as being sources of nutritious food. However, the type of livestock (*e.g.* goats, sheep, cattle, chickens or donkeys)

determined the use of such livestock; with large livestock being used as status symbols and a store of wealth resulting in sparse consumption. Small stock such as goats are frequently consumed. On the sustainability aspect, an analysis of the livestock system using the SES framework demonstrated that most attributes of the livestock system were weak, and this contributed to the fragility of the livestock system. There is a major discrepancy between the prevailing livestock system and the desired livestock system; one fundamental transformation needed to achieve a sustainable and desired livestock system is infrastructure transformation. Given the foregoing, there are efforts by multiple actors, both governmental and non-governmental, aimed at addressing the challenges which are contributing to the fragility of the livestock system in the study area. These interventions include transformation of the digital infrastructure through projects such as MOSMAC. However, the contributions of such interventions towards the sustainable and desired livestock systems need to be examined. Therefore, in the next chapter, the study shifts to closely examine the state of infrastructure in the study area and demonstrate how this may be contributing to the fragility of the livestock system and other livelihood options. Following this, the next chapter then turns to present details on donor-led interventions being implemented in the study area specifically focusing on the complexities which context may present in implementing such interventions.

CHAPTER SIX: INFRASTRUCTURE TRANSFORMATION IN BEITBRIDGE[40]

Chapter overview

Chapter Five has provided a thick description of the study area through the SES lens. The empirical evidence presented in the chapter showed that in Beitbridge, the average household holds large numbers of livestock, and the different livestock species owned by the households play many roles towards household well-being, including household food security. However, further characterisation revealed that the livestock system in the study area is fragile, which emanates from the current state of the attributes of the livestock system and key among these: a shortage of actors (specifically buyers), limited human constructed facilities (infrastructure), the unpredictability of the system dynamics and poor governance systems. The fragility of the livestock system impacts the livelihood of the livestock-dependent community, specifically on a household's income as well as household food security. However, even though current livestock systems are fragile, the livestock smallholder farmers in the study area also have a specific desired livestock system. The conclusions drawn from Chapter Five suggest the need to improve infrastructure in the study area, as this has been identified as one of the major underlying causes of the livestock system fragility. However, as most governments in developing countries are resource-constrained, infrastructure development interventions such as the MOSMAC project are mainly donor-led. While this has become a common trend, the political nature of infrastructure means that the processes of infrastructure development can be complex. For instance, Zimbabwe's current largest telecoms company, Econet, endured a decade-long battle with the Zimbabwean government to successfully secure an operating licence. This chapter presents the implementation of the MOSMAC intervention in Beitbridge, describing the steps taken with the aim to depict how the Zimbabwean "context" impacts the establishment of ICT for Development (ICT4D) initiatives. With this understanding, the development and transferability of ICT4D initiatives such as local community networks (CNs) can be accelerated. In theory, the chapter seeks to link the livestock SES to ICT4D by engaging in critical reflexivity. In practice, this chapter is a "preparatory guide"

[40] This chapter is based on the papers: **Gwaka, L.T**. 2017. Digital technologies and sustainable livestock systems in rural communities, *Electronic Journal of Information Systems in Developing Countries*, 81, 6, 1-24 and **Gwaka L**, May J, Tucker W. Towards low-cost community networks in rural communities: The impact of context using the case study of Beitbridge, Zimbabwe. *E J Info Sys Dev Countries*. 2018; e12029. https://doi.org/10.1002/isd2.12029.

for the development of low-cost CNs in rural areas such as Beitbridge. The rest of the chapter is structured as follows. Before presenting and describing the intervention (community information centre and community network), the chapter provides an extended overview of the state of ICT in the study area in Section 6.1. The section explores the state of digital infrastructure in the study area focusing on connectivity, ICT access and household expenditure on ICTs. In section 6.2, the study then explores the MOSMAC intervention focusing on the selection of the intervention, community engagement and the community contributions towards the intervention implementation. The section aims to outline the dynamics which occur during the implementation of an ICT intervention within a community and the complex caveats which need to be observed and/or overcome (cf. Krauss, 2010; 2012). The third section of the chapter, section 6.3, then describes the intervention (Community information centre) after its establishment. This is followed by a summary in section 6.4.

6.1 THE STATE OF DIGITAL INFRASTRUCTURE IN BEITBRIDGE

A brief description of the state of infrastructure in Beitbridge has been provided in Chapter 2 under Section 2.3.3. In that discussion, it was highlighted that the study area is characterised by infrastructure deficits. In the same vein, the empirical evidence presented in Chapter 5 indicated that improving digital infrastructure (telecommunication base stations and ICT centre) is among the preconditions for achieving the desired as well as sustainable livestock systems in the study area. Calls for infrastructure transformation, specifically within livestock systems, also emerge from the literature presented in Chapter Three which also suggested that many rural areas are characterised by poor digital infrastructure (see, Mavedzenge *et al*., 2008). From a theoretical perspective, Kleine's (2010; 2013) Choice Framework argues that access to ICTs (part of structure) and information resources (agency) are part of the preconditions for the existence of dimensions of choice. On the other hand, technology affordances theory can only be applicable if the community has access to ICTs (with affordances) and in the SES framework, technologies form part of the socio-ecological system's attributes. Therefore, understanding the state of digital infrastructure in the study area is critical. To this end, this section presents the state of digital infrastructure in the study area focusing on connectivity, ICT ownership, ICT access, household expenditure on ICTs and the perceptions of individuals on the costs of using ICTs within the study area.

6.1.1 Connectivity in Beitbridge

Most developing countries including Zimbabwe lag in technological advances and most innovations in rural communities are delivered through mobile phones which have a high penetration rate. Therefore, when studies (*e.g.* Van Stam, 2012; Rey-Moreno, 2015; Gwaka, 2017; Foster *et al*., 2018) argue that rural communities lack appropriate infrastructure, mobile connectivity is a major focus. In Zimbabwe, mobile network base stations in urban communities outnumber those in rural communities despite official statistics showing that the latter account for 67% of the national population. As depicted in Table 6.1, in the context of digital infrastructure, urban communities have *more of everything* including fixed telephone, LTE base stations, 3G base stations and even 2G base stations.

Table 6.1: Base stations distribution between rural and urban areas in Zimbabwe

	Rural		Urban		Total
Population	-	67%	-	33%	-
2G Base stations	1 690	36%	3 045	64%	4 735
3G Base stations	648	28%	1 627	72%	2 275
LTE	4	1%	754	99%	758
Fixed Telephone	10 499	3%	295 221	97%	305 720

Source: POTRAZ (2015)

Zimbabwe has three major mobile service providers: Econet, Telecel and NetOne, with Econet having the largest market share. However, the study area is uniquely positioned at the border of Zimbabwe and South Africa, and the proximity to South Africa allows households in the study area to access South African networks. When respondents were asked about the network(s) they use, results show that 59% of the respondents use Econet (Zimbabwean network) and up to 39% of the respondents use at least one of the South African networks. Telecel and NetOne networks have the least number of users, with 2% and 1% of the respondents, respectively. Despite the existence of several mobile networks, Figure 6.1 shows that during the community resource mapping, participants indicated that the study area does not have a network base station within its boundaries and relies on network base stations located outside the community. The closest network base station is located approximately 25 km away at Lutumba business centre. This finding corroborates with the statistics presented in Table 6.1 on the lack of adequate base stations in rural communities.

Figure 6.1: Community mapping of digital infrastructure

In addition to the findings on availability of network base stations, the distribution of mobile network subscriptions according to villages (geographic location) was further explored.

Table 6.2: Mobile network subscription per village

Location			Mobile Network				(n=195)
			NetOne	Econet	Telecel	South African	
Village	Dumba	n	0	8	1	53	62
		%	0%	13%	2%	**85%**	100%
	Mapayi	n	1	26	1	8	36
		%	3%	**72%**	3%	22%	100%
	Old Nuli	n	1	49	1	2	53
		%	2%	**93%**	2%	3%	100%
	Shabwe	n	0	31	0	13	44
		%	0%	**70%**	0%	30%	100%
Total		n	2	114	3	76	195
		%	1%	58%	2%	39%	100%

Chi-square test = 93.220; df = 9; p < 0.001

The Pearson chi-square test showed a significant difference ($p < 0.001$) between the village of respondent and the network used. Findings presented in Table 6.2 show that 85% of households in Dumba, a village located closest to the Limpopo River, use South African network(s) while respondents in the three other villages rely mostly on Zimbabwean mobile networks.[41] This, according to the Choice Framework, is a geographic resource (agency) which means, due to the geographic location, the inhabitants of Dumba have the choice to use either the Zimbabwean

[41] The table has many empty cells, and cells with less than 5 cases. This has implications for the reliability of the chi square statistics. However, the findings demonstrate that the subscription to a network was influenced by the geographic location of the household.

network or the South African networks, an extended freedom. However, the study found that it is a common practice within the study area for individuals to use multiple networks as each network has its advantages and disadvantages. This practise is also accompanied by the availability of new multi-SIM mobile phone handsets. With the villages using different mobile networks, the study further asked respondents how they perceived network reliability among the different service providers. Despite the significant difference between the village and the network used, the study findings, as indicated in Table 6.3, found that there was general dissatisfaction with regards to network reliability across all the villages

Table 6.3: User perception on mobile network

			Perception on mobile Network Reliability			
			Extremely Reliable	Average	Extremely unreliable	Total
Village	Dumba	Count	23	37	13	73
		%	32%	51%	17%	100%
	Mapayi	Count	17	17	4	38
		%	45%	45%	10%	100%
	Old Nuli	Count	21	31	3	55
		%	38%	56%	6%	100%
	Shabwe	Count	16	27	5	48
		%	33%	56%	11%	100%
Total		Count	77	112	25	214
		%	36%	52%	12%	100%

Chi-square = 6.432; df = 6; p = 0.381

Study findings show that there was no significant difference (p = 0.381) between network reliability and the village of the respondent, suggesting that the source of service does not affect the quality of the service. In all four villages, less than 50% of the total respondents selected "extremely reliable". Further corroborative evidence was obtained from the focus group discussions with one of the community members arguing that:

> *Networks are poor but those staying closer to the booster have better reception. The networks get bad as you go far further away from the base stations to an extent that the majority of those staying close to the Limpopo River make use of the South African networks.*[42]

[42] Focus Group Discussion, young female, Shabwe village

With these comments, the study further explored whether proximity to the base station improved a respondent's perception on network reliability. The study findings depicted in Table 6.4 show that there is no significant difference (p=0.106) between infrastructure visibility and satisfaction.

Table 6.4: Digital infrastructure satisfaction

			How satisfied are you with ICTs			Total n=211
			Extremely satisfied	Average	Extremely unsatisfied	
Are there visible network infrastructures?	Yes	Count	19	24	2	45
		%	42%	53%	5%	100.0%
	No	Count	50	92	24	166
		%	30%	55%	15%	100.0%

Chi-square = 4.494, df = 2, p = 0.106. Average represents the undecided respondents.

6.1.2 ICT access, ownership and use in Beitbridge

In line with first presenting context (the SES), and then discussing human engagement with ICT within this context, ICT access and ownership (quantitative findings) have been presented in section 5.1.3 in the preceding chapter. The findings already presented indicate that mobile phones are the most accessible form of ICTs in rural communities. Following this, the study further explored gender dynamics relating to ICT ownership and access; and from the discussions with the respondents, it emerged that ICT ownership and access among women has significantly improved. Women themselves acknowledged this transformation as one female respondent suggested that:

> *In our village, most women have mobile phones. Very few still don't have but they can share with their friends. Mobile phones are essential for our projects and for those with smartphones; we even have a WhatsApp group. The most exciting thing is that women are teaching each other how to operate the phones and don't have to rely on men anymore.*[43]

However, some male household heads maintain reservations over women's ownership of and access to ICTs, specifically the mobile phone. There are deeply entrenched social concerns such as fidelity issues which men still believe can be driven by ownership of and access to mobile

[43] Female respondent, 30 years, FGD, Shabwe

phones. Also, men, who subsequently decide on whether a woman can buy a mobile phone, mainly control women's incomes. As one male respondent pointed out that:

> *Women's access to mobile phones has improved over time but when I was buying mobile phones for my children, the boys got their phones first before the girls since the boys are almost always away from home and girls will be at home.*[44]

In addition to this, the study findings also show that male youths are more likely to own and/or access a mobile phone (or other technologies) earlier than female youths. Therefore, even though there are notable improvements on women's ownership of and access to ICTs, gender inequalities on ICT access and ownership persist. To bridge the ICT gap in the country, government has embarked on project to promote ICT learning in schools and has donated computers to schools, as well as establish community information centres mainly in urban areas. The school programs are playing a key role towards bridging the gender inequality on ICT access. However, at the community information centres, it was observed that the majority of those using the facility are male youths, with fewer female youths using the facility. This observation reiterates inequalities on ICT access stemming from among many factors, societal beliefs and attitudes (cf. Hilbert, 2011). The poor access to internet in the study area is not unique to the area but is a characteristic of most rural communities. Accordingly, May (2012:40) suggests that these low access rates to the internet among the rural households, "*is indicative of a major constraint to the delivery of privately-owned internet access through conventional technologies common to most countries in Africa*". However, in all this, there are also efforts by government institutions and non-governmental organisations to address some of these challenges, as stated by one of the livestock technicians that:

> *The government is focusing on introducing ICTs in livestock systems with support from different organisations including Non-Governmental Organisation E.g. Catholic Relief Service (CRS). Technicians and other officers are already receiving training on using ICTs to perform their duties. However, there is a huge gap between modern technologies and what farmers have or can access.*[45]

Therefore, from the study findings, it was established that in the study area ICT access among households varies but access to mobile phones is high. Despite the considerable ownership of and

[44] Male respondent, 44 years old, Old Nuli
[45] Key informant interview, livestock technician, Dumba village

access to mobile phones, as well as the use of these mobile phones, the mobile networks (connectivity) are poor in the study area. Furthermore, there is need to improve access to other technologies such as computers and internet access among the households. The study now turns to explore the use of the technologies to which the communities have access. Respondents were asked whether they had used any ICT (mobile phone, radio, television, and computer) to perform selected tasks such as sending or receiving news, as well as agriculture information. From the findings presented in Table 6.5, 63% of the respondents had used at least one of the listed ICTs to send or receive general news, but only 14% and 12% had used at least one of the listed ICTs to send or receive agriculture information or livestock health information, respectively. A chi-square test ($p = 0.001$) show that there is a significant difference between ICTs use and gender in the study area.

Table 6.5: ICT use in community

Activity		Male	Female	Total Responses (n=224)	
Receive or send general news	N	78	62	140	63%
	%	56%	44%	100%	
Receive or send agriculture Information	N	8	23	31	14%
	%	26%	74%	100%	
Receive or send education information	N	9	20	29	13%
	%	31%	69%	100%	
Receive or send livestock health information	N	8	19	27	12%
	%	30%	70%	100%	

The findings reveal that the use of ICTs for and in livestock remains extremely poor within the study area. From the study, it was established that most farmers involved in livestock production are elderly males with limited education and this contributed towards the limited use of technology within the livestock system. In addition, there were other reasons cited by the respondents for not using technologies to seek or share information; and these include the lack of facilities to help communities gain access to technologies, costs associated with the use of technologies and the lack of ICT skills among the respondents. In this context, respondents were further asked if they can operate the mobile phones with no help. The findings show that 63% of the respondents can

operate a mobile phone with no help and less than 1% can use a computer with no help. Among the elderly community members, mobile phones were supplied (bought) by their children, mostly working and staying away, *e.g.* in South Africa. Thus, the most common use of the mobile phones among the respondents is to receive calls, with minimum calls being placed. Furthermore, the elderly who lack skills to operate the mobile phones rely on the young household members such as grandchildren to help them operate the mobile phones.

6.1.3 Household expenditure on ICT

Despite the affordances of DTs, mobile phones specifically, the cost element remains a concern for most current and potential users in rural communities. ICT developers are scrambling to capture poor communities as a lucrative market for ICT products (Kuriyan *et al*., 2012). Rey-Moreno (2015) suggests that in developing countries, households often sacrifice basic needs to purchase airtime recharge. Recent International Telecommunication Union (ITU) reports show that in Africa, Zimbabwe remains one of the countries with more expensive mobile services rates. Also, in a recent official report, POTRAZ reported the Average Revenue per User (ARPU) in Zimbabwe across the three networks is are above the daily average household income in rural communities such as Beitbridge. Results presented in Table 6.6 show that ARPU of Econet, the leading mobile service provider, is approximately three times the Beitbridge household daily average income of US$2 per day. Furthermore, mobile service price hikes are common in Zimbabwe, particularly in response to currency changes (Shezi, 2016).

Table 6.6: Monthly average revenue per user in Zimbabwe

	January	February	March
Econet	$5.88	$6.19	$5.88
Telecel	$3.60	$3.24	$3.32
NetOne	$2.22	$2.13	$2.23

Source: POTRAZ (2016)

Apart from the findings obtained from POTRAZ official reports, respondents were asked about their perception of the cost of using mobile phones. The study findings show that both groups, women and men, perceived the cost of using mobile phones to be high. Subsequently, the Pearson Chi-Square in Table 6.7 show that there was no significant difference ($p = 0.398$) between gender

of the respondent and the user perception on the cost of using mobile phone. Thus, most of the respondents, regardless of the gender group, considered the cost of using mobile phones to be high.

Table 6.7: User perception on cost of using mobile based on income groups

		Gender		Total
		Male	Female	
Perception on cost of using mobile	Low	18	54	72
	%	25%	75%	100%
	High	26	101	127
	%	20%	80%	100%
	N/A	3	22	25
		12%	88%	100%
Total		47	177	224

The study then explored whether respondents' recharge amounts were related to the household average monthly income. Study results in Table 6.8 show that there was no significant difference (p=0.739) between the average recharge amounts and the household monthly income. Thus, regardless of the household income, the average recharge patterns in the study area are similar. Further analysis based on household head also revealed no significant difference on the average recharge amounts

Table 6.8: Average recharge amount based on household average income

			Weekly recharge amount		
			< US$5	US$5 - US$10	(n=213)
Household average monthly Income	0 – 300	N	176	13	189
		%	93%	7%	100%
	301 - 500	N	16	1	17
		%	94%	6%	100%
	501+	Count	6	1	7
		%	86%	14%	100%
Total		N	198	15	213
		%	93%	7%	100%

Chi-square = 4.604[a], df = 2, p = 0.739:

Most respondents in the different income groups show that their average recharge is US$1 per day. The expenditure is further exacerbated by the need to buy recharge for different mobile networks. Across the different networks, most respondents recharge less than US$5 per week. However, respondents using the South African networks were more likely to recharge more than US$5 per week compared to the respondents using other networks. In the same vein, the study further found that in the study area, resellers sell South African airtime vouchers at an excessive profit, *e.g.* to buy airtime voucher for US$ 1 (approximately 14 ZAR), one must pay ZAR 22. Incredibly, the need to communicate pressurises rural households to allocate an excessive percentage of income to purchase recharge vouchers (for voice, data and SMS). For instance, during the research period, households were selling unshelled baobab fruits harvest at $0.12/kg; thus, for a sack, they received approximately $3. On average, an individual sold 5 sacks, and thus obtained just below $20. Of this, an individual would buy a recharge voucher of $1, representing 5% of income. The top-up would allow one to make a call for less than 5 minutes or buy a WhatsApp bundle for a week. The current pricing models for most telecommunication service providers (see for example, Table 6.9) are considered expensive by most community members in rural communities. From the community workshops respondents indicated that:

> *We enjoy using mobile phones, but the airtime costs are excessive, and we must make sacrifices to be able to recharge. Our children working in South Africa and other towns here in Zimbabwe send us airtime and this helps us a lot.*[46]

Against this background, it is evident that the cost of using mobile phones, the most common form of technology accessible in the rural communities, remains exorbitant for the rural households (Gambanga, 2016).

Table 6.9: Estimated mobile tariffs in Zimbabwe[47]

Function	Pre-Adjustment 2009-2017	Post-Adjustment
SMS	US$0.9 per SMS	US$0.5/ per SMS

[46] Elderly female, community meeting, Shabwe.

[47] Retrieved June 19, 2018 from: https://www.econet.co.zw/promotions/data-portfolio-terms-conditions/ and https://www.techzim.co.zw/2014/10/econet-telecel-netone-ordered-by-potraz-to-slash-mobile-voice-tariffs/ However, as of 21 June 2018 a further reduction of the mobile tariffs was announced reaching US$0.05/MB from US$0.125/MB. See https://www.fin24.com/Companies/ICT/zimbabwe-slashes-mobile-data-costs-significantly-as-election-nears-20180620

Voice	US$0.23/minute	US$0.15/minute
Data	US$10 - 650MB +650MB Wi-Fi	

6.2 THE MOSMAC INTERVENTION

Having described the state of digital infrastructure in the study area, this section presents my intervention implemented in the area, the MOSMAC project, which was funded through a grant support from the USAID through the ResilientAfrica Network. Following the description of the intervention implementation process, the study further investigates the impact of ICT4D on the livestock SES. As an action-oriented study, the project focused on improving the community's digital infrastructure through establishing a community information centre as well as exploring the potential to establish a community network. This section of the study is premised on the basis that while the intervention outcomes and impacts are critical, it is also imperative to understand the processes of implementing interventions which are not only technical in nature, but socio-political. Understanding these processes is critical in the planning processes for future interventions or replication of successful ones (Gwaka *et al*., 2018).

6.2.1 Intervention selection

In the past decade, rural communities in developing countries have been inundated with ICT projects like the MOSMAC project to overcome the various challenges facing these communities. However, despite the huge investments in these interventions, many of these have failed, with no significant outcomes being achieved in most rural communities.[48] To this end, studies such as Dodson *et al*. (2012) have focused on questioning the ICT interventions in rural communities. Reflecting on the ICT intervention failures, Dodson *et al*. (2012:19) indicate that, "[c]areful consideration of development objectives, perspective, and focus is essential in all phases of an ICTD project, from design through deployment." Therefore, based on these remarks, it is critical to reflect on the MOSMAC intervention selection as often, the *selection of interventions* in rural areas has been a subject of debate with many arguing that most interventions fail at the intervention selection level. In selecting interventions, many studies such as McCarthy (2014) advocate the use of bottom-up approaches in which communities participate in the identification of problems and the subsequent selection of interventions. As Dodson *et al*. (2012:29) show, "top-down,

[48] The term outcomes is used to refer to the human development outcomes (health, food security, education); thus, the circumstances of the communities and not the establishment of specific artefacts (*e.g.* a telecentre/community lab).

technology-centric, goal-diffuse approaches to ICTD contribute to unsatisfactory development results."

The MOSMAC intervention emerged from a response to a call for proposals issued by the ResilientAfrica Network.[49] Accordingly, RAN had conducted a preliminary survey in the study area on the problems facing the Beitbridge community (Chingarande & Ayo-Yusuf, 2016).[50] From the preliminary survey, RAN then developed different pathways of interventions based on context; *e.g.* the preliminary survey established that many households in Beitbridge owned large numbers of livestock and yet the majority of these households (with large numbers of livestock) were living in extreme poverty conditions. RAN then challenged innovators to develop projects which could help the livestock farmers improve their circumstances, as depicted in Figure 6.2.

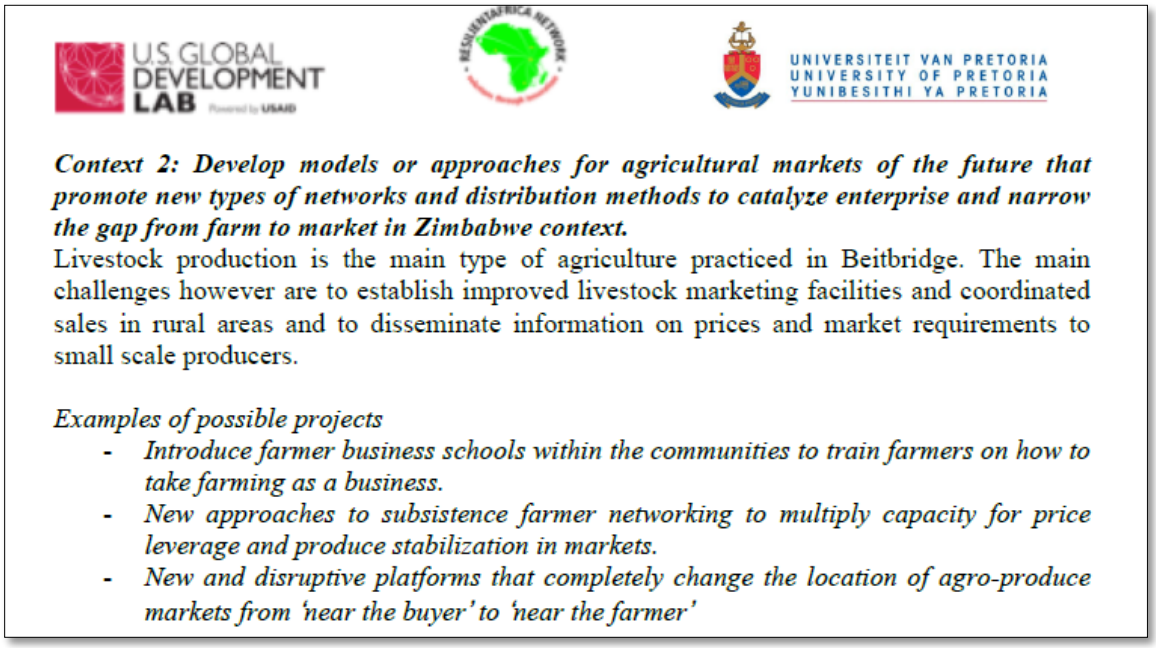


Figure 6.2: The donor-suggested projects from which MOSMAC was developed
Source: RAN (2014)

In soliciting responses to the call for proposals, RAN indicated that:

> *Our two-pronged approach to sourcing innovations allows us to draw upon expert judgment on intervention priorities but at the same time allowing us to tap into the enormous innovation potential of independent innovators (including those from target*

[49]RAN SA RILab Grants Call RIC4FIG is Now Open. Retrieved October, 4 2018 from: http://www.ngopulse.org/opportunity/ran-sa-rilab-grants-call-ric4fig-now-open
[50] https://www.ranlab.org/wp-content/uploads/2013/11/Zimbabwe-Report.pdf

communities), better positioning RAN for resilience impact. This call is seeking innovative solutions to resilience challenges that have been identified and developed using the DTCC process (RAN, 2014: np).

While based on the preliminary survey, the original idea of the MOSMAC intervention was conceptualised by innovators and not the community. The innovators then further engaged the community in a needs-findings process but the potential interventions had already been submitted to the funder based on the context given in the preliminary report and not intimate knowledge about the community. Nonetheless, the intervention selection approach omitted innovators from the community, as the implementers of the project came from outside the community, as has happened elsewhere (Mutsvangwa-Sammie *et al.*, 2017:325). The intervention selected for the community was aligned to the on-going regional and national development activities. At the time of selection of the MOSMAC intervention, there were on-going efforts across Zimbabwe to establish information centres by converting existing post offices. Apart from this, the MOSMAC intervention was influenced by the success of community projects implemented in South Africa, Zambia and Zimbabwe. In South Africa, the Zenzeleni project had successfully connected a rural area, so had Macha Works in Zambia, as well as Murambinda Works in Zimbabwe.

6.2.2 Negotiating community entry

In Chapter Four, the community entry process was briefly discussed as part of the research methodology. In rural communities, there are several community gatekeepers including local authorities (government-defined) and traditional leadership, as well as other undefined structures which need to be negotiated. In the context of this study, negotiations were conducted at various levels but mainly followed the structure of rural governance, as presented in Table 6.10.

Table 6.10: The tripartite structure of rural governance in Zimbabwe

Admin Level	Traditional	Local Government	Central Government
District	Chief	Council	District Administrator
Ward	Headman	Councillor	n/a
Village	Village Head	n/a	n/a

Table 6.10 indicates that in rural areas such as Beitbridge, different governing systems co-exist; that is, traditional governance, local government and central government all operate concurrently. These are also represented at different levels: district, ward and village. Therefore, for an ICT

intervention to be implemented, community entry negotiations must be done at all different levels. In this section, the study reflects on the engagements of the main community gatekeepers, namely *local authorities and traditional leaders,* as well as the community at large during the process of implementing the intervention.

- **Meeting with the local authorities and related departments**

There are various structures of governance in rural communities in Zimbabwe, and Mutandi (1999) describes the hierarchy of the governance structures. In the context of rural communities, the local government authorities are the rural districts while the district administrator represent the central government. There are also government departments at district level, and these include: Agritex, Ministry of ICTs, Home Affairs (Police), Ministry of Women Affairs and DLPD. In Zimbabwe, districts are administrative areas under the governance of local rural district councils as well as local district administrator. In November 2015, together with the donor representatives, introductory meetings were held with the District Administrator and the council's Chief Executive Officer. During these meetings, I presented the details of the proposed project with a specific focus on the background to this project and the proposed activities. While the District Administrator and the Chief Executive Officer are charged with overall oversight of the district, there are also specific government departments within the district which are responsible for specific areas, *e.g.* the DLPD was the department responsible for livestock related matters. It emerged during the process that there are some departments which were compulsory to engage, while others were optional, as presented in Table 6.11. Therefore, in addition to engaging the administrative local authorities, I also engaged the various departments to explore the different ways of collaborating or working together during and after the implementation of the MOSMAC intervention.

Table 6.11: Community entry meetings with key stakeholders

Stakeholder	Purpose	Compulsory or Optional	Engagement
Ministry of ICT	Technical partner	Compulsory	Meeting and email
Other NGOs operating in Beitbridge *e.g.* Catholic Relief Services[51]	Potential leverages	Optional	Emails, formal and informal discussions, meetings
District Administrator	Local authority	Compulsory	Meeting; email; in-depth interview
Chief Executive Officer	Local authority	Compulsory	Meeting; email; in-depth interview
District Police Officer	Security clearance	Compulsory	Meeting
Ministry of State Security	Security clearance	Compulsory	Project activities
Primary schools	Integrated ICT Learning	Optional	Formal and informal discussion
Ministry of Education	Clearance for use of school facilities	Compulsory	Meeting
Department of Livestock	Livestock specialist	Compulsory	In-depth interviews; meetings, e-mail
Forestry commission	Potential leverages	Optional	Informal discussion

Following all the engagements with the relevant departments, a formal memorandum of understanding between the local authorities and MOSMAC was signed (see Appendix G). At the signing of the MOU, the then-acting Chief Executive Officer remarked:

> *We are fortunate that we have yet another program coming to our district to work with us and the communities. This project will indeed support our on-going efforts to introduce technology in our operations as a district. You will see that we also have a small budget allocation for ICT development in the district and maybe there will be overlaps and we need to capitalise on these.*[52]

However, during the engagement of the local authorities and other relevant departments, it was evident that the process of bringing interventions, mainly donor-funded interventions, to rural communities involve extensive bureaucratic processes. For instance, the local authorities conducted extensive scrutiny of the project specifically to understand if there were any political

[51] CRS Facilitating e-learning for extension workers' in Beitbridge
[52] Meeting, Acting Chief Executive Officer, Beitbridge RDC

linkages to the MOSMAC project. Furthermore, during the various meetings, there was a recurrent theme of ensuring that traditional leaders were respected and involved at all the stages of the intervention implementation, as the District Administrator suggested:

> *The success of your project depends extremely on how you will engage with the community leaders. The people in the area respect these leaders and respond to the calls made by the leadership, so make sure you develop good relations with them.*[53]

Apart from these observations, the local authorities and other related departments, however, concurred that the MOSMAC intervention, while ambitious in the context of the study area[54], was timely and would complement other on-going development efforts in the area. For instance, at the time of the project, the district, through the Ministry of ICTs, had received equipment to establish an information sharing platform but there were several challenges which had led to delay of this initiative. The government had also established a community information centre; thus, the District Information Officer indicated that:

> *This is a timely project. We surely need to find a synergy between what you intend to do and what we are currently working on.*[55]

For the duration of the project, there were several engagements, interactions and follow up meetings with local authorities and relevant departments. Furthermore, the local authorities and relevant departments also conducted regular visits to the site were the project was being implemented. While support was received from the local authorities, the bureaucratic processes often strained the efforts, and in some cases, resources, which could be directed towards project implementation (also observed in Vedantham, 1990:7). However, it would have not been possible to undertake the project activities without their clearance and guidance. Apart from the administrative (and technical) authorities, the community entry process also involved engaging the traditional authorities.

[53] Assistant District Administrator, Formal Meeting, Beitbridge District
[54] The MOSMAC project was different from the usual aid interventions and there was pessimism on its success since the government initiative to bring ICT in rural areas had also not achieved the success hoped for.
[55] District Information Officer, formal meeting, Beitbridge District

- **Meeting the traditional leaders**

Following the meetings with local authorities, the councillor introduced me to the community traditional leaders. In the study area, the traditional leadership comprises of a headman, senior village heads, village heads and the village development committee. Meetings with the traditional leaders required observation of cultural practices; thus, a female researcher who was part of the research team had to observe community cultural practices, *e.g. she was not able to sit on the chair and had to sit on the floor* during the meetings with the traditional leaders. However, since she was part of the project implementation team, there was some flexibility.

As Krauss (2012) shows, meetings with traditional leaders during implementation of ICT interventions in rural communities are critical for several reasons. Firstly, within the community, any project which comes need to be authorized by the traditional leaders; thus, we engaged the traditional leaders as part of the protocol. Secondly, apart from securing permission to engage the community members, it is generally believed that interventions within the community need to receive benedictions from the community traditional leaders; thus, by engaging the community leaders, the MOSMAC project was receiving blessings. Thirdly, and perhaps most importantly, the meetings provided an opportunity to understand the community from the leaders' perspectives. During these meetings, issues discussed included community livelihoods, challenges within the community and on-going programs (interventions), as well as community cultural practices which are critical to observe when engaging with the community. During these meetings, I observed several trends such as power dynamics among the community leaders, and some of these included arguments on where the intervention would be located. The village head for Dumba was particularly vocal suggesting that:

> *All the projects always come and provide or locate here at Old Nuli but for us in other villages we are just consulted and left with nothing, why then do you even bother consulting us? I hope this time this intervention will be located in my village; we are always overlooked because we are far from everyone. So please, consider that*.[56]

In a speculative manner, the Headman voiced that:

[56]Dumba village head, formal meeting with local leaders, Old Nuli Primary

I am optimistic that this project will have major impact on our communities and our children will grow up with technology skills and knowledge just like others in the more developed places.[57]

The reception of the MOSMAC project by the traditional leaders was helped by the fact that the project had received clearance from the local authorities. The meeting with traditional leaders was a major step towards securing clearance to engage the wider community. Following the engagements with the community leaders, the project was then allowed to carry out the various activities which had been planned and presented. The next section describes the community engagement based on the needs-finding approach which was recommended by the funder.

6.2.3 Community engagement: a needs finding approach

The community engagements clearly demonstrated that among the communities, the establishment of the community information centre was not an immediate priority. Yet there was a sense of optimism on the potential of the intervention, especially among those who had knowledge on and interests in technology. Following the meetings with the local authorities and traditional leaders, which paved way for project activities in the study area, community mobilization was conducted with the assistance of traditional leaders. In line with the funder's requirements, the community engagement processes were conducted using a bottom-up approach (needs-finding approach) with the aim of avoiding the imposition of solutions to community problems. To develop skills on applying the needs-finding participatory process, the researcher, together with other funded innovators attended a workshop offered by the funding agent .[58]

Following the community mobilization exercises, community engagement activities were conducted in each of the four villages and at times, with the villages combined. In all the villages,

[57] Headman, formal meeting with local leaders, Old Nuli Primary

[58] In the initial RFP document, RAN had identified the main challenges and subsequently, suggested the nature of interventions (projects) which could help the community. However, during the first 6 months of the project, the project team was mandated to engage in needs-finding and yet, the initial intervention had been submitted to the funder at the application stage. While the initiative to establish community needs before deciding on the intervention is critical, it is often conducted poorly. I contest that once a preliminary solution is identified before engaging the community to establish their needs and context, it would be difficult to completely change the intervention even when evidence from the community suggest that the intervention may not work. My experience was that since we conducted needs-finding after submitting the preliminary intervention to the funder, community engagements were done with already pre-conceived outcomes. It would have been difficult for me to go back to the funder and suggest that the intervention was not the main priority of the community since by doing this, I would risk losing the funding.

the engagements were conducted at local schools, as this is the tradition in the study area due to lack of infrastructure. During the workshops, participants were given opportunities to identify the different challenges they are facing as a community and the potential solutions they would want to see implemented. The motivation to use participatory approaches was to ensure that the intervention was prompted by the needs of the community; even so this was not realistic since I (*as an innovator for a competitive grant*) had already developed a potential solution, that of a community information centre. In this context, the community, due to several donor programs, expected specific forms of assistance (*e.g.* food aid or cash) and during a community engagement in Dumba village, one participant questioned the project approach and asked:

> *Maybe I missed the point, I want to know exactly what you have brought for us because we are living in extreme poverty and all other programs have specific goods – what are you really offering us?*[59]

At this point, it was critical to manage community expectations as the intervention was structured in a way that implementation of pilot stage was subject to the success of the needs-finding stage. During this meeting, the project methodology was outlined, specifically showing that the project's focus was on empowering the communities to enable them to take part in identifying the potential solutions and solving the problems they are facing (participatory rural development strategies). However, due to several donor programs already existing in the study area, when the participants were asked for solutions to the various problems they faced, in all the four villages, most responses (see Annexure G) suggested immediate relief measures such as money (*e.g.* cash transfers), food aid, government support and repair of existing infrastructure. In all these responses, a few individuals mentioned the establishment of ICT facilities such as a community information centre or electrification. Even those who suggested the ICT related facilities identified these at the bottom of the list. During a discussion with one extension officer in Mapai, it emerged that the communities were open to specific type of assistance that directly impact their immediate needs. The extension worker argued that:

> *Our communities are poor, and they are more receptive to projects which address their immediate needs. It will take one who has a broader understanding to suggest solutions*

[59] Elderly male, community workshop, Dumba village

such as the projects which you are bringing. They have been government projects on ICT, but these failed.[60]

From the continued community engagements, it was evident that due to extreme poverty in the community, ICT projects only appealed to a few individuals who could benefit directly from these. For instance, in all four villages, teachers who participated at the workshops expressed enthusiasm about ICT-related intervention. Evidently, the findings suggest that community priorities are based on the everyday experiences (context); and thus, context impacts the process of digital infrastructure transformation. Following the evaluation of the needs-finding approach, the funder subsequently proposed to adopt *Collaborative Resilience Innovation Design (CRID)* and using this approach, the funder suggest that the *CRID approach involves teams of stakeholders working together to create innovation projects that address targeted pathways.* In reflecting on the needs-findings approach towards intervention implementation in rural communities, I argue that in attempting to avoid top-down criticism, intervention instigators are applying new techniques but some of these techniques continue to resemble a top-down approach. For instance, while ICT and related interventions were not the top priorities of the community, the MOSMAC intervention continued. During the needs-finding process, the project team probed for responses and often hoped that the community would suggest ICT. The eventual establishment of the MOSMAC intervention, a community information centre, remain attributed to community needs. Nonetheless, it is prudent to argue that the intervention was not the priority, and the resources could have been channelled to other activities which the community identified as top priorities.

6.2.4 Community contributions and intra-community power dynamics

Even though the study area is considered one of the poorest in Zimbabwe, development initiatives often require the community to contribute in certain ways. Even though donor funds were available to support the project, there were also restrictions on what the funds could be used for (based on donor restrictions). For instance, purchasing material for construction was disallowed; thus, the project team had to find alternative resources to leverage. Upon discussion of the restrictions and

[60] Extension worker, Focus Group Discussion, Mapai village

limitations, the community members indicated willingness to contribute to the construction (refurbishment) of an old room to be used for the project. One community leader suggested that:

> *As a community we are always prepared to contribute to projects that will benefit us in future because in the end, these projects belong to us. You see that classroom block; we only received some material and the rest were contributed by the community. Therefore, in this project, we will also mobilise resources from the community and help with what we can.*[61]

From the community engagement activities, one of the evident elements which would affect the project were the apparent interpersonal relationships and intra-community power dynamics (cf. McCarthy, 2014). Firstly, among the community leaders, specifically village heads, there were concerns on where the intervention would be situated. Given that the process adopted for the intervention required a prototype first before mass roll out, every community leader hoped that the information centre would be in their village, and even those in villages without electricity suggested that the facility could be solar-powered. Secondly, during the initial phases of the project, a project team had to be selected and there were tensions among the community members on who would be involved. However, in the first series of meetings, it became apparent that there are several individuals who are always involved in the community projects and these had to be considered. As McCarthy (2014) observed from other donor projects, the involvement of community members in donor projects is often associated with material benefits; thus, there are often power struggles among who gets involved in the projects.

As indicated earlier in the study, the study area consists of 4 villages; all without public access to ICTs. As such, to establish the community information centre, consultations with various stakeholders were conducted until a suitable location was identified and recommended by the community as a potential site for the setup of the information centre. The challenge however remained that the setup of the community information centre was based on the availability of infrastructure (*e.g.* a building) and not the location of the intended users. This finding supported the claims that infrastructure attracts infrastructure.

[61] Shabwe village head, community visioning workshop,

6.3 MOSMAC COMMUNITY INFORMATION CENTRE

To bridge and address the ICT access gap in the study area, a community information centre was identified by the community as desirable in the community.[62] The selection of a community information centre intervention was based on several factors including the Zimbabwean government's efforts, through the Ministry of ICT, Postal and Courier Services, to establish community information centres to promote ICT access.[63] As shown in Figure 6.3, the MOSMAC intervention comprised a community information centre equipped with computers and internet access using satellite data access.

Figure 6.3: Information centre equipped with computers and internet access

In the context of study, the MOSMAC intervention was implemented as a potential solution to solving the fragility of local value chains, specifically the livestock system. In the characterisation of the livestock system, it was indicated that the livestock system actors had limited use of technology, as there were limited human constructed facilities to support the livestock system. Therefore, the MOSMAC intervention was premised on the potential of technology (connectedness) to overcome some of these challenges. Thus, when applying a socio-ecological systems lens, the MOSMAC intervention represented a transformation of the livestock system; with additional human constructed facilities and technologies. On the other hand, Kleine's Choice Framework would argue that the MOSMAC intervention is a transformation of the society's structure which would subsequently influence the dimensions of choice for livestock system actors.

[62] This remark considers the previous discussion on intervention selection and community engagement.
[63] See, Establishment of Community Information Centers (CICs). Retrieved June 25, 2018 from http://www.ictministry.gov.zw/?q=cics

For the community members to use and benefit from the facility, it was established that specific training had to be extended to the community. A basic manual on ICT4D was developed and after the establishment of the community information centre, community members started to receive training on the use of computers (Figure 6.4). Since the community information centre was positioned at a school, it is prudent to suggest that the local school incidentally became a major beneficiary as school children could use the community information centre to learn computer skills, which is a basic requirement of the revised education curriculum. Arguably, in some way, these children will in turn become future smallholder farmers; thus, the intervention is preparing a future generation of farmers to possess digital skills. Like MOSMAC, there are also other ICT initiatives focusing on empowering communities with digital skills in rural Zimbabwe (see for example, Bishi *et al*., 2016).

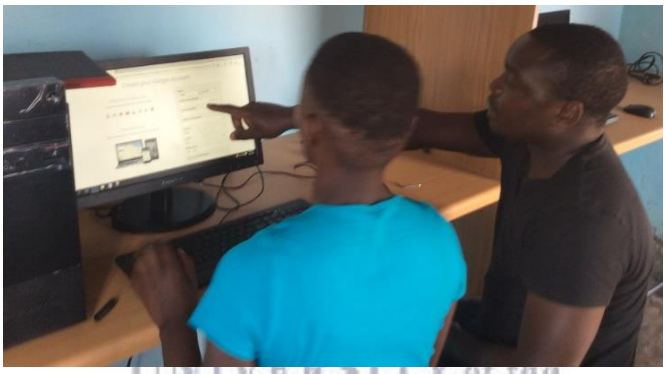


Figure 6.4: A female community member being trained to use email

However, interventions within rural areas are not without complications especially in complex contexts such as Zimbabwe. During the establishment of the community information centre, it was recognized that institutional dynamics, power dynamics and political manoeuvring influenced the processes of infrastructure transformation. This was a clear reflection of Star's (1999) argument that technological artefacts are political. Perhaps it could be argued that the timing of the MOSMAC intervention could have impacted community perceptions about the project since it was completed moving towards the presidential elections. Thus, in subsequent visits to the community, post-implementation, some community members suggested that there were rumours that the project had political connotations, and this had influenced the community attitude towards the facility. Unfortunately, this had also been the fate of other donor-funded projects within the community. However, from a sustainability perspective, the local community even suggested

contributing towards maintenance of the community information centre since the facility would benefit the entire community. While the community information centre helps the communities to overcome the ICT access challenge and skills development, the challenge of connectivity and costs also need to be addressed, and this could be achieved through low-cost community networks. However, another challenge surfaced upon the completion of the facility. At the beginning of the project, the community decided to locate the information centre facility at Old Nuli primary school. This decision was done on the premises that the school is central and secure compared to other potential places. However, upon completion, it was learnt that the Ministry of Primary and Secondary Education had strict rules on the access of schools by the public. In a meeting with the District school's inspector, he suggested that:

> *I think you have done a good thing and the community will surely benefit. However, you need to write a formal letter to the Provincial Education Director for clearance.*[64]

At this point, it was becoming evident that while the consultations with the relevant stakeholders were done, some provisions, rules and regulations were not properly outlined and discussed. Due to bureaucratic processes, the application for clearance was further delayed and the community started to perceive the project as only for the teachers. While the establishment of the community information centre is a milestone towards overcoming the digital gap, the study area identified access and costs as major challenges. The access challenge was addressed, partly, by the community information centre but the cost of connectivity was not fully addressed. This was mainly due to the timeframe of the funding cycle.

At the time of the MOSMAC intervention, the Zimbabwe's telecommunication regulatory framework was on the verge of countenancing the development of community networks, and for this reason, the MOSMAC project ambitiously explored the possibility of forming a cooperative which would drive the process of applying for a community network licence (Gwaka *et al*., 2018). The MOSMAC efforts were in line with the suggestion by Diniz *et al*. (2014:16) that, "users might modify not the technology, but the social, organizational, political, economic, cultural, or other context surrounding use." According to Rey-Moreno, community networks can provide a localised fix for a market failure in the telecommunication sector in many countries (Takavarasha *et al*., 2018). These community networks run on low-cost devices enabling communication at very

[64] Formal Meeting, District Schools Inspector, Beitbridge District

affordable prices (Rey-Moreno *et al.*, 2013). For example, using community networks, voice services can be offered at a fraction of incumbent mobile network prices and data can be offered 30-40 times more cheaply (Tucker, 2017). The MOSMAC intervention's further plan is to develop a local community network and efforts to do are already underway. For instance, discussions with POTRAZ officials have already been started (see also, Gwaka *et al*., 2018). Figure 6.5 shows my email exchange with a POTRAZ official on the processes leading to granting of licenses for establishing and operating a local community network. POTRAZ's willingness to engage in the community networks conversations was in itself a major achievement. Goodstein and Velamuri (2009) detail how often similar discussions are often blocked off with the state using power to dominate specific sectors.

Thank you for your kind email.
I am very excited to learn about this development. I have visited your website and it indicates calls for comments on the CLF (due Nov 2015).[65] *Kindly assist me, if possible, with a rough timeline on the progress of this process - perhaps if you know when approval is likely to be.*
Thanks once more for your response and looking forward to further engagements.

Response:

The purpose of the CLF consultative document was to get comments from the stakeholders. We have since held the first consultative workshop on CLF. We are now finalizing the draft CLF document to be presented in the second and final workshop in July. After the workshop, we present to the ministry for approval and then to the Attorney General for drafting into law. Once the process is concluded the CLF will be implemented. Our target is January 2017.

Figure 6.5: Email correspondence with a POTRAZ official

These national efforts to improve digital infrastructure are also being translated at provincial and district levels. During an interview with the Acting Chief Executive Officer of Beitbridge Rural District Council, BBRDC, it emerged that:

> *BBRDC is aware of the importance of ICTs and has therefore developed a strategy to use ICTs in their work. To date, the council is connected to the internet and it is waiting for the rest of the stakeholders to be online and to conduct transactions online. However, infrastructural development is a key challenge*.[66]

[65] Converged Licensing Framework
[66] Acting Chief Executive Officer of BBRDC, key informant interview, Beitbridge.

Further to these sentiments, the council has embedded within its strategic plan the concerns of connectivity and/or digital infrastructure. The local authorities are making efforts to improve 'coverage' and/or 'connectivity' of the individuals within the rural communities of Beitbridge. To this end, the council's strategic objective 7.4.5 reads, "*Increase coverage of cellular phone network and utilization of modern state-of-the-art communication devices by 2015*"[67]

6.4 CHAPTER SUMMARY

This chapter has presented the implementation of the MOSMAC intervention in Beitbridge. Particularly, the chapter set to provide empirical evidence towards the question: how does context impact interventions implementations? To provide an empirical background to the intervention, empirical findings on the state of digital infrastructure in the study area were presented showing that there was urgent need to address ICT access and connectivity. By presenting the intervention selection process, the chapter demonstrated that interventions remain driven by the top-down approach based on donor requirements. On the other hand, the chapter demonstrated bureaucratic processes which often delay the implementations of interventions in rural communities. It is inevitable that intervention implementation in marginalised communities will continue to be characterised by these concerns, but it is encouraging that communities are willing to contribute towards interventions meant to assist them. Considering the history of Zimbabwe and the background of the Econet battle, it is encouraging to also establish that the government is increasingly becoming accommodative in allowing projects such as MOSMAC to be established in rural communities (see for example, Vedantham's (1990) description of telecommunications in Zimbabwe in the early 1990s). The chapter demonstrated that policies in Zimbabwe are increasingly recognizing technological advances, creating an enabling environment for digital infrastructure transformation in rural areas. However, with the progress and promises of digital infrastructure transformation interventions such as MOSMAC, one main challenge remains: critically evaluating the impact of these interventions on the livelihoods of the communities.

[67] Beitbridge Rural District Council Strategic Plan. Retrieved from https://www.bbrdc.co.zw/downloads/downloads/

CHAPTER SEVEN: MOSMAC INTERVENTION IMPACT ASSESSMENT

> *The very purpose of interventions is to produce change and the mission of the systematic review is to find out whether they do so.* (Pawson, 2006:20)

Chapter overview

Digital infrastructure investments in marginalised communities such as Beitbridge through donor-funded interventions such as the MOSMAC project are likely to increase in the coming years. These interventions are premised on the perceived potential of digital technologies to contribute towards solving societal problems, including solving the fragility of critical value chains in rural areas, such as the livestock value chain. However, to date, there are mixed empirical findings on the impacts of such interventions on the overall development of poor societies.[68] In the same vein, there are on-going debates relating to the determination of impacts, including how impact is defined in different contexts, the timing of intervention impact assessment and the metrics used to measure impact. To this end, there has been an upsurge in studies calling for the application of non-conventional approaches towards impact assessment of such interventions. These calls are even more pertinent to donor-funded interventions which have inundated rural communities. Therefore, this chapter, using a critical reflexivity approach, presents an intervention impact assessment. The chapter explores whether the MOSMAC intervention implemented in the study area achieved, or is likely to achieve, the intended project outcomes. To do so, in section 7.1, the study focuses on detailing the funder's approach to the intervention impact assessment guided by the theory of change concept. Following this assessment, section 7.2 then applies a theoretical approach to impact assessment, leveraging Kleine's Choice Framework to examine the intervention's impact on the livestock system in the study area. Section 7.3 focuses on exploring the empirical findings on the intervention's impact based on responses obtained from various livestock system actors in the study area. Following the impact assessments using different approaches, section 7.4 then critically interrogates the intervention approaches to development focusing on processes, outcomes and impacts. In addition, the chapter identifies the unintended (both positive and negative) consequences of the intervention and develops explanations, linking

[68] Again, the term development must be considered from diverse perspectives.

the theoretical lenses guiding the study, on the trajectory of the intervention's impact. The evidence presented throughout this thesis suggest that there is need for interventions within livestock systems in low-income countries if these livestock systems are to continue playing critical roles towards household well-being, including contributions towards household food security. However, to date, debates continue on what interventions work or not (Lindahl *et al*., 2018). The confusion on this matter has resulted in several interventions, some of which are on-going; but there are increasing calls for evaluation of these interventions to establish whether they should be prioritized, scaled up and replicated or discontinued. To a great extent, this need prompted this study to explore, using critical reflexivity, whether digital infrastructure transformation in a rural community impacts the sustainability of a livestock system since Lindahl *et al*. (2018: np) suggest that, "many of these interventions are never able to show any impact or potential to be scaled out to benefit a substantial number of the population."

7.1 EXTERNAL IMPACT ASSESSMENT BY FUNDING AGENT

Interventions in communities are implemented with expectations that they will achieve specific predetermined goals for which they are implemented; and these predetermined targets are then used to determine whether the interventions can be considered a success or not. The extent to which a project is deemed successful, in the context of most donor-funded interventions, often determines the future funding of other interventions, replication and/or scale up of the successful interventions. In this case, since the outcomes (success or failure) of the intervention influence the future activities of a project or organisation, the impact assessment processes are vulnerable to manipulation, with evaluators likely to report findings which would appease the funder.[69] Apart from this concern, project evaluations of donor funded projects, such as the MOSMAC project, are often conducted by external consultants who spend too little time within project areas to be able to determine the intrinsic impacts of projects which otherwise may not be on the evaluation checklists and questionnaires. These evaluators conduct impact assessment within strict timelines and budget; thus, tend to rely on pre-constructed checklists which are linked to the initial objectives of a project. Furthermore, even for projects which claim to adopt the bottom-up approaches, impact evaluation tends to occur top-down, based on pre-determined donor metrics. In support of this

[69] It is likely that if the project is scaled up or replicated, the evaluators will also have future job security (contracts), particularly if these evaluators are locally sourced.

claim, Bamberger (2000:96) suggests that, in relation to donor-funded projects' impact evaluation, "[d]onors' information priorities and evaluation methodologies continue to exert considerable influence on how evaluation is practiced and used," and this was also evident in the MOSMAC project.

As already indicated in preceding sections of the study, the MOSMAC intervention described in Chapter 6 was a donor-funded project and following its implementation, as well as at various stages of its implementation, was subject to impact evaluation based on donor guidelines. In this section, the study presents the monitoring and evaluation process relating to the MOSMAC intervention as part of efforts to critically explore how intervention impact assessment occurs on donor funded projects. To start with, the theory of change for the different funded projects, based on the initial Request for Proposal document, is presented. This is followed by a discussion of some of the monitoring and evaluation reports, as well as impact assessment discussions between the donor representative and the MOSMAC project implementation team.

7.1.1Theory of change

From the inception of the MOSMAC intervention, the funder had developed a theory of change which would guide the selection, implementation and evaluation of the interventions. In the context of intervention impact assessment, Rogers (2014) supports this approach and suggests that the theory of change approach can be applied to intervention impact assessment (evaluation). According to the funder, developing theories of change was key in helping innovators align interventions with the priorities of resilience innovation pathways and achieve vital short-term outcomes (RAN, 2017:51). Therefore, the theory of change underpinning the selection, implementation and evaluation of the interventions funded under the broader Resilience Innovation Challenge 4 Food Security and Improved Income Generation (RIC4FIG) program which included the MOSMAC project was that:

> "*The resilience of people and systems in Africa will be strengthened by leveraging the knowledge, scholarship and creativity that exists across the Resilient Africa Network to incubate, test, and scale innovations that target people and/or communities' capabilities and reduce their vulnerabilities as identified by a scientific, data driven, and evidenced-based resilience framework for sub-Saharan Africa*" (RAN, 2014:5).

In addition to this, the funder postulated that:

> *"If the 'right innovations' are applied to a reasonable degree of scale in target communities (i.e. that a 'substantial' proportion of the population in the target communities 'adopts' them), they will significantly contribute to 'improving' the resilience of these communities. We emphasize community participation and we are using the term 'strengthening resilience' other than 'building resilience' because we believe that communities will not start from zero there is existing strength and background resilience (in form of adaptive capacities) in the communities on which we shall build. The impact of resilience interventions on communities should be measurable. Successful innovations/interventions are expected to impact on at-least one or more building blocks of resilience in the target communities"* (RAN, 2014:5).

In addition to the above, the funder also suggested approaches to impact assessment and suggested that the assessment of the impact of innovations will be measured in two ways. Firstly,

> *"At the testing and scale up stage: Each innovator will be required to collect relevant quantitative and qualitative data on a case-study basis to show the potential utility of their innovation on the test communities, in line with the output and outcome indicators specified in the M&E plan for their project. Innovators will be supported during Level II of their incubation process to develop a theory of change, aligned with one or more dimensions of RAN's resilience framework. In addition to the in-built M&E framework for each project, innovators will be required to avail their prototypes/deliverables for inspection as part of RAN's follow-up on grant performance."* (RAN, 2014:5).

This was followed by:

> *"Term surveys in target communities: The RILabs will conduct periodic term surveys on study communities to assess impact of interventions on resilience"* (RAN, 2014:5).

In the evaluation of the MOSMAC intervention, the funder reported that MOSMAC's implementation in the study area was expected to follow a *pathway to resilience* demonstrated in

Figure 7.1.[70] Based on Figure 7.1, the MOSMAC intervention primarily represented a transformation of infrastructure. In turn, the infrastructure transformation was expected to have a direct impact (solid arrow) on human capital (skills & knowledge), as well as indirect impact (broken arrow) on the psychosocial dimension of the community. In turn the transformation of the human capital dimensions was expected to have direct impact on the wealth dimension (income) and an indirect impact on the health dimension like the psychosocial transformation. The changes in the health dimension would also directly impact the wealth dimension. Ultimately, the changes in wealth dimension had an impact on the food security status of the community and in a broader perspective, the 2nd SDG.[71] In essence, the funder's evaluation acknowledged the systems level impact of the MOSMAC intervention in the community.

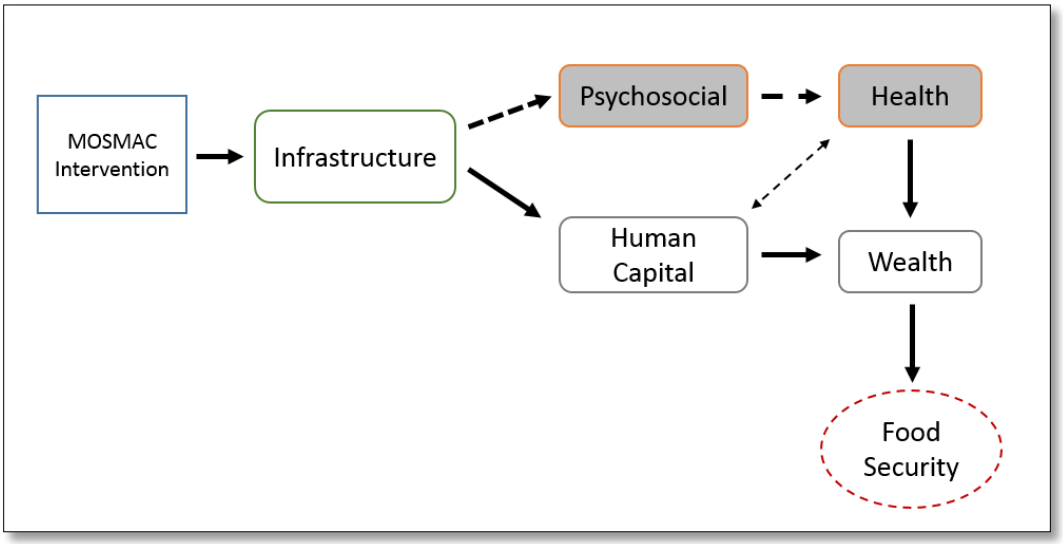


Figure 7.1: An analysis of MOSMAC intervention impact on the community's resilience
Source: RAN (2017:43)

The expected MOSMAC impact pathway presented in Figure 7.1 makes several assumptions. For instance, it assumes that the intervention is accepted by community and integrated into everyday activities without resistance. Furthermore, it is assumed that the different dimensions will have a

[70] I argue that this is the donor's expected pathway since the final report was produced before these outcomes were achieved in the study area; they are anticipated to manifest with time.
[71] I also argue that this analysis applied a narrow perspective to food security considering that in Table 3.1, food security has been explored using various dimensions. Thus, the funder only assessed MOSMAC contribution to food access and to an extent, availability, but not food utilisation and stability.

linear relationship and yet in reality, there are often non-linear. However, it is critical to indicate that reports developed by funders often depict what is set out in the initial groundwork, particularly if such reports are to be used to solicit further funding. On the contrary, the expected pathways cannot be overlooked but it is likely that a specific impact pathway will depend on several elements such as community attitude towards the intervention, intervention success and even the impact evaluators; and these can be broadly cast into the "context" bracket. In addition to the theory of change approach, the MOSMAC intervention, at an operational level, was continuously monitored and the field assessment is presented in the next section.

7.1.2 Field assessment

Even though the funder had developed the theory of change, as well as the monitoring and evaluation plan, there were impact evaluation activities at different stages of the intervention's implementation. As part of the project implementation, the funder requested periodic project reports (developed from predefined templates) to be submitted to the *technical officer*. Table 7.1 presents an extract of a report submitted to the funder for monitoring purposes.

Table 7.1: Extract of monitoring and evaluation report submitted to funder

Goals & objectives	Indicators of progress	Key activities done to-date	Milestones	Results attained	Main challenges
To engage community to be able to understand and provide a detailed livestock auction system description	• System documentation developed • Number of interviews with key informants for the system description completed	Literature review on livestock markets Primary data collection Policy and archival documents read	Signing of Memorandum of Understanding Livestock auction system documents and analysed to identify efficiencies and inefficiencies	Activity done with satisfaction. MOSMAC managed to attend auctions, discuss with stakeholders and we have a full understanding the livestock auction system	Bureaucracy of processes
Detailed livestock auction and management system analysis	• Number of meetings/ interviews/FGs • Objective discussions on livestock auction system • Number of stakeholder groups engaged	Literature review Community engagement to discuss their perspectives	Detailed objective analysis of the livestock auction and management system completed	Objective achieved with satisfaction	Obtaining buyers' buy-in in the analysis was a challenge
The identification, profiling and confirmation of livestock system problems and potential solutions	• Number of problems identified in the system • Percentage of stakeholders involved • Nature of solutions proposed	Literature review Community engagement	MOSMAC has documented the challenges facing smallholder livestock farmers in Beitbridge Potential solutions have also been discussed and proposed	MOSMAC managed to articulate the problem and solutions for the purpose of this project	
Conceptualising and developing prototypes (app, SMS, web-based service) and knowledge centre	• Number of prototype frames developed • Actual demo of prototype • Knowledge centre set up	Computers acquired and letter of approval to set up knowledge centre obtained Demos being finalised	Letter of approval to set up knowledge centre obtained from the relevant authorities	Conceptualising has been done and completed Digital development is currently being completed (in-progress)	Poor time management by MOSMAC
Community members test-use developed prototype	• Number of transactions completed using prototypes • Number of community members aware and willing to use developed prototype	Computers acquired – location for knowledge centre under consideration for approval	Material for community training secured Computer for ICT introduction has been purchased	MOSMAC is lagging behind on this target as community members are yet to test the prototype and also knowledge centre yet to be set up	Time constraint and poor time management on the MOSMAC side. Going forward, activities will be aligned to fit within timeframes and realistic timeframes will be set

Based on the submitted reports such as the report extract presented in Table 7.1, the funder, through the technical officer, requested community contacts from the project implementers to be engaged in assessing the progress of the project. From this approach, it was observed that due to limited resources such as time, the efforts dedicated to the intervention's impact assessment by the funder were limited and from a critical lens, this approach suggests flaws within the impact assessment approach. Since the evaluators often spent extremely limited time within the community in which the intervention was implemented, the impact assessment was then based on information obtained from individuals who were easily accessible to the funders. This further resonates with Kleine's (2010:113) suggestion that:

> *More commonly of impacts, often operate with a set of impacts as defined by the funding body, government, international organisation or commercial sponsor. This set of impacts then acts as a checklist informing the construction of questionnaires and interview guides, possibly with some scope for "other activities".*

In addition to this, the engagement of conveniently available individuals also suggests that mostly individuals with interests in the intervention were engaged and the impact assessment overlooked deeply entrenched impacts which can only be articulated through one's immersion in the society. It was further evident that the funder evaluations were prone to manipulation in that the responses of participants on an intervention's impact were often linked to an individual's interests in the intervention, which may include financial or social interests. For instance, at the time of evaluation of the MOSMAC intervention, one participant who participated in the evaluation meeting communicated via SMS to me saying that:

> *Boss, all went well. We tried our best to defend the project, you know boss! They said they will extend you project's funding. Just a few others were trying to discredit your work but don't worry![72]*

At the time, the message from the participant was clear that whether the intervention was making the desired impact or not, they were ready to defend it; thus, report that it was progressing. Evidently, from this SMS, it was evident that within the community, a project's importance was tied to one's interests in it more than the overall impacts of the project on the broader community. This can also be linked to earlier discussions in Chapter 6 which outlined that project teams are

[72] SMS received from a community member engaged as a focal person in the study area

often made up of the outspoken individuals within the community who are often involved within several other projects; and this also occurs within impact assessment. Overall, this dynamic in rural communities suggests that there is need to revisit the ways through which impacts of interventions, such as digital infrastructure transformation interventions in rural communities, are assessed.

In summary, external impact assessment of interventions in rural communities remains plagued with several challenges. In this section, the study has demonstrated that there are several areas which need improvement with respect to the methodological approach to impact assessment. For example, the MOSMAC intervention was assessed based on predetermined resilience dimensions but these dimensions may not be a true reflection of the key dimensions of a society. In this case, the gender and/or sociocultural dimensions have been overlooked and yet, these are indispensable in the context of rural livelihoods. Also, if the dimensions are accepted, these dimensions are long-term dimensions with transformations often taking many years to be realised. Therefore, new approaches which can reveal short-term and immediate impacts are needed. In all, external impact assessment cannot be discarded but needs to be supported by other evaluation approaches; thus, in the next section, the study attempts to move towards application of the Choice Framework to reveal, at individual or household level, the potential impacts of the MOSMAC intervention.

7.2 APPLYING THE CHOICE FRAMEWORK TO IMPACT ASSESSMENT

The purpose of the MOSMAC intervention, like many other interventions, was to contribute to the 'development' of the Beitbridge community. Specifically, the implementation of the intervention was an attempt to ensure that smallholder farmers in the study area, through use of digital technologies (brought through the intervention and those already existing in the community), achieve a sustainable and desired livestock system. However, as literature demonstrates, the terms development and sustainability attract different definitions depending on context. Kleine's Choice Framework argues that the structure of a community, which includes ICT and in the context of this study, where the ICT intervention is positioned, interacts with the agency (resources) of an individual/community to create dimensions of choice which lead to the outcomes of choice, which are further classified as primary and secondary. This section discusses the observed and potential impact of the MOSMAC intervention on the livestock system by applying the Choice Framework. Figure 7.2 is a reconstruction of Kleine's Choice Framework template diagram using findings from the study area, and the elements of the framework are individually discussed below.

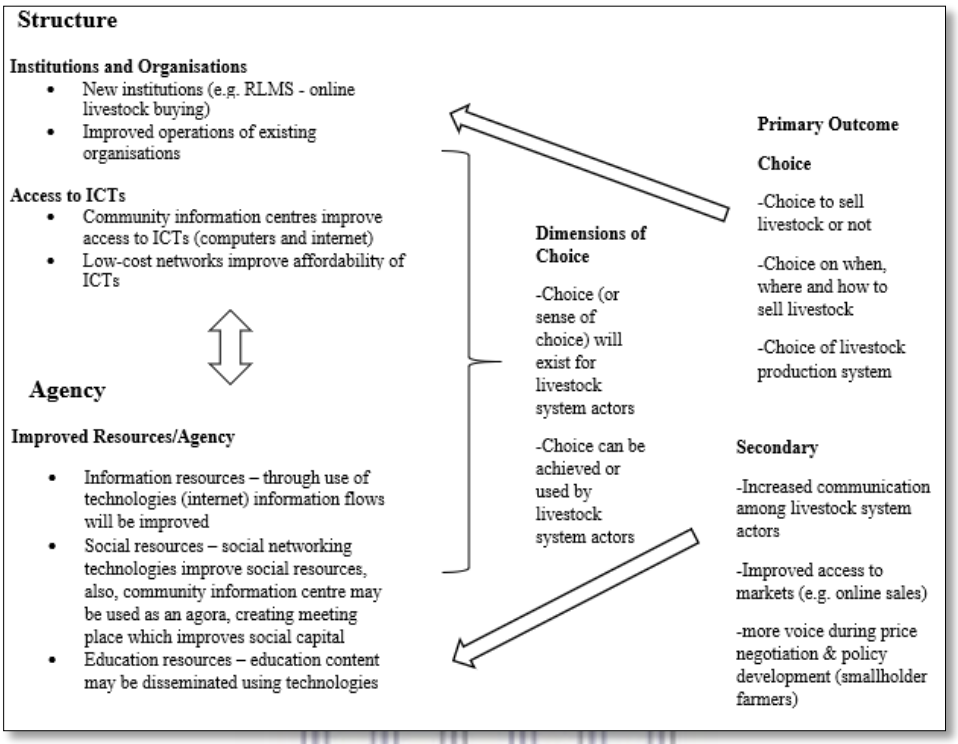


Figure 7.2: The impact of digital infrastructure on the livestock systems in Beitbridge
Source: Developed from Kleine (2010)

- **Primary Outcomes**

One of the fundamental aspects of the Choice Framework is the development outcomes from ICT interventions. Kleine (2010) suggests that the primary outcome is choice; and thereafter, secondary outcomes which are dependent on an individual. However, in applying the Choice Framework to conduct an impact assessment (of an intervention), Kleine (2010:113) cautions against using top-down approaches; and thus, recommends starting by "asking people about what they value and what outcomes they want to see." For this study, this was achieved by articulating the desired livestock system in the study area. Therefore, impacts of the MOSMAC intervention presented in Figure 7.2 are realistic outcomes which the community members indicated they would want to achieve using the intervention.

From the community engagement activities, it was established that key challenges among the livestock farmers in the community include information asymmetry and lack of access to markets

(diverse), as well as poor coordination among the livestock system actors. These challenges emanate from many aspects including structure (lack of access to ICTs). Based on the Choice Framework, it can be argued that the MOSMAC intervention transformed the structure by improving access to ICTs (made ICTs available and affordable; and imparted ICT skills). From an outcome perspective, it can be argued that through the MOSMAC intervention, smallholder farmers are able to exercise choice. For instance, some of the choices available include the choice to sell livestock or not, the choice on when, where and how to sell livestock; as well as the choice of the production system to adopt. In addition to these primary choices, there are also secondary outcomes which could be achieved and these include: increased communication among the livestock system actors (including use of emails, low-cost community networks); improved access to livestock markets (online options); and improved engagement of smallholder farmers achieved from acquisition of additional information. Reflecting on all these possibilities, and linking them to empirical evidence from the extensive engagements with the community, a key outcome for the community would be the choice on when, where and how to sell, as suggested by the village headman that:

> *Our major concern is on the lack of options relating to where to sell, ways of selling and the timing to sell. All these are currently determined for us by other people. We can only sell at auctions or when buyers come to use and this needs to change. We hope the project can help us on this.*[73]

In the community engagement activities, it emerged that information asymmetry persisted among the smallholder farmers. With poor connectivity, even mobile phones have not improved the information seeking patterns. However, the establishment of the community information centre provides the smallholder farmers with an alternative place to access critical information. The centrality of the information centre means that the physical journeys often made by the smallholder farmers in attempts to access information will be reduced. Further to reducing physical journeys, before the set-up of the community information centre, the community relied on mobile phones and other traditional ways to communicate. However, the community information centre, which is equipped with Internet, provides an additional option for information access; thereby increasing

[73] Village headman, leaders meeting, Old Nuli.

choices which smallholder farmers have. The community information centre broadens information access and transmission options. However, the Choice Framework also suggests that the dimensions of choice, and ultimately the choice itself, are influenced by the individual's agency; and in turn, the choice feeds back to impact an individual's agency.

- **Agency**

The MOSMAC intervention was implemented in a community with specific resources and combined with its overall structure, these create the dimensions of choice. The study findings presented have indicated poor education among households, with limited ICT skills. To bridge this gap, the MOSMAC intervention provided ICT training to the community (see Figure 6.4); and thus, modified the agency of individuals and the community. From the study findings, it was established that most smallholder farmers lacked the prerequisite knowledge to enable them to use technology. However, local teachers and technicians were able to use these ICTs, and then pass the information to those without prerequisite skills. In this vein, it was observed that even those without skills to use ICTs still visited the facility and relied on the social resources to access information. The MOSMAC intervention provided a space for social interaction. Therefore, the MOSMAC intervention contributed to transformation of community resources; specifically, educational resources, information resources and social resources. While there are several calls for adoption and use of ICTs in rural communities, findings in this study show that households use significant portions of household income to use ICTs, *e.g.* the cost of buying airtime recharge cards. However, the MOSMAC intervention sought to provide donor-sponsored access to connectivity; and subsequently, low-cost community networks which will also be less costly (than mobile data, for example). In this context, the study argues that the MOSMAC intervention can positively impact the financial resources of the community in that it saves the end-users significant financial resources (cf. Madon, 2000). However, one of the continual challenges remains ensuring the sustainability of such interventions. The study further argues that interventions should still charge end-users, but low-cost options should be prioritized in favour of technologies based on conventional commercial models.

- **Dimensions of choice**

A major concern, then, would be the increasing marginalisation of the extremely poor. The CF shows that structure combines with resources to produce degrees of freedom. Implicitly, it can be argued that those with more resources, normally attributable to individuals, such as financial and/or education resources, are likely to have greater degrees of freedom than those with limited resources. Another example could be resources running counter to development efforts, *e.g.* cultural resources may proscribe women's voicing left out of policy development. For the elderly smallholder farmers, the uptake of digital training (once ICTs were made available) was further limited by limited *educational resources* while for the agricultural extension workers and the local schoolteachers, *the ones with educational resources,* the uptake of digital technologies was easy. However, from a systems' perspective, the access to information by the extension workers improves internal efficiencies within the livestock systems, thereby benefitting even the smallholder farmers who might be unable to use the ICTs. As one technician highlighted:

> *There were days during which we experienced various diseases and didn't know how to diagnose these. But with the setup of the community information centre we can quickly upload pictures and email to other technicians who can help with the diagnosis. Alternatively, I google for the disease and the remedies. This will surely help our farmers in reducing livestock mortality.*[74]

- **Structure**

The setup of the community information centre at Old Nuli primary school was a clear indication of the influence of existing institutions and organisations on subsequent interventions in communities. In direct comparison to Kleine's observation in Chile, the MOSMAC intervention had to look for existing institutions which would be able to accommodate the hardware. However, since the community information centre was located within a school, it was critical to observe the rules set out by the Ministry of Education, since there were concerns that the facility could interfere with the on-going learning activities. Nonetheless, since the school was now using the computers,

[74] Livestock technician, Key Informant Interview, Mapai.

it can also be argued that the MOSMAC intervention contributed towards the transformation of the institutions, too.

In addition to the above, structure also includes access to ICTs which can be broadened into availability, affordability and necessary skills. In this regard, it could be argued that the impact of the MOSMAC intervention was evident. At the beginning of the MOSMAC project, there were no public facilities to access ICTs, including internet access. However, the setup of the community information centre and the planned low-cost community network represent a total transformation of the community structure in that access to ICTs is enabled. As a donor-funded intervention, the MOSMAC project has facilitated the availability of ICTs; and since there is no charge, affordability; and through training, imparted the necessary skills to use ICTs.

- **Overall impact assessment based on the CF**

The Choice Framework is indeed a work in progress, as Attwood and May (2015) suggest. The framework still requires fine-tuning, and they make several suggestions on how this could be achieved (*ibid*). However, in its original state, the framework allows for examining an ICT intervention and its impacts in specific communities. In this study, the Choice Framework has been applied to understand how an intervention, the MOSMAC project, impacts a livestock system which is characterised by several challenges. The study has demonstrated that in addition to the Choice Framework's help to explore an intervention's impacts in terms of choice, the Choice Framework also helps development practitioners to understand the pathways through which ultimate choice is achieved. In analysing the MOSMAC intervention's impact, the study has first situated the intervention in both the structure of the community and in indicating the intervention's impact on agency. The importance of situating the intervention within the structure and relating to agency is that it contextualizes an intervention. However, applying the CF to analyse the impacts of the MOSMAC intervention unfortunately suffers from two of the three limitations which Kleine (2010) identifies as limitations to applying the CF. Firstly, the MOSMAC intervention is implemented to help a community of smallholder farmers; specifically, livestock smallholder farmers; and in this context, Kleine (2010) argues that the "challenge will be how to apply the framework to groups of individuals, communities, or even nations" (p. 114). Secondly, Kleine (2010) indicates that applying the CF will be a challenge mainly to donor-funded projects such as MOSMAC since "funders prefer predefined and clearly measurable impacts" (p.115).

7.3 EMPIRICAL EVIDENCE ON INTERVENTION IMPACT

The impacts of an intervention are dynamic and extend beyond the point in time when an impact assessment is normally undertaken. As a result, long term impact which emerges beyond the funding period may never be revisited. Based on this, this study attempts to present both observed and speculated impacts. The study used non-conventional approaches to impact assessment by considering the impacts of the intervention at various stages of the project rather than waiting to conduct a post-implementation impact assessment. This includes critical self-reflection of the impact assessment process itself. At the onset of the project, as discussed in earlier sections of the study, stakeholder meetings (*e.g.* with community members, local governing authorities and various government departments) were held in the area. During these meetings, the intended intervention was outlined and this generated mixed reactions of optimism and pessimism. One pessimistic stakeholder during a meeting with the traditional leaders argued that:

> *We have heard about these projects. They simply come, do research and go. In the end, there is nothing which is left in the community to show for these projects. How different are you from all the others who came before you?*[75]

Indeed, these claims were substantiated in that the study area is replete with donor projects and some of these projects are only conducting feasibility work without further activities. Also, most research-based projects only engage the communities without further physical developments in the community. From these remarks, it became evident that the community, to some extent, measured a project's success based on the physical developments achieved (*e.g.* buildings, boreholes, roads and in the context of MOSMAC, a community information centre).[76] Furthermore, in discussion with the livestock extension workers during the various phases of the study, it became evident that one way which the MOSMAC intervention would impact the sustainability of the livestock system, and indeed several other value chains, would be incentivizing the retention of skilled personnel such as livestock technicians in the community; as well as improving the operating conditions of these individuals. For instance, before the establishment of the MOSMAC community information centre, the agricultural technicians travelled to the district office, approximately 30 km, to access

[75] Traditional leader, formal meeting, Shabwe

[76] This was a challenge for me since the nature of the project was structured in phases. Phase 1 was only the needs-finding phase without guarantee of further funding for the pilot stage which was set for the intervention implementation. Therefore, it was critical to manage the expectations of the community without promising activities which may have failed to materialize.

internet and other services necessary for compiling their reports. However, from the onset of the MOSMAC project, one technician highlighted that:

> *With internet accessible in my ward, there won't be need for me to go to the district office. I can work from the ward and email the reports, and this will save me time and costs. I also think with more developments like these, the area becomes more inhabitable and there won't be any reason for me to seek a transfer to other districts. But please, kindly ensure that we also have a standard printer if funds permit.*[77]

These sentiments were also echoed by the senior teacher at the primary school where the community information centre is located. From this, it was evident that individuals with knowledge and skills to use technology realised the potential impact of the intervention; and critically, the technicians and teachers indicated willingness to teach the local farmers on using the technologies supporting Davison and Ou's (2017:135) suggestion that the digitally literate within a digitally challenged environment "insist on accessing technology [and] whatever tools they can access" and ultimately act as bricoleurs. However, among the farmers, the intervention was received with mixed perceptions. The study found that the *socioeconomic* characteristics of the farmers played a critical role in how they related to the intervention. As one farmer indicated during a focus group discussion in Dumba:

> *While I like the idea of selling livestock in the comfort of my home, going to the show has become part of our lives. We go there not only to sell livestock but also to interact with others and even show off our wealth. That is the reason why it takes the whole day or even two. In addition, there is always the band playing after showa. So, these technologies might really disrupt all these activities if we are not careful.*[78]

However, while the MOSMAC intervention could be supporting the livestock technicians and even pacifying them to commit to the study area, it was equally worrying that the remarks of other technicians suggested potential power dynamics which could further marginalise the rural farmers. For instance, one technician indicated that:

> *Once the facilities are complete, we will be working from here all the time and even advancing ourselves.*[79]

[77] Livestock technician, community meeting, Shabwe
[78] Elderly male, Focus Group Discussion, Dumba
[79] Livestock Technician, key informant interview, Old Nuli

The challenge is that within rural communities, representatives of government departments command immense respect due to their positions. It is likely that due to these power dynamics, community members will feel less comfortable to challenge a government officer for a chance to use a computer at the community information centre. This early observation was critical in helping with the development of community information centre regulations to ensure equitable use of the facilities. The equitable-use plan also recognised the issue of gender dynamics; thus, females were also engaged as local trainers.

Further to the above, during the participant observation of the livestock auction at the various auction sites, it was evident that the livestock buyers were organized and well-coordinated. The buyers even acknowledged that they discussed buying strategies and maintain contact through social technologies. However, this self-organisation and coordination was absent among the smallholder farmers. This was evidenced by the admission of the smallholder farmers who indicated that for years, the community has struggled to develop a constitution for regulating the buying and selling of natural resources. History shows that in the past decades, communities (mostly male) frequently had social gatherings and at these gatherings, coordination was enforced. In modern day societies, these practices have become less common. In this context, it was anticipated that through the community information centre and low-cost community networks, interaction of community could be improved. For instance, one study participant remarked that:

> *This place [community information centre] will allow us, including the livestock farmers, to have more interactions, work together, teach each other or even come and relax and socialize with others. The low-cost calling options will also improve our coordination as a community.*[80]

In this context, the study suggests that digital infrastructure transformation in the community, specifically the establishment of the community information centre, represents a creation of a metaphorical agora (cf. Matavire, 2016) which in the ancient times was central to social and political fabric of communities (ibid; Thompson & Wycherley, 1972). Due to spatial dynamics in the study area, *e.g.* vast spaces between households, interactions are limited to social functions and this has impacted the social capital among the smallholder farmers. Outside of the social functions,

[80] Young male, formal meeting, Old Nuli

there are limited, if any, spaces accommodative to all age groups. As Matavire (2016) illustrates, infrastructure changes create new spaces for interaction, both physical and virtual.

In addition to the above, after the completion of the community information centre, there was limited use of the facility by the community members targeted by the intervention, livestock smallholder farmers. The livestock extension officers were the only livestock system actors making use of the facility. Despite this, most community members coming to the community information centre only suggested that they were 'passing by' or were there to 'while up time' but not use the computers or internet. When one of the community members was asked for his opinion on why this trend was common, he suggested that:

> *The community information centre is more suited for the young ones (including youths) as well as the teachers and extension officers. Very few elderly people feel comfortable to use the computers – and limited knowledge was also inhibiting them from getting involved.*[81]

The argument provided by the respondent demonstrates Kleine's (2010; 2013) argument that an individual's agency (*e.g.* education) is a determining factor in one's dimensions of choice. For instance, in the context of this research, the community was provided with ICTs (or rather, access to ICTs) but the access needs to be matched with an individual's agency (resources, *e.g.* education) to create the dimensions of choice. The MOSMAC project is an on-going project and currently in the phase of developing Wi-Fi broadcasting towers in the community to create hotspots for internet access. However, reflecting on the original goal of the project, it was evident that the intervention had obvious problems which resulted in intended beneficiaries not making use of the facility. Despite this, there were also unintended beneficiaries who became real winners in this project. In a formal meeting with project stakeholders held at the community information centre, the head of the primary school were the facility is located expressed gratitude on how the intervention was timely as the schools were now expected to teach ICTs based on the revised education curriculum. He said:

> *I am grateful to MOSMAC for this project. While the community (farmers specifically) are the targeted users, sometimes fortune comes your ways and it surely did for us as a school. We were struggling to teach the students ICT aspects of the curriculum but now it has*

[81] Elderly male, informal discussion at the community information centre

> *become much better. I am sure we are now one of the advanced schools in the district. Also, my fellow teachers are excited with the Wi-Fi connection and some are evening contemplating distance education,* ***ndo livhuwa nga maanda*** *(I am eternally grateful).*[82]

When study participants were asked about their perceptions on the technological advances, it was evident that most respondents across the different groups of livestock actors (smallholder farmers, government departments and buyers) suggested that technological advances had brought new products and services, some specifically for the livestock system, which previously did not exist. To this end, the respondents suggested that they hoped the MOSMAC intervention could be integrated with already existing technologies. For instance, one smallholder farmer, with reference to mobile money services (Ecocash), indicated that:

> *It used to take days for my son working in another town to send me money to buy vaccines for livestock and sometimes, the money would not even reach me. By the time I received the money to buy vaccines, in some cases, it would be too late, and I would lose livestock. However, with the emergence of Eco-cash, its instant and I can get vaccines in time.*[83]

Apart from the farmers, another group benefiting from the affordances of the digital technologies is the group of extension workers. The extension workers indicated that the different platforms such as Dial-A-Mudhumeni and social media platforms (WhatsApp and Facebook) are enabling them to undertake their work in improved ways as one extension worker elaborated:

> *We have a WhatsApp group of extension workers and this has improved our work in many ways. We share information about our work and even sharing knowledge by sending pictures, videos and documents. We are eager to explore more options of improving our work as technologies advance.*[84]

While realistic and speculative impacts discussed so far point to the improvement of the livestock system structure, it is prudent to also acknowledge the likelihood of undesirable outcomes within the livestock system emanating from the transformation of digital infrastructure. Mavedzenge *et al* (2008) argued that cattle rustling (theft) has always been a part of livestock production in Zimbabwe, especially in the border areas. The transformation of infrastructure, *e.g.* setup of or improvement of connectivity among the community, may be detrimental if cattle rustlers use the

[82] School head, formal meeting, Old Nuli Primary
[83] Elderly male, focus group discussion, Dumba
[84] Extension worker, key informant interview, Shabwe

resources to further organise the cattle theft; *i.e.* improved coordination amongst cattle rustlers is likely to impact the community negatively.

In addition, during the entire process, it was already observed that different smallholder farmers reacted differently to the MOSMAC intervention. A small group of farmers showed enthusiasm in using the innovations such as RLMS to undertake livestock related activities, while a bigger group felt that they were comfortable with the old system. Already, the intervention is showing that it can further split the different groups, weakening the social capital of the community. The unity of the farmers is always demonstrated at the livestock auctions when farmers help each other with decision making. Thus, if the result of the intervention is a division of the community, it is likely to be a negative outcome of the intervention.

7.4 INTERROGATING THE MOSMAC INTERVENTION SUCCESS IN BEITBRIDGE

So far, the chapter has presented the intervention's impact assessment based on three perspectives which are the *funder's perspective, a theoretical perspective* (using Kleine's Choice Framework) as well *as empirical perspective* based on different responses from the community. As already argued in section 3.5, over the years, interventions' impact assessment in general has been goal driven. Thus, impact assessments have been conducted against pre-defined checklists (projected outcomes). This approach has resulted in the negation and overlook of other potential impacts and (unintended) consequences, both positive and negative. Evidence from critical studies on intervention impact assessment suggest that the determination of a project's success hinges on several elements which also need to be critically interrogated. Already, in the preceding sections, the study has demonstrated that impact assessment can be conducted by different groups (*e.g.* external groups such as hired consultants on behalf of funding agencies, or even internal groups such as target users) using different impact metrics and dimensions. However, while these diverse impact assessment approaches are critical, interventions can also be examined from other perspectives to understand the holistic impacts. Therefore, this section attempts to present a critical analysis of the MOSMAC intervention from an assemblage lens before drawing key conclusions on whether interventions, similar to MOSMAC, should be prioritised, supported and/or even scaled.

7.4.1 MOSMAC intervention from an assemblage lens

Interventions in poor communities, such as the MOSMAC intervention in Beitbridge, are premised on long-standing beliefs that interventions (projects) implemented in communities will help these communities to overcome societal challenges which range from health problems and poor education standards to food insecurity. Evidence exists to show that those implementing interventions in rural communities believe that through these interventions, society's circumstances would be improved. However, these beliefs are hinged upon several assumptions already discussed in section 7.1. For instance, several interventions implemented in communities have been based on assumptions that, firstly the community will readily accept and integrate the intervention in their everyday life. The second assumption often made in intervention implementation is that a linear causality will be achieved (*see also*, Figure 7.1); *i.e.* the intervention will directly impact the targeted elements, resulting in solving of problems. Thirdly, assumptions can be made that the intervention implemented in the community is the appropriate intervention. During the implementation of the MOSMAC intervention in the Beitbridge community, the project team inherently made these assumptions that the community would accept and integrate the community information centre in their daily living; the technologies would improve the livestock system, promoting sustainability; and that the MOSMAC project was the ideal intervention needed in the community. However, as the empirical evidence presented shows, some, perhaps all, of these assumptions were inaccurate. In addition to the above reflection, another critical reflection in the context of the intervention is to question how the intervention is linked to development; thus, even ask the hard questions on what comprises development. Thus, this study argues that in some cases, actors perceive interventions viewed as ends in themselves, even though such views have strongly been refuted (Midgley, 2000).

Many studies, such as Barrett *et al*. (2017) and Mavedzenge *et al*. (2008), suggest that rural infrastructure needs to be improved. In line with these studies, the MOSMAC intervention was identified as an intervention that would address the infrastructure dimension in the study area (see Figure 7.1). In section 3.1.5, the study has suggested that an assemblage perspective can be adopted to explore the impacts of the MOSMAC intervention; and thus, explore the impacts of the MOSMAC intervention in relation to other units of infrastructure in the society and not as a singular unit. Drawing from empirical findings already presented, the MOSMAC intervention was introduced in a society which already had an existing SES, structure and agency (*e.g.* the society

had livestock systems, other livelihoods systems, schools, roads and wealth); thus, it was being embedded as 'part of the whole'. In the context of impact assessment, it is key to understand an intervention from an assemblage perspective in that it helps to reveal the broader impacts; including those which may have been overlooked by predefined evaluation checklists. The MOSMAC intervention clearly demonstrated this when the community information centre became more beneficial to the school children (being used for teaching and learning of ICT) than the initially intended farmers. This finding is critical in that it demonstrates the need for intervention impact assessments to frame evaluations based on broader frames, *e.g.* including impacts in terms of intervention's relations with other units such as the school, roads and markets. Mackenzie and Wajcman (1999) make two key suggestions which can also help to speculate potential impacts of digital infrastructure transformation in the study area, from an assemblage thinking perspective. They suggest that existing technologies are an important precondition of new technologies, and are introduced into a system, not in isolation. These suggestions also have critical implications on impact evaluation and put more interestingly:

> "*Invention is not a matter of a sudden flash of inspiration from which a new device emerges 'ready-made'. Largely it is a matter of the minute and painstaking modification of existing technology. It is a creative and imaginative process, but that imagination lies above all in seeing ways in which existing devices can be improved, and in extending the scope of techniques successful in one are into new areas*" (Mackenzie and Wajcman, 1999:8)

Further to the above, interventions, like infrastructure, can be relational, and even emotional (cf. Star, 1999). Thus, interventions are accepted or rejected differently by different people, carry different meanings for different people and as a result, different groups are impacted upon differently by the interventions. Therefore, the impacts of interventions such as the MOSMAC hinge on how the community and *other infrastructure* in the community relate to it. Larkin (2013) argues that for communities seeking to achieve modernity, digital infrastructure transformation can "generate desire and awe in autonomy of its technical function*"*; essentially transforming an individual's agency (or attitude towards technology). For instance, from the engagement, it emerged that the livestock technicians were more enthusiastic to use the facility to perform their jobs as one clearly demonstrated:

I am looking forward to using this facility and I have no doubt that it will change ways we work in this ward. I will also be enrolling for further education (distance learning) and I can use this facility. Farmers will benefit from my improved skills.[85]

In addition to this Larkin (2013:332) further shows that "by promoting circulation, infrastructures bring about change, and through change they enact progress, and through progress we gain freedom." Infrastructure transformations can have intrinsic impacts which are difficult to establish but nevertheless exist. To establish these impacts, researchers need prolonged and intimate engagements with the community. On the other hand, other studies argue that infrastructure is often invisible. Thus, it works in the background. These studies argue that the importance of specific infrastructure only becomes visible when it breaks down. To this end, I argue that the impact of the MOSMAC intervention perhaps will also be better identified during times when the infrastructure is not working (*e.g.* when there is no electricity) (cf. Graham, 2010).

The arguments presented in this section suggest that the MOSMAC intervention's impacts need to be considered not only from a technical perspective but a broader perspective. Essentially, the section demonstrates that the intervention is situated and embedded in broader systems, or assemblages. As the theoretical analysis has already demonstrated, the MOSMAC intervention represents a transformation of the community structure and agency (Kleine, 2010) as well as the human constructed facilities (Marshall, 2015), and broadly these are transformation of the community assemblages. However, the impacts of transformation of assemblages are often slow and manifest after many years. In addition to this, the discussion has also demonstrated that other impacts of infrastructure transformation are intangible and require context-specific metrics to measure these. For instance, Larkin (2013:333) argues that in terms of infrastructure transformation impacts "one can never analyze the thing itself but must confront, instead, one's own past, one's own desires, and the fantasies."

7.4.2 Should infrastructure transformation interventions be prioritized?

The race to find solutions towards one of the global challenges, food insecurity, is intensifying. To ensure that the growing global population is food secure, establishing the interventions which work

[85] Livestock technician, informal discussion, Old Nuli.

in overcoming food systems fragility and scaling these is an immediate priority. In the process of establishing interventions which work, it is inherent that several other interventions which unfortunately do not work, or do not deliver the desired impacts, will also be implemented, and some even scaled, as a result of lack of rigorous impact assessment. To this end, this thesis has attempted to contribute towards intervention impact assessment by assessing MOSMAC. In doing so, the thesis sought to expand on the knowledge to the extent to which interventions targeting digital infrastructure transformation in rural areas, such as the MOSMAC intervention in Beitbridge, contribute to the transformation and sustainability of the food system; thereby "providing lasting solutions to the problems of vulnerability" in rural communities such as Beitbridge (cf. McCarthy, 2014:145). This assessment is key towards deciding whether similar type of interventions warrants being prioritized, replicated and scaled up in efforts to achieve food security.

7.4.2.1 Feasibility, desirability and necessity:

So far, the evidence presented in this thesis demonstrates that the decisions on digital infrastructure transformation interventions are complex, with many factors to consider before arriving at a conclusion. Chapter 6 has demonstrated the complexities faced in implementing the MOSMAC intervention (*e.g.* delays due to bureaucratic processes). However, the MOSMAC intervention in Beitbridge is a key demonstration of how caveats within complex context such as Zimbabwe can be negotiated. In reflection to one of the sub-questions of the study outlined in Chapter 1 which interrogates the impact of context on the process of digital infrastructure transformation, based on the evidence obtained and presented in this study, as well as my personal experiences during the implementation of the MOSMAC intervention, it was evident that context can either create an enabling environment for or constrict the process of digital infrastructure transformation. In terms of the context creating an enabling environment, during the implementation of the project, at the time of MOSMAC implementation, there were negotiations to transform the licensing legislation, to accommodate community networks in Zimbabwe. I even engaged with POTRAZ officials and such an engagement would not have been possible in the past years (see for instance the complexity faced by Econet to set up). Apart from this, within the study area, the local authorities and the community were welcoming and cooperating which had positive impacts on the implementation of the digital infrastructure even though there were also other elements (context) which were

strenuous. Therefore, in terms of feasibility of interventions, particularly digital interventions, this study argues that the Zimbabwe environment is transforming and becoming more accommodative to allow digital infrastructure interventions.

The study has demonstrated that the livestock system in the study area is fragile. This fragility is likely to be similar in other value chains not explored in this study. Even though there is an urgent need to address elements contributing to value chain fragility in rural areas (*e.g.* infrastructure), there are several and often, complex, challenges which have resulted in communities having simultaneous competing concerns. The global development agencies are therefore chipping in with interventions which they often deem to be the appropriate solutions. The evidence presented in this study, including RAN's interconnections of resilience dimensions, it is evident that infrastructure deficits in rural areas are common and addressing this should be prioritised. However, the study findings also show that in terms of digital infrastructure, rural communities are not too concerned with its lack but considering the current trends, and future (*e.g.* discussions on 5G networks and the 4th Industrial Revolution), the study submits that it is desirable[86] for interventions such as MOSMAC to be implemented in rural communities. In the study, there was realisation (even though this was by limited people) that the digital infrastructure would be integrated with existing assemblages; thus, there was a desire to have the digital infrastructure project completed. Thus, the intervention was considered as part of the whole rather than isolated units. The MOSMAC intervention's repurposing for education by the local school was a demonstration of how interventions are integrated into broader community assemblages. Even though this was not the primary intention, the intervention's integration into the school addressed a major challenge in terms of lack of ICTs needed for education. In this regard, the intervention can be regarded as necessary. However, farmers had scepticism with ICTs (*e.g.* rejected Ecocash) and were unlikely to immediately adopt and use the intervention. However, as the funding agent speculated, there is a likelihood that the intervention will follow a specific pathway which will ultimately impact the sustainability of the livestock system. For instance, with the MOSMAC intervention, extension workers will develop more knowledge (human capital) and further teach

[86] The term desirable infrastructure suggests infrastructure which improves the well-being of the rural area but which the community can manage without.

farmers on new livestock management techniques and approaches (human capital), and in the long run, this could contribute to sustainable livestock management approaches.

7.4.2.2 Some reflection:

Interventions such as MOSMAC, focusing on transforming digital infrastructure in rural communities are likely to increase with ICTs continuing to be part of human living. Questions on the changes which these interventions bring will also continue especially with limited empirical evidence to demonstrate impact. Through the evidence presented in this study, I argue that an intervention's impacts manifest in different ways and at different times. From the study findings, it was evident that there are several impacts which respondents speculated and these must still be established in the future. Based on this, I argue that an intervention's impact (for example on a system's sustainability) need to be split between short and long term. Secondly, an intervention becomes integrated into existing systems but this may take time (*e.g.* pending clearances, or as people get accustomed) and its realistic impacts then can be explored from a broader perspective. It is insufficient to measure impact of an intervention as a singular unit. For instance, in the study, it has been demonstrated that short term intervention impacts are manifesting in other sectors and not the targeted livestock system. Thus, an intervention's impacts, using a systems thinking approach can be direct or indirect. In this regard, the MOSMAC intervention's impacts on other systems such as education, can be argued to be indirectly impacting the livestock system. There are several other hidden (intangible) impacts, direct and indirect, which this study has suggested. While the funding agent argued that impacts occur through a theory of change (linear relationships), Kleine's CF demonstrates that impacts are realised through changes in structure, agency and choice. Finally, the study focused on an inherently complex system, the food system, which means assessing the impact of an intervention on that system would be challenging. Within the food systems debates, there are several issues which still need to be resolved; particularly solutions to food insecurity/ food system fragility. The solutions to these problems are often multiple and simultaneous; thus, it may be difficult to establish changes directly attributable to an intervention. Also, in complex systems such as food systems, practitioners often find themselves in the predicament of not knowing whether a solution works. In terms of replication and upscaling, I argue that interventions such as MOSMAC offer communities multiple benefits, including direct impacts which can contribute to sustainable food systems if considered from a systems/assemblage

perspective, and these should be replicated. However, interventions such as these "ultimately rely on political judgement and will be caught in political processes" May (2007:16).

7.5 CHAPTER SUMMARY

This chapter set out to provide an impact assessment on the MOSMAC intervention. The impact assessment was presented from three perspectives which are the donor's approach, theoretical and empirical perspectives. The funder provided a pathway to resilience which demonstrated the expected impacts of the MOSMAC intervention in the community. The funding of the MOSMAC project until the piloting stage demonstrates the funder's satisfaction with the progress but it can also be argued that the MOSMAC intervention impact assessment by the donor was mainly based on predetermined outcomes; thus, could have omitted other unintended outcomes, both desirable and undesirable. From a theoretical perspective, the Choice Framework was applied, and it demonstrated that the MOSMAC intervention transformed the structure and agency of the community. The chapter argues that the MOSMAC intervention has impacts on the development outcomes (choices), but an individual's agency will be critical on whether an individual (or household, village or community) is able to expand the dimensions of choice through the MOSMAC intervention. Empirical evidence on the intervention's impact show that there are diversified impacts on different dimensions. For instance, the intervention impacted upon social dimensions, economic and cultural, in some cases negatively. However, evidence presented shows that the intervention has the capability to help the community to overcome many challenges faced within the livestock system; thus, ultimately contribute to improved household wealth, individual health, human capital development and food security. Accordingly, Van Berkum *et al*. (2018:23) suggest that, "a broader approach is required when analysing the impact of interventions aimed at enhancing food security" considering that interventions influence the behaviour of actors within that system through changes in the system context, and also taking into account the effects of an intervention on other parts of the system. Therefore, if we adopt a broader approach, such as a systems thinking perspective, a digital infrastructure intervention such as MOSMAC has impacts on the livestock system and can contribute towards sustainable livestock systems in rural communities. The impacts on an intervention may not manifest in the short term; thus, it is critical to be future-oriented when assessing the impacts of an intervention.

CHAPTER EIGHT: SUMMARY OF FINDINGS AND CONCLUSION

8.1 SUMMARY OF KEY FINDINGS

This thesis emerged as part of the on-going efforts to address global challenges, particularly food insecurity in rural communities. The study makes a critical reflection on the potential contributions of digital interventions towards overcoming problems within key local value chains. In practical terms, the thesis has focused on examining the MOSMAC intervention in Beitbridge to build evidence on whether such digital infrastructure interventions could play a role towards creating sustainable food systems in rural communities and subsequently improve food security. To do so, an overall systems approach was adopted. Using mixed methods and participatory action research, the thesis has generated new insights on the study area (socio-economic systems), the livestock SES (including insights on its sustainability) and the intervention (process of implementing and assessing impact). A summary of the key findings from the study is presented in this section which then leads to the drawing of the study's conclusion.

In socioeconomic terms, the study found that in the study area, households are characteristically poor, with low household income, living in extreme poverty and subsequently food insecure. Due to the poor resource base, livelihood options are restricted.[87] In addition to this, the climatic conditions in the area are extremely hostile for crop production and as a result, livestock production is a primary livelihood option for most households. Admittedly, livestock play many roles towards the well-being of households by providing diverse services and products in the study area. Study findings demonstrated that livestock contribute towards the different dimensions of food security but mainly towards food access and to some extent, food availability. The study found that households sell livestock to generate income to buy food although often, the income generated from livestock sales is also distributed to other household expenses such as medical bills and school fees; thus, may not always suffice for the households to buy food. In terms of food availability, small livestock such as goats and chickens were frequently included in household diets; and thus, contributed to household food availability. Large stock (*e.g.* cattle) are mainly slaughtered at special occasions (*e.g.* wedding, celebration or funeral), when the livestock is sick

[87] Kleine refers to this as agency which includes educational, information, financial, material, health, social and natural resources.

and/or during times of distress. The study findings concur with existing studies on the roles of livestock towards livelihoods in rural communities and significantly, towards household food security (cf. Herrero & Thornton, 2013; HLPE, 2016; Jodlowski *et al*., 2016).

Given the key contributions of livestock towards household well-being (food security included) in the study area, the study further explored the livestock system's sustainability. This was critical in that, for livestock to continue playing a key role towards food security, the livestock system needs to be sustainable (in all dimensions of sustainability). This study applied Ostrom's (2009) SES framework to describe the livestock system attributes and found that several attributes of the livestock SES were contributing to the fragility of the livestock system. In the context of this study, a major concern was the poor state and/or absence of infrastructure (human constructed facilities) which several studies identify as a main contributor to value chain fragility. Lack of infrastructure, including digital infrastructure, contribute to several other problems in the value chain. Other poor SES attributes of the livestock SES identified in this study include poor predictability of livestock SES dynamics, fewer livestock system actors (specifically buyers) and poor governance systems. It was evident from the empirical evidence obtained that the livestock system in the study area is fragile. The system fragility is further intensified by the global environmental changes resulting in massive livestock deaths and decline in livestock quality. The macro-economic challenges facing Zimbabwe are also contributing to the fragility of the livestock SES. For instance, farmers are neither able to access export markets nor access loans (financial support) to improve the livestock management process. The study findings suggest that the challenges faced in the study area are not unique to the livestock SES but also extend to other value chains and livelihood options. Therefore, efforts are needed to address these challenges and in the current situation, solutions which can apply to more value chains are desirable.

The challenges facing livestock farmers established during the study are not new, and responses from the study as well as the literature show that some of these challenges have prevailed for long periods. Over the years, the government (and governing institutions) have made several efforts to address these challenges but in developing countries such as Zimbabwe, most governments have limited resources. In Beitbridge, the study found that the local council's allocation for ICT transformation was insufficient to achieve the desired change. Furthermore, the challenge of politics in infrastructure development cannot be discounted. However, in all this, current efforts

and/or interventions implemented to overcome various problems in rural areas, including value chain fragility, are being implemented by external parties (global development agencies). In addition to this, the study also found that the efforts of global development agencies to implement certain interventions can be constrained by context. In Zimbabwe, the study found that historically, legislation was restrictive in terms of ICT interventions but recent and on-going transformations in legislation are creating a conducive environment for ICT interventions like community networks. Furthermore, the political environment (including governance systems), social and economic dynamics of the community play a key role towards the implementation of interventions. The MOSMAC intervention implementation was aided by support from the community and local authorities, existence of supporting infrastructure (*e.g.* a school to set up the facility) but also, was delayed by bureaucratic process and threatened by economic context.

The study then sought to explore the impact of the intervention on the sustainability of the livestock system. There are diverse ways of undertaking impact assessment which means different people taking the evaluations and using different metrics. The study found that most interventions' impact assessments follow top-down approaches with limited community consultation and participation and are failing to yield significant desired lessons; rather, they are conducted to fulfil a requirement. The MOSMAC intervention was assessed by different groups (funding agent using a theory of change, myself through theoretical frameworks and the target users, reported through empirical findings). From each impact assessment, different impacts were identified. The theory of change projected the pathways of impact; the theoretical frameworks demonstrated the specific impacts expected to be achieved and how these would be achieved (indeed, with several assumptions); and the study respondents suggested the impacts they hoped for. Even though the MOSMAC intervention was targeting the livestock system, it clearly emerged from the study findings that this intervention was assimilated into the broader system (assemblages) and the impacts of this interventions would, unsurprisingly, continue to emerge; even in areas previously not thought of. For the livestock system, this would mean that the MOSMAC intervention has both direct and indirect impacts. Reflecting on all this, this study found that that the impact assessment approaches that are available excessively simplify the complex reality to a point that they are unable to account for the changes that have taken place. However, with the increase in the number of development interventions, the study found an urgent need for the development of robust impact

assessment approaches towards development interventions to ensure that decisions on interventions (replicating and scaling) are based on realistic impacts.

8.2 CONCLUSIONS

Throughout the thesis, I have attempted to address the study's research sub-questions building towards answering the main research question which focuses on exploring whether digital infrastructure transformations in the rural communities such as the MOSMAC project impact the sustainability of livestock systems, and if so, how and in what ways? Before presenting the conclusion to this question, based on empirical evidence and literature, I will briefly revisit the research sub-questions.

In terms of the role of livestock towards household food security and the sustainability of the livestock system, the study has argued that livestock species play a key role towards food security. Critically, livestock contribute to the different dimensions of food security and further, provide other services (such as manure) which are key to household food security (see also, Swanepoel *et al*., 2010). However, the livestock SES in the study area faces several challenges and collectively, the system is fragile. The fragility of the livestock SES compromises the contributions of livestock towards household food security. However, further analysis of the livestock SES sustainability shows that different dimensions of sustainability are fragile to different degrees. For instance, economic sustainability is crippled by the national economic crisis (cash shortage) but the existence of functional auction markets (when other districts have no operational auction markets) demonstrates a level of sustainability. Also, in comparison to environmental sustainability, economic sustainability can be addressed (*e.g.* opting to move to other profitable markets) but environmental sustainability may be difficult to address. Therefore, this study suggests that the livestock system in the study area is fragile based on an aggregate of all sustainability dimensions; cognisant of the fact that an analysis of specific sustainability dimensions only may produce different findings. The aggregate analysis was achieved using the SES framework.

In addition to the above, the study moves to draw conclusions on the potential of digital technologies in creating and maintaining sustainable food systems. Based on the technology affordances theory, technologies are created with specific affordances which, when appropriated correctly, can deliver specific outcomes. In agriculture-related activities, digital technologies can

play a key role in information dissemination, including market information (cf. Wyche & Steinfield, 2016). However, empirical findings in this study further demonstrated that even when technologies with desired affordances exist, these can be rejected by the intended beneficiaries. This was the case when farmers rejected being paid using Ecocash system during the livestock auction. This case can further be linked to Kleine's suggestions on technology and choices. Kleine argues that ICT access and availability need to be combined with agency for dimensions of choice to exist. For instance, most households lack financial means to buy recharge vouchers and as a result, opt not to explore affordances of mobile phones. Therefore, building on this, and the rejection of Ecocash observed during the livestock auction, the adoption and use of digital technologies may contribute to a sustainable livestock system only when the technology affordances are correctly appropriated and system actors have the intention (desire) and agency to appropriate the affordances (cf. Yeo *et al*., 2011; Mutsonziwa & Maposa, 2016).

Building from the preceding remark, two of the factors which determine digital technologies' contribution to development are the availability and accessibility of ICTs. In this study, like many other studies, it has been demonstrated that in rural communities, ICT availability and access are poor and/or simply non-existent. In Beitbridge, connectivity is a major concern and when accessible, the services are extremely exorbitant. There are several on-going efforts to overcome infrastructure deficits in rural communities, including interventions such as the MOSMAC project. However, the processes of implementing interventions in complex environments (socially, economically, and politically) such as Zimbabwe can be tedious and discouraging. Further to this, it remains a challenge to accurately determine the impacts of interventions already implemented. Thus, it is taking longer to establish whether specific interventions are correct solutions to particular problems. From the study findings, it is the study's submission that context plays a significant role towards the process of digital digital infrastructure transformation. Context determines whether an enabling environment exists or not. Establishing the context in which interventions are being introduced can no longer be considered as an option but rather, should be central to intervention selection and implementation (cf. Moran & Dourish, 2001; Musiyandaka *et al*., 2013) In terms of impact assessment, non-conventional approaches entail extended analysis of a system under investigation and collaborative formulation of impact assessment metrics, driven by internal and external actors. However, in all this, Diniz *et al.* (2014) suggest that context is malleable; and thus, can be altered to suit specific interventions.

Finally, the study turns to develop conclusions on the main research question which read as: Do digital infrastructure transformations in the rural communities in Zimbabwe impact the sustainability of livestock systems, and if so, how and in what ways? However, before unpacking the conclusion for the study, it is critical to restate that this study has developed working definitions in Chapter 3 for the key terms used during the study since these terms are often interchangeably used. Therefore, the interpretation of the study conclusions must also be in context of the study's definition of these key terms as discussed earlier in the study.

In the context of Kleine's Choice Framework, a sustainable livestock system can be argued to be a system in which the livestock system actors, through the existing structure and available agency have dimensions of choice which enable them to achieve choice: primary (*e.g.* where to sell, when and how) and secondary outcomes (*e.g.* improved communication). Based on this theoretical underpinning, this study concludes that the transformation of digital infrastructure in the rural communities such as Beitbridge represents a transformation of both the structure (ICT availability, access and affordability) and agency (information resources) which in turn impacts the dimensions of choice for livestock actors and results in the achievement of choice. In this regard, it is therefore argued that transforming digital infrastructure is likely to result in the transformation of choice and secondary outcomes; and thus, can result in a sustainable livestock SES. As presented in Chapter 7, the digital infrastructure intervention in Beitbridge has already altered the structure of the community; and thus, has improved the access to ICTs, addressed affordability and made skills available. However, the dimensions of choice for different individuals, households and groups will be determined by the available agency; and thus, can be assessed at different levels. For instance, the dimensions of choice for livestock technicians who already had the pre-requisite educational resources are different from those of individuals who lacked educational resources. It is critical to consider Star (1999:377) who argues that "[i]nfrastructure is both relational and ecological [in that] it means different things to different groups and it is part of the balance of action, tools." Thus, the digital infrastructure transformation may have different impacts on different groups. In this vein, the study also cautiously concurs with Toyama (2011; 2015) regarding the amplification of ICTs on existing human intent; and submits that the impacts of digital infrastructure interventions in rural communities on the sustainability of the livestock system will also depend on the livestock system actors' intention to take actions towards a sustainable livestock system.

Further to this, in the SES framework, technologies are situated as a second level attribute of an SES. Therefore, digital infrastructure transformations represent a transformation of the livestock SES in that the digital infrastructure transformations would mean improved technologies as well as improved human constructed facilities; both of which are attributes of an SES. In other words, digital infrastructure transformations represent transformations of attributes of a livestock SES like the changes in the structure and agency in the Choice Framework. Thus, these transformations of attributes of a livestock SES may mean changes in the way livestock SES attributes interact. If we are to extend the analysis further, the study suggests that a transformation of the technologies attribute can result in the introduction of new products and services (*e.g.* digital payments, improved data flow or information equality) but this also depends on how the transformed attribute interacts with other primary attributes of the SES. For instance, the governance system could encourage, or may even restrict, the use of technologies.

Apart from the theoretical conclusions, the study, through empirical findings, has shown that there is optimism among the livestock SES actors on the potential of digital infrastructure to contribute towards achieving sustainable livestock systems. Through the assemblage approach, the study's contention is that digital infrastructure transformation in the study area impacts several other elements of the society which in turn can also create positive benefits for the livestock system. For instance, MOSMAC's use to educate school children can be deemed as a future benefit in that these school children could in turn become future livestock SES actors armed with ICT skills. Undeniably, the transformation of digital infrastructure, at least the introduction of ICTs, within any value chain may also create many challenges. For instance, inequality within the system can be exacerbated further.

In reflection on Oliver *et al.*'s (2018) indication that the challenge relates to knowing which interventions to prioritize, it is important to consider then, that in the context of rural areas such as Beitbridge, such interventions can be prioritized. May (2017) indicates that problems (food insecurity, system fragility) are wicked problems, and take long to solve; and it takes even longer to check whether a particular intervention works. To this end, "[t]he divergence between intended and actual outcomes of development interventions should not be interpreted to mean that outcomes of development interventions do not provide any benefit or that they always fail" (Miroro, 2014:2). Therefore, based on this, the study concludes that with the MOSMAC intervention, there are

several benefits which accrue to the community (in the short term and long term) whether linked to livestock system or not, and these will eventually link back to overcoming food insecurity. As Gibson and Olivia (2010:717) suggest, there "would be gains from development strategies that improve both the access to and the quality of rural infrastructure."

8.3 STUDY CONTRIBUTIONS

8.3.1 Study contribution to knowledge

This thesis contributes to knowledge and understanding of complex systems, natural and man-made. Livestock systems are complex and inherently, understanding the problems of fragility and potential interventions is complex. I have demonstrated that in contrast to other approaches of exploring such complex systems, the SES framework is helpful to characterize and understand the system dynamics (system components and interaction of components). In this vein, the thesis has demonstrated how digital infrastructure is part of the livestock SES as an *intrinsic element* (either as human constructed facilities or technologies); and yet, in other analyses, it is often perceived as an external component. The thesis further demonstrated how the transformation of the digital infrastructure results in transformation of the livestock SES. Through this analysis, I argue that to develop deeper insights on specific complex systems, there is need to apply and use frameworks that characterise (breakdown of components) and show interactions of these components. In addition to the above, the study also contributes to the extension of the application of Kleine's Choice Framework. In this thesis, I have demonstrated that while the SES framework helps to understand system dynamics and interaction of system attributes, it falls short in terms of understanding system outcomes. Kleine's CF proves helpful in this regard. With the CF, the thesis has demonstrated how the digital infrastructure transformation doubles as a change in structure and agency. Furthermore, the study contributes to knowledge of impact assessment. The study has prompted the need to ask hard questions on impact evaluation, particularly on the definition of impact, decisions on impact metrics and application (use of impact results).

8.3.2 Study contribution to methods

In addition to the contribution to knowledge, this thesis also contributes to research methods on complex systems such as the livestock system and digital infrastructure systems. While building

on existing ethnographic methods, this study has applied participatory research approaches, particularly community visioning, to articulate problems and brainstorm potential solutions to both livestock and digital infrastructure systems. The thesis has applied methods, originally developed for specific disciplines, to explore the livestock SES and digital infrastructure. Admittedly, limited studies have applied community visioning in rural communities on their livelihoods with this method being preferred to explore urban development in affluent cities. Even though I question the approach, I have demonstrated a needs-findings approach which emphasises establishing human needs and using these needs as a guide for intervention development. This method is key in development research as well as in the implementation of development interventions. In addition to this, I applied reflexivity, *recognising that I am part of the society I was studying; part of a global food system that is fragile*. In applying reflexivity, I have subjected myself and this work to objective critique in favour of robust assessments to establish appropriate interventions suitable for scaling and replication. In the vein of impact assessment, the thesis also contributes to the development of methods of impact assessment. Essentially, the study challenges existing impact assessment approaches in that they need to be revised to ensure that comprehensive approaches are established, *e.g.* integration of context via socio-technical assemblage.

8.3.3 Study contribution to policy and practice

The thesis contribution also extends to policy and practice. In terms of policy, the thesis contributes towards understanding and providing pathways to achieve clusters of the ZimAsset as well as selected SDGs. The ZimAsset focuses on empowering communities through digital infrastructure and promoting food security. The thesis demonstrates how digital infrastructure in rural communities can be transformed and used to promote sustainable food/livestock systems and ultimately, food security. The study contributes by demonstrating how policies can be translated into practice at grassroots levels. The study demonstrated policy translation by entertaining POTRAZ's proposed regulations towards community networks which provide evidence key for policy makers to decide on policies. It does so by demonstrating how the policy can be instrumental to community development and by providing practical evidence on community network initiatives, the study could expedite the countenance of the community networks policy. In terms of practice, the participatory processes (*e.g.* visioning workshops) conducted during the study have promoted

creative ways to solve complex problems in societies. The community members engaged in the study have learnt creative approaches which can applied to understand the resource around them and work together to solve problems. In terms of livestock system fragility, extension workers acknowledged the SES frameworks broad approach; and thus, have begun to reframe the problems within the livestock system to consider previously overlooked attributes. In the context of digital infrastructure, this study has led to improved utilization of the community information centre facility, although not necessarily as envisaged by the funder. The community information centre is currently providing internet access to school children who are required to learn about ICTs in the new curriculum.

8.4 FUTURE RESEARCH

In completing the study, new insights emerged, and these led to new research questions which have not been answered in this study. Firstly, the study has demonstrated that a livestock system (and/or value chain) can be analysed using Ostrom's SES framework. It would be helpful if future studies could adopt the framework to also characterise other livestock systems in different rural communities to enable a comparison on sustainability. Also, future research can explore the differential impacts of technologies on the livestock systems – i.e. impacts on animal health compared to impacts on market systems. Furthermore, as Foster *et al*. (2018) suggest, ICT impacts are sector specific; and thus, it cannot be generalised that the impacts of digital infrastructure transformations on the livestock system presented in this study will be similar on other value chains. It is therefore suggested that future research can explore the integration, and impacts thereof, if any, of digital infrastructure transformations on the neglected value chains such as a natural resources value chain (baobab, mopane worms and *ilala*). From a technology perspective, the transformation of digital infrastructure within the study area cannot be viewed in isolation, as infrastructures are relational in nature. Therefore, further research can also focus on the interoperability of infrastructure, specifically to understand how the digital infrastructure relates to other infrastructure. Furthermore, in the immediate future, it is critical to focus more on the sustainability of digital infrastructure transformations within the context of rural areas in Zimbabwe; and following Avgerou *et al*. (2016), future research can focus on investigating how the work presented in this study can be expanded.

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APPENDIX A: HOUSEHOLD SURVEY QUESTIONNAIRE

SECTION A: GENERAL HOUSEHOLD INFORMATION: INFORMED CONSENT OBTAINED

1. Village Name	**1= Dumba 2=Mapayi 3=Old Nuli 4=Shabwe**	
2. Gender of respondent	**1=Male 2=Female**	
3. Is the respondent the HHH[88]	**1=[yes] 2=[no]**	
4. If respondent not HHH, relationship		
5. Age of respondent	**1=[18-25] 2=[26-35] 3=[36-45] 4=[46+]**	

SECTION B: HOUSEHOLD DEMOGRAPHICS

Demographic Data	
6. HHH – Gender **1=Male 2=Female**	
7. Household Size **Insert Number**	
8. Highest education qualification for HHH **1=No formal 2=Primary 3=Secondary 4=Tertiary**	
9. Highest education qualification for any other h.h. member **1=No formal 2=Primary 3=Secondary 4=Tertiary**	
10. Has the HHH received any vocational training? **1=[yes] 2=[no]**	
11. Has any other H.H. member received vocational training? **1=[yes] 2=[no]**	
12. Has any H.H. member suffered from malnutrition related illness in the past 12 months? **1=[yes] 2=[no]**	

SECTION C: HOUSEHOLD ASSETS

13. Do you own Farming land? **1=[yes] 2=[no]**	

[88] HHH – Household Head; H.H. - household

Livestock Ownership		14a. Do you make use for the following Use: **1=[yes] 2=[no]**			
14. Livestock Ownership (HH)	**Number**	**Sell**	**Draught Power**	**Food**	**Investment**
Cattle					
Donkey					
Goats			n/a		
Sheep			n/a		
Chicken			n/a		
15. **Other Assets:**	**Total**				
Motor Car					
Tractor					
Scotch cart					
Plough					
Bicycle					
16. **What water Source do you use?**					
Community shared **1=[yes] 2=[no]**					
Own source **1=[yes] 2=[no]**					
17. **What Energy Source do you use?**					
Electricity **1=[yes] 2=[no]**					
Solar **1=[yes] 2=[no]**					
Generator **1=[yes] 2=[no]**					

SECTION D: LIVELIHOOD ACTIVITIES

INCOME GENERATING ACTIVITIES	
18. Is the HHH formally employed? **1=[yes] 2=[no]**	
19. Is any other H.H. member formally employed? **1=[yes] 2=[no]**	
20. What is the average household income per month [**1= 0-300] [2=301-500] [3=501+]**	
21. If you sell livestock, what do you perceive to be the main challenges in livestock selling? Rank the options **a=Pricing b=Few buyers c=Lack of Information d=Quality of livestock due to drought (rank these)**	

22. How far is the livestock auctioning market? **1=<20km 2= (20+) km**	
23. If you sell livestock, how do you make the decision? **1= HHH decision 2= Collective decision 3= Both**	
24. Has the changes in weather patterns affected your Livestock production? **1=[yes] 2=[no]**	
25. What are the other sources of income in the H.H.? **1= Mining 2=Petty trading 3=Community gardens 4= Nat. Resources**	
26. Do you or any member of the H.H. have a bank account? **1=[yes] 2=[no]**	
27. Do you or any member of the H.H. have access to loan schemes? **1=[yes] 2=[no]**	

SECTION E: FOOD SYSTEMS

28. On average, how many meals do you eat per day? **1= [sometimes 0] 2= [1] 3= [2] 4= [3 or more]**	
29. What are the problems you face in production of food? (Rank) **a=Climate change b=Economic crisis c=Tech d=Lack of labour**	
30. Do you have access to farming inputs? **1=[yes] 2=[no]**	
31. To what extent do you rely on livestock for food? **1=[extremely] 2=[moderate] 3=[lesser extent]**	
32. Have you received food aid in the last 6 months? **1=[yes] 2=[no]**	
33. Do you prefer to receive food aid, buy or grow own food? **1= food aid 2= buy 3= grow own food**	
34. What form of aid would you prefer? **1=money 2=inputs 3=other**	
35. Do you use any of the following as part of your diet?	
Wild fruits: **1=[yes] 2=[no]**	
Wild vegetables: **1=[yes] 2=[no]**	
Insects: **1=[yes] 2=[no]**	

SECTION F: DIGITAL INFRASTRUCTURE AND INFORMATION AND COMMUNICATION TECHNOLOGY

36.	Do you Own: **1=[yes] 2=[no]**	Can you Access: **1=[yes] 2=[no]**	Can you Use with no help: **1=[yes] 2=[no]**	Received training **1=[yes] 2=[no]**	Cost of use: **1=low; 2=high; 3=n/a**
Mobile Phone					

Desktop/Laptop					
Television					
DVD Player					
Internet					

SECTION F: INFORMATION ACCESS

37.	General News **1=[yes] 2=[no]**	Agriculture Information **1=[yes] 2=[no]**	Market Information **1=[yes] 2=[no]**	Food Related Information **1=[yes] 2=[no]**	Education Content **1=[yes] 2=[no]**
Mobile Phone					
Desktop/Laptop					
Television					
DVD Player					
Internet					

SECTION G: NETWORKS/INFRASTRUCTURE

38. Which telecommunication network do you use? **1= TelOne 2=Econet 3=Telecel 4 =South African**	
39. Are there any visible physical network infrastructures? **1=[yes] 2=[no]**	
40. How strong is the network connectivity **1=extremely poor 2=weak 3=average 4=strong 5=very strong**	
41. How reliable is your network? **1=Extremely reliable 2=Average 3=Extremely unreliable**	
42. Does the whole family use the same network? **1=[yes] 2=[no]**	
43. How satisfied are you with the current digital infrastructure? **1=Extremely satisfied 2=Average 3=Extremely unsatisfied**	
44. Are you willing to try a new network? **1=[yes] 2=[no]**	
45. What would do you expect in a new network?	
46. What Feature of the phone is most important to you? **1=Battery life 2=Screen Size 3=Brand name**	
47. If you do not have a mobile phone, Reasons for not having cellphone? **1=Cost 2=Share with others 3=Don't need it**	
48. If you use a mobile phone, how much airtime do you normally recharge with per week? **1=<$5 2=$5-10 3=$11+**	
Do you use WhatsApp: **1=[yes] 2=[no]**	
Do you use Facebook: **1=[yes] 2=[no]**	

Do you use Eco-cash: **1=[yes] 2=[no]**	
Do you use E-mail: **1=[yes] 2=[no]**	
49. Do you think that the mobile phone impacts on food (livestock) system? **1=[yes] 2=[no]**	
50. What infrastructure is critical to the livestock system (rank) **a=roads b=markets c=digital (technology)**	

Thank you for participating in this research. If you would like to receive results from this study, kindly provide your contact details:

E-mail: _____ Cell: _____

APPENDIX B: INTERVIEW GUIDE

Key Informant Interview Protocol

Introduction

I am Leon Gwaka, a PhD student at the University of the Western Cape. My research focuses on understanding the impact of digital infrastructure transformation on the livestock systems and food security in Beitbridge. You have been identified as a key stakeholder in the livestock system and hence the request for you to participate in this key informant interview. To ensure that I do not miss any details we discuss, I will be recording the information (digitally) and making notes. However, if you are not comfortable with recording, I will only make notes. Should I miss any notes, I may request that we revisit the question. All the responses will be kept confidential and will only be used for academic purpose. Remember that you don't have to talk about anything you are not comfortable with. You have the right to withdrawal from this interview. By proceeding to participate in this interview; you consent to what we have discussed. Our interview is estimated to take approximately 30-45 minutes.

Questions:

1. What is the focus of your business in Beitbridge?
2. Who are the main stakeholders you deal with and how do you interact with them?
3. How are you involved in the Beitbridge livestock system and how significant is livestock to you and the community at large?
4. Can you kindly describe how the livestock system in Beitbridge is structured?
5. Think back over the years, what are some of the key highlights for the livestock system?
6. What are the key challenges within the livestock systems and how can these be solved?
7. Based on your experience, what changes are happening in the livestock system and why?
8. How would you want the livestock to function – making reference to how it has functioned in the past 5 years?
9. How do you feel about the state of the infrastructure (specific reference to digital) in Beitbridge and its importance in creating the livestock system you desire?
10. What are your thoughts on integrating mobile technology in the livestock system?
11. In what ways do you think the community can be engaged to promote the adoption and use new technology in the livestock system? Are there any efforts currently?
12. What challenges are likely to be encountered in trying to integrate technology in the livestock system?
13. Do you have any questions, comments or suggestions on this topic?

Thank you for your time. If interested in these results, kindly provided your contact details:

Name & Surname: _____Contact:_____

---------- The end of our interview ----------

APPENDIX C: INSTITUTIONAL ETHICAL CLEARANCE

UNIVERSITY of the WESTERN CAPE

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11 April 2017

Mr T Gwaka
Institute for Social Development
Faculty of Economic and Management Sciences

Ethics Reference Number: HS17/3/2

Project Title: Digital Infrastructure and food systems in rural communities in Zimbabwe.

Approval Period: 10 April 2017 – 10 April 2018

I hereby certify that the Humanities and Social Science Research Ethics Committee of the University of the Western Cape approved the methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval. Please remember to submit a progress report in good time for annual renewal.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

PROVISIONAL REC NUMBER - 130416-049

FROM HOPE TO ACTION THROUGH KNOWLEDGE.

APPENDIX C1: INSTITUTIONAL ETHICAL CLEARANCE

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.
- FWA 00002567, Approved dd 22 May 2002 and Expires 20 Oct 2016.
- IRB 0000 2235 IORG0001762 Approved dd 22/04/2014 and Expires 22/04/2017.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

28/01/2016

Approval Certificate
New Application

Ethics Reference No.: 468/2015

Title: Participatory needs assessment for innovative resilience interventions to improve food security and income generation in four Southern African communities: A qualitative study

Dear Olalekan AyoYusuf

The **New Application** as supported by documents specified in your cover letter dated 26/01/2016 for your research received on the 26/01/2016, was approved by the Faculty of Health Sciences Research Ethics Committee on its quorate meeting of 27/01/2016.

Please note the following about your ethics approval:
- Ethics Approval is valid for 1 year
- Please remember to use your protocol number (**468/2015**) on any documents or correspondence with the Research Ethics Committee regarding your research.
- Please note that the Research Ethics Committee may ask further questions, seek additional information, require further modification, or monitor the conduct of your research.

Ethics approval is subject to the following:
- The ethics approval is conditional on the receipt of 6 monthly written Progress Reports, and
- The ethics approval is conditional on the research being conducted as stipulated by the details of all documents submitted to the Committee. In the event that a further need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

We wish you the best with your research.

Yours sincerely

Professor Werdie (CW) Van Staden
MBChB MMed(Psych) MD FCPsych FTCL UPLM
Chairperson: Faculty of Health Sciences Research Ethics Committee

The Faculty of Health Sciences Research Ethics Committee complies with the SA National Act 61 of 2003 as it pertains to health research and the United States Code of Federal Regulations Title 45 and 46. This committee abides by the ethical norms and principles for research, established by the Declaration of Helsinki, the South African Medical Research Council Guidelines as well as the Guidelines for Ethical Research: Principles Structures and Processes 2004 (Department of Health).

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✉ Private Bag X323, Arcadia, 0007 - 31 Bophelo Road, HW Snyman South Building, Level 2, Room 2.33, Gezina, Pretoria

APPENDIX C2: EXTRACT FROM THE MOSMAC CONTRACT

5.7.1. No information relating to this Contract shall be released other than to authorized employees of the Grant Beneficiary requiring the information for the performance of work as laid out in the Work Plan, without the prior written approval of MakSPH and UP SA RILab. In no event shall the interests of MakSPH and UP SA RILab in this Contract be indicated in any advertising or publicity without the prior written approval of MakSPH and UP SA RILab.

5.7.2. The Grant Beneficiary consents to share information and data related to performance of the work funded by MakSPH and UP SA RILab even after the funding period, especially for innovations that go to pilot and beyond. Such information and data may include additional funds attracted in support of the innovation, new partnerships forged to advance the innovation, and uptake and usage statistics of the innovation and subsequent modifications.

5.7.3. This Contract shall not prevent or hinder the students of both Parties from submitting theses for the purpose of obtaining their degrees based on the results obtained during the course of work undertaken pursuant to this Contract nor prevent or hinder the Parties from publishing the research output developed pursuant to this Contract.

For Makerere University School of Public Health:

Thus done and signed at Makerere this 29 day of June 2017

Prof. William Bazeyo
Dean Makerere University School of Public Health/
RAN Chief of Party

As witnesses:
1.
HARRIET GRACE MAGALA
ADVOCATE

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NB: Extract of the MOSMAC contract. Point 5.7.3 allowed the use of data from MOSMAC project for thesis completion and publication of manuscripts.

APPENDIX D: CLEARANCE FROM LOCAL AUTHORITIES

MINISTRY OF RURAL DEVELOPMENT, PROMOTION AND PRESERVATION OF NATIONAL CULTURE AND HERITAGE

TEL: (0286) 22300/ 22481/22118

All correspondence to be addressed to:
The District Administrator

ZIMBABWE

Reference:

DISTRICT ADMINISTRATOR'S OFFICE
BEITBRIDGE DISTRICT
HAGELTHORN ROAD
P. O Box 61
BEITBRIDGE

15 AUGUST 2017

TO WHOM IT MAY CONCERN

REF: PERMISSION TO UNDERTAKE FIELD WORK IN WARD 15, BEITBRIDGE DISTRICT FOR MR LEON GWAKA [ID:61-057010 P61] UNIVERSITY OF THE WESTERN CAPE

The above matter refers:

May you please receive Mr Leon Gwaka who is carrying out a research study in ***Digital Infrastructure And Food Systems In Rural Communities In Zimbabwe***, Ward 15 Beitbridge District in Zimbabwe.

Please take note of the following:

1. **The study will adhere to ethical requirements [HS17/3/2]**
2. **The researcher will engage and acknowledge the existence of traditional leadership within the specific villages in which the study will be conducted**
3. **The data gathered during this study will solely be used for academic purposes.**

May you kindly work with him.

Thank you

JAHSON MUGODZWA

.....

A/DISTRICT ADMINISTRATOR

DISTRICT ADMINISTRATOR
15/08/17
P.O. Box 61, BEITBRIDGE
Telephone 300

MINISTRY OF RURAL DEVELOPMENT, PROMOTION AND PRESERVATION OF NATIONAL CULTURE AND HERITAGE

APPENDIX E: INFORMATION SHEET FOR FOCUS GROUP DISCUSSIONS

Private Bag X17, Bellville 7535, Cape Town, South Africa
Telephone :(021) 959 3858/6 Fax: (021) 959 3865
E-mail: julian.may120@gmail.com *or* wdtucker@gmail.com

INFORMATION SHEET FOR FOCUS GROUP DISCUSSIONS

Project Title: Digital Infrastructure and food systems in rural communities in Zimbabwe

What is this study about?

This research project is being conducted by Leon Gwaka, a PhD student at the University of the Western Cape. Due to your experiences within the food system of Ward 15, you have been identified as a key stakeholder who can make relevant contribution to this study through your participation in a Focus Group Discussion. The purpose of this research study is to understand opportunities and challenges of digital transformation in the community and how this transformation in digital infrastructure may impact on the food system. Also, the study aims to understand the desired future food systems in Ward 15. The results of the study will assist policy makers to determine the necessary digital transformations required which can assist the community to achieve its desired food systems.

What will I be asked to do if I agree to participate?

As a participant in the FGD, you will be asked to make contribution towards the discussion of a central topic. While there are no right or wrong answers, as the facilitator I will provide guidance on issues of discussion to ensure that the discussion is relevant and within the stipulated time. Also, as a participant, you will be required to observe set rules for the discussion and respect the opinion of other participants. This FGD is expected to take between 1-2 hours. You may be required to undertake some activities during the FGD. However, you have the right not to contribute if you deem necessary.

Would my participation in this study be kept confidential?

All your personal information will be kept confidential and will remain anonymous if that is your choice. You will be required to sign a consent form to protect your privacy and confidentiality while participating in this study. The identity of the people to be interviewed will be kept confidentially and details of identity will only be provided voluntary or used only with consent. The information collected will be kept safe and used for the purpose for this research project. In this research report, identity of the participants will be protected to the maximum.

What are the risks of this research?

There are no risks involved in participating in this research project. From the beginning, aims and objectives will be clear.

What are the benefits of this research?

This research is designed to inform policy and strategy for community development. Even though no personal benefits are envisioned, the discussions can provide useful insights which individuals can reflect on to inform their livelihood strategies.

Do I have to be in this research and may I stop participating at any time?

Your participation in this research is completely voluntary. You may choose not to participate and to stop participating at any time you want. If you stop or decide not to participate, you will not lose anything.

Is any assistance available if I am negatively affected by participating in this study?

There are no negative effects that could happen from participating in this study.

What if I have questions?

This research is being conducted by **Leon Gwaka**, a student at the University of the Western Cape. His contact number is +27 61 802 6318. Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact my supervisor **Prof William Tucker**, Faculty of Natural Science, Computer Science Department, University of the Western Cape, his telephone number, +27 21 959 2516.

This research has been approved by the University of the Western Cape's Senate Research Committee and Ethics Committee (**Reference HS17/3/2**).

APPENDIX F: LETTER OF CONSENT

University of the Western Cape

Private Bag X17, Bellville 7535, Cape Town, South Africa
Telephone :(021) 959 3858/6 Fax: (021) 959 3865
E-mail: julian.may120@gmail.com *or* wdtucker@gmail.com

Letter of consent:

I……., have had the opportunity to ask any questions related to this study, and received satisfactory answers to my questions, and any additional details I wanted.

I agree to take part in this research.

I understand that my participation in this study is voluntary. I am free not to participate and have the right to withdraw from the study at any time, without having to explain myself. I am aware that this interview might result in research which may be published, but my name may be/ not be used (circle appropriate). I understand that if I don't want my name to be used that this will be ensured by the researcher. I may also refuse to answer any questions that I don't want to answer.

Date: ……

Participant Name: …….

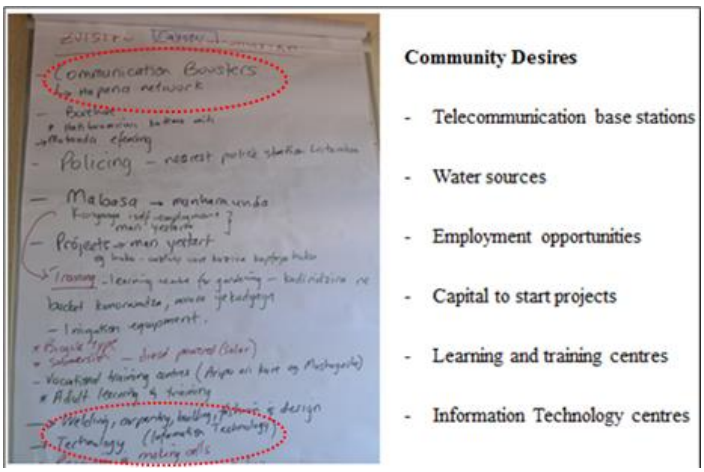
Participant Signature: …….

Interviewer name: ……..

Interviewer Signature: …….

If you have any questions concerning this research, feel free to call (Leon Gwaka, +27 61 802 6318) or my supervisor, (Professor William Tucker, +27 21 959 2516). NB: During the participation, a translator will be used to facilitate translation to local language.

APPENDIX G: ADDITIONAL SUPPORTING EVIDENCE



Top Figure: Notes generated during community engagement

Middle Figure: Community visioning exercise in Beitbridge

Bottom Figure: Signing the MOU with the Acting Chief Executive Officer at Beitbridge RDC offices