

DIGITAL TECHNOLOGIES AND SUSTAINABLE LIVESTOCK SYSTEMS IN RURAL COMMUNITIES

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ABSTRACT

The 43rd Committee on World Food Security (CFS) convention reiterated the importance of livestock towards eliminating food insecurity across the globe. Livestock provides extensive services and products which are critical in addressing the issues of hunger, malnutrition, health and diseases. However, despite such importance, livestock systems across the globe continue to face the challenge of sustainability. In this research article, using ethnographic research techniques, we examine the Beitbridge livestock systems to understand the vulnerabilities within the system and current efforts to overcome. The article identifies that the Beitbridge livestock system, similar to many others, faces numerous socio-ecological and political economy challenges. Also, in the past engagement of the author and the community, it emerged that there was limited use of digital technologies within the community. Therefore, this study explore whether digital technologies can contribute towards sustainability of livestock and if so, how. The major findings of the study are that, DTs have affordances which can be exploited to contribute towards the sustainability of the livestock system. However, in order for this to happen, there is need for convergence of conditions e.g. presence of supporting institutions and improvement of digital infrastructure. These findings confirm the need for context based studies on DTs. The findings of the study provide practitioners and policy makers ‘something to think about’ in the development of DTs and supporting systems.

KEYWORDS

Zimbabwe, Food Security, Livestock Systems, Sustainability, ICTs, DTs

1. INTRODUCTION

The focus of this research is to investigate whether digital technologies¹ (DTs) can contribute towards creating and maintaining resilient and sustainable livestock systems in Beitbridge rural communities for smallholder livestock farmers, and if so, how and in what ways (Vallauri, 2014, p. 173, p. 178; Lekakis, 2014). Resilient and sustainable livestock systems are a cornerstone of food secure communities and the demand for livestock products and services is set to increase in the near future due to the projected global population increase (McDermott et al., 2010; Herrero & Thornton, 2013). However, despite the importance of livestock, the resilience and sustainability of the livestock systems across the globe, particularly in rural communities, is increasingly under threat due to general environmental challenges (GEC), volatile commodity markets and fragile political economies. Also, as complex systems with a plethora of actors, livestock systems are affected extensively by the unpredictable interactions of actors within the systems e.g. power dynamics. It is prudent therefore to indicate that modern livestock systems are facing major strains which are

¹ There are several definitions for digital technologies. In this research paper, DTs refer to “... internet, mobile phones and related technologies that facilitate the collection, storage, analysis and sharing of data and information ...” (Deichmann et al., 2016).

projected to continue (Tendall et al., 2015). As a result of this, Gahukar (2016) specifically indicates that "... [r]elying on food strategies including livestock production [systems] to feed our ever-growing human population seems to be impossible." For this reason, if communities are to be food secure, there is need to establish mechanisms to overcome the challenges threatening modern livestock systems and this may include effecting infrastructure transformations or even deploying DTs (Thimm, 1993; Mulligan & Berti, 2015). While developing sustainable livestock systems requires a 'cocktail' of solutions, Mulligan and Berti (2015) suggest that DTs may hold the key to coordinating sustainable food systems. Based on this, the research attempts to critically examine the potential of DTs in positively transforming livestock systems also considering Choi and Graham's perspective that, "... practices of food production, consumption, and distribution have the potential to go through immensely transformative shifts as information and communication technologies (ICTs)² become increasingly embedded in every domain of contemporary life" (Choi & Graham, 2014).

The use of DTs in agriculture is not an entirely new concept even in developing countries despite many researchers focusing on the limitation of the digital divide in developing countries. Based on current research, it is expected that by the year 2019 at least 930 million people in Africa will be making use of mobile phones and 75% of these will be accessing the internet (Caine et al., 2015). Based on these predictions, it is inevitable and reasonable to consider that, critical systems, such as livestock systems will be transforming to accommodate ICTs as they become embedded in everyday life even in rural communities (Hearn et al., 2014, p. 203). However, to date, there are extremely limited studies to draw lessons from on how ICTs can be and/or will be embedded in livestock systems specifically to improve the resilience and sustainability of these systems in the context of rural communities such as Beitbridge. As such, this research builds on this to investigate several questions on the potential to integrate DTs in the livestock systems i.e. can DTs fit in the livestock systems, how and where? What impact would the integration of DTs into the livestock system have on the systems' sustainability? Finally, what opportunities and challenges exist to integrate these DTs in the livestock systems? (Debsu et al., 2016) The questions probed in this research have implications on and are relevant to the work of technology designers i.e. (are DTs designed to fit in the livestock systems? If not, can they? (Moran & Dourish, 2001)), technology users (are users able to identify and exploit technology affordances? Do users have adequate agency, resources and support to use DTs?), and finally, policy makers (are the policies in place conducive enough to allow the introduction and use of DTs in the livestock system?)

Before exploring the role of DTs in achieving and maintaining resilient and sustainable food systems, Svenfelt and Zapico (2016) suggest that it is necessary to think about what sustainable and resilient systems are³. In order to be able to answer the research questions set above, there is, therefore, a need to also critically examine the livestock system considering that it is a complex socio-ecological system⁴ comprising of many actors, drivers, resource units, process and outcomes (Marshall, 2015). By understanding the livestock systems as a complex system, it will be possible to determine the efficiencies and inefficiencies within the value chain of the system and thus, also identify the potential areas

² Also, in this study, DTs is interchangeably used with ICTs.

³ Sustainable and resilient food systems remain contested concepts normally referring to future ability of the system (Esguerra et al, 2017; Pfister et al, 2016; Lankoski et al, 2016) and, in this study, it refers to food systems which communities desire or wish for or would love to have (which the community value – see *Kleine, 2010; 2013*).

⁴ Socio-ecological systems also known as human-environment system (social and ecological) (Young et al, 2006)

to embed DTs. Analysis of complex systems, therefore, can be better completed using systems thinking approach – thus, taking into consideration all the elements relating to the livestock system and viewing them as critical rather than as less important (Ison et al., 1997).

This research study takes form of a critical strand and thus also factors in the fact that “... ICTs can have both positive and negative effects, both intended and unintended...” (Majchrzak et al., 2016) and as a result, these ICTs “... may not always result directly in the outcomes that ICT is hypothesised to influence” (ibid). The majority of studies on ICT hypothesize ICTs to have positive impact in any area in which the ICTs are deployed and yet, the impacts which DTs have on the society or on any system are not always based on the technical affordances of technology but are also an “... extension or amplification of the human intention.” (Toyama, 2011). Further to this, DTs’ impact on societies also depends on how such DTs are embedded and accepted in the sub-systems such as the socio-cultural system of the communities. DTs which fail to capture dynamics of sub-systems such as socio-cultural, religious and even political systems are likely to have less success and impact especially on systems such as the livestock systems which have social and cultural associations within societies.

2. OVERVIEW OF THE BEITBRIDGE LIVESTOCK SYSTEM

Food insecurity has been and continues to be a dominating topic of discussion on the global agenda (Rush et al., 1978, p. 114; Choi & Graham, 2014, p. 152). Most recently, the question of food insecurity was re-drafted into the Sustainable Development Goals (SDGs) as goal number 2 which aims to “End hunger, achieve food security and improved nutrition, and promote sustainable agriculture” (United Nations, 2016). In the 43rd convention of the Committee on World Food Security (CFS), it emerged that livestock is and will continue to be a key to the achievement of food security through the diverse products and services offered by livestock (CFS, 2016). However, despite this, the livestock sector remains an overlooked sector as a poverty reduction strategy in most developing countries and transformations in this sector are not occurring at the desired rate (Alary et al., 2011). Before Alary and co-authors made these observations, Mavedzenge et al. (2006) had already proposed that African communities need to take advantage of the global trends on the rising demand for livestock products but this did not happen fast enough. Now that livestock is increasingly becoming critical towards addressing food security, there are renewed interests in exploring how to exploit benefits from the livestock. However, the global environmental changes and political economy challenges are complicating the livestock systems threatening the resilience and sustainability of the livestock systems (Herrero & Thornton, 2013). It is critical however to indicate that even though climate change and political economy challenges are universal challenges, livestock systems are context-specific and need to be explored on a case by case without rushing to draw generalisations.

Beitbridge is located at the border of South Africa and Zimbabwe. The area lies in the agro-ecological region (V) which experiences a limited amount of rainfall (<500mm) per annum (Mugandani et al., 2012). As a result of the harsh climatic conditions, crop production is extremely restricted and many households’ primary livelihood activity is livestock production often complemented by natural resources harvesting and selling. Households also rely on remittances as well border-related income generating activities – both legal and illegal⁵. Households’ food security in Beitbridge is closely tied to livestock in several ways. To cover immediate social needs which require cash, households sell livestock either at the formal auction or farm-gate (Alary et al., 2011). Furthermore, livestock provides other essential products for food and nutrition security such as meat and milk. In crop producing

⁵ Findings from field work conducted between November 2015 and August 2016

regions e.g. Rushinga, households use livestock as draught power while utilising the waste as manure and processing the waste to produce biogas. Also, there is a considerable number of young uneducated male employed as livestock attendants (herd boys) and as such, livestock creates employment for these young men. Apart from the products and service delivered by livestock, African communities generally use livestock as ‘storage of value’ or ‘live banks’ which is further associated with status within the society. Livestock further has cultural significance being used during marriage negotiations in most African communities.

Even though the majority of households in rural communities such as Beitbridge have considerable numbers of livestock, the quality of life that these households lead are extremely poor e.g. they are food insecure, have poor housing and cannot afford the basic needs. The mere ownership of livestock in rural communities does not result in improved quality of life as there is a need for *convergence of conditions for this to happen*. Beitbridge rural communities are characterised by poor infrastructure, poor supporting institutions, poor policies and regulations which all lead to poor markets for livestock. The majority of households in Beitbridge Ward 15 are unable to access reliable Zimbabwean telecommunication and radio services. As a result, households rely on South African mobile networks and pirate radio stations. The net impact of these conditions is that smallholder farmers are unable to obtain optimal returns on their livestock when they sell. The spill-over impact of smallholder farmers obtaining sub-optimal returns on livestock is a failure to access adequate nutritious food and hence food insecurity.

In addition to these challenges, the recent global environmental changes are posing a threat to the resilience and sustainability of the Beitbridge livestock system. Between November 2015 and March 2016, the entire district lost an estimate 7000 herd of cattle as a result of lack of quality feed, lack of water, heat stress and other climate-induced diseases. It is increasingly becoming evident that smallholder farmers in Beitbridge are failing to cope with the impact of climate change. Apart from the losses of livestock, climate change is also impacting the auctioning of livestock further straining household incomes in Beitbridge. Traditionally, the livestock market in Beitbridge is considered a *thin market* with extremely limited buyers to match the large numbers of smallholder farmers (Mathews et al., 2015). However, the process of livestock auction further deteriorates during phases of livestock feed shortages. Smallholder farmers have limited access to credit as well as limited income generating ventures resulting in failure to purchase supplementary feed. The lack of feed, water coupled with heat and stress result in poor quality livestock at auctions which fetch extremely low prices. During feed shortage periods, smallholder farmers are ‘forced’ to engage in distress sales and lose out extremely.

3. SITUATING THE STUDY IN ICT4D AND EXPLORING THE ‘D’

The study of existing and potential links between ICTs and ‘development’ is classified under the ICTD⁶ banner (Burrell & Toyama, 2009; Heeks, 2009). Heeks is one of the leading scholars in the field of ICTD and based on his experience in studying, teaching and researching on ICTD, he mapped out research in the field to indicate the highest and lowest research gaps within the field of ICT4D. However, even though Heeks mapped out these research gaps, it is critical to understand that these indications are not absolute and universal and can only be ‘in context’. For instance, one community may be concerned more with health issues than agricultural issues thus, the positioning of ICTs in communities should be mapped based on community needs than existing studies nor technology designers’ needs.

The focus of this study, DTs and livestock systems, can be linked to the following areas selected by Heeks; ICTs and poverty, e-Agriculture, ICTs and food (Heeks, 2014). The

⁶ The acronym is interchangeably used with ICT4D – both reflecting Information Technologies for development

livestock system is directly linked to several aspects of a society including poverty, agriculture and food. Based on this, it applies therefore that the integration of ICTs in the livestock system directly addresses poverty, agriculture and food related issues. There are often contestations on the exact meaning of the 'D' in the ICTD (Dearden & Tucker, 2016). The 'D' explored in this research, therefore, relates to the *resilience and sustainability of the livestock system* which ultimately contributes to improved food security

The concept of sustainability has taken a centre stage in many discussions and debates. There are many unclarified issues e.g. definitions, measurement, meaning and applicability between different schools of thought. However, Hinrichs (2010) posits that achievement of sustainability, whichever context she applies the term, is likely to result from "multiple recipes" thus, directly suggesting that it takes many efforts therefore to achieve. However, in the context of this research study, *resilience* refers to the ability of the livestock system to withstand the biophysical (climate change) and political economy challenges while *sustainability* is considered as the continuous "...balanced relationship among environmental, socio-cultural and economic aspect" within the livestock system. Therefore, in this study, if the livestock system within Beitbridge can withstand the biophysical and political economy while maintaining balanced relationships between socio-economic, cultural and environment aspects, this would be considered 'development'. Therefore, the study seeks to understand whether the appropriation of DTs within the Beitbridge livestock system can result in development hence classification of the study under the ICTD banner.

4. THEORETICAL AND CONCEPTUAL FRAMEWORKS

Several research studies have been conducted to examine the intersection of DTs and development areas including but not limited to agriculture, education, health and politics (Bello & Aderbigbe, 2014). For this reason, this research is also framed on existing theories which contribute to the better understanding of the DTs in society dimension. The research triangulates selected theories to provide a holistic analysis considering the potential weaknesses entrenched in each theory and/or framework. The theories selected here, based on previous studies, are the technology affordances and capabilities approach.

Firstly, the study uses the Technology Affordances theory. The Technology Affordance theory has been examined and applied in many studies (see Leonardi, 2011; Majchrzak, 2016; Majchrzak & Marcus, 2013). In the context of DTs, Rao (2009) argues that "[t]he importance of ICTs is not in the technology but in its affordances or enabling and facilitating component." Affordances are identified as "... properties of the world defined with respect to people's interaction with it." (Gaver, 1991). However, it is critical to indicate that different individuals may perceive one object to have different affordances even though Gaver (1991) indicates that technology affordances are independent of an individual's perception. As such, technology affordances exist whether an individual knows about them, cares about them or not. An individual's perception of technology affordances is determined by among other elements, one's culture, social setting, experience and intentions of the user of the specific artefact. In order for a targeted user in this instance, smallholder livestock farmers, to exploit the technology affordance, there is a need for the user to accept the technological artefact.

Livestock systems are considered complex socio-ecological systems and studying such complex systems often requires the application of several frameworks and theories to obtain a holistic understanding. For this reason, this study also applies the Choice Framework developed by Kleine (2010; 2013) as an effort to operationalise Amartya Sen's Capabilities Approach. In applying the Choice Framework, Kleine suggests identifying 'development' as an individual's ability to make choices and "to lead the lives they have reason to value" (Kleine, 2010). Furthermore, in supporting Sen's opinion, Kleine (2010; 2013) proposes that

development outcomes should not be predetermined but rather should be determined by individuals and this was the approach used in this study. A needs finding engagement enabled the authors to determine and confirm the community desired impacts within the livestock system. Within the Choice Framework, 'structure' is critical to support 'agency' (Kleine, 2010). Thus, in the context of this study, we also examined the existence of relevant policies, supporting institutions as well as access to DTs. For instance, the study managed to determine that within the community under study, there is limited connectivity on Zimbabwean mobile networks and as a result, community members decided to use South African networks. Within the study area, there are certain smallholder livestock farmers making use of DTs already and these expressed 'a sense of choice' compared to those who are yet to use DTs. Therefore, the Choice Framework provides a critical framework for the analysis of the DTs' embedding within the livestock systems in Beitbridge.

5. DATA COLLECTION

Data used for this study were collected between November 2015 and August 2016 as part of a larger project focusing on improving livestock markets in Beitbridge. The researcher employed qualitative techniques to obtain data using key informant interviews (government department officials e.g. livestock production officers, extension officers), observations and focus groups discussions techniques. Research participants were drawn from Ward 15 which comprises of 4 villages, Mapai, Dumba, Shabwe and Old Nuli. However, Ward 15 mixes with Ward 5 during livestock auction at Lutumba cattle pens and thus, during observations, some observed results may be from smallholder farmers in Ward 5. Ethical clearance was obtained from the University of Pretoria, and subsequent permissions were granted by local authorities and local leadership.

5.1. Key Informant Interviews

Key informant interviews were conducted with selected smallholder farmers, traditional leaders, representatives of farmer groups as well as representatives of the relevant government institutions or departments involved in livestock systems. The main purpose of the key informant interviews were to generate insights from knowledgeable individuals on livestock systems. Key informant interviews helped the researchers to obtain a thorough understanding of not only how but also, why people do certain things within the livestock system in Beitbridge. Furthermore, key informant interviews were conducted with carefully selected individuals who were identified through various processes including but not limited to 'snowball techniques'. Interview guides were developed and used to provide guidance to the researcher on issues to discuss and also, provided a guide on how the interview should flow. During the interview process, the researcher, in addition to audio tapping, also recorded responses provided by interviewees. The researcher developed notes which were further expanded and developed into themes and categories. The process of developing themes was cyclical but consisted of four major phases (Vaismoradi et al., 2016). The process started with *initialisation* to capture participant's accounts. This was followed by the *construction* phase which 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.

5.2. Participant Observation at Livestock Auction

The researcher also conducted observations of the livestock auctioning process and other relevant livestock related activities within the selected research area e.g. livestock dips. Auctioning of livestock is conducted once a month at selected auction places resulting in a

continuous week of livestock auctioning. The researcher attended the auction at Lutumba twice and also visited other auction sites outside of Ward 15. Even though the livestock auction is a public event, authorization to take photographic evidence was requested in writing by the researcher from the local authorities. During the observation, the researcher attempted to collect data that did not emerge from key informant interviews and focus group discussion.

5.3. Focus Group Discussion

In addition to the key informant interviews and participant observation, focus group discussions were also conducted to collect data in a triangulation of data collection methods. Participants in the focus groups discussions were randomly selected smallholder farmers drawn from the four villages and were mainly those involved in and/or with interests in the livestock production and trading. Firstly, a focus group discussion was done in each of the four villages and then two further focus groups discussions combined two villages. In total, six focus group discussions were conducted averaging 11 participants per focus group discussion. The discussions were guided by a focus group discussion guide. Responses from the focus group discussion were audio-tapped using a digital voice recorder (Olympus VN-731PC). Thematic analysis was conducted to analyse the data sets from the focus group discussions.

Table 1: Summary of the Data Collection Activities

Data Collection Method	Research Participants	Selection Criteria	Total Participants
Key Informant Interviews	Smallholder farmers	Farmers in Ward 15 with livestock	10
	Officers of selected government departments	Office bearer in government department related to livestock (more than 2 years in Beitbridge)	6
	Local leadership	Local leaders	4 (one per village)
	Other stakeholders	Participants in livestock system e.g. buyers and agents	5
Focus Group Discussions	Smallholder farmers	Farmers in Ward 15 with livestock	6 FGDs (average participants = 11)
Participant Observation	Livestock systems actors	Participants at livestock auction	5 auctions attended

6. DIGITAL INNOVATIONS IN ZIMBABWE

There are many technological innovations including digital platforms which have recently emerged in developing countries including Zimbabwe. These technological innovations are mostly in the form of mobile applications or simply 'Apps'. The surge of mobile phones in developing countries, even most deep rural parts, continue to provide an opportunity for start-ups to develop low-cost innovations compatible with the mobile phones. The integration of DTs in the food systems and livestock systems specifically can, therefore, be expected to be championed largely through mobile platforms (Rathod, Chander & Bardhan, 2016). However, the majority of rural households have access to feature phones capable of voice, text and basic functions and yet, mobile Apps are designed for smartphones (Karippacheril et al., 2013). The issue of whether to continuously develop new Apps or services is deliberated on in Wyche, Densmore and Geyer (2015) and it appears that there is a massive duplication

of Apps and services and yet, collaboration could benefit these different developers. Price reduction of smartphones is expected in the near future and it can be expected that smartphones will also be dominant in rural communities (Karippacheril et al., 2013). Also, for this reason, most successful innovations targeting rural communities are those using USSD services e.g. Eco-cash.

Table 2: List of Selected Digital Innovations Accessible in Zimbabwe

Innovation/ Platform	Functionality	Technology	Basic Requirement	Aspect
Remote Livestock Marketing System	Online livestock marketing	Web-based system	PC/Smartphone	Livestock sales
E-mkambo	Agric Info System	Mobile phone/Web/App	PC/Smartphone/Feature Phone	Commodity Prices
Eco-Cash, Telecash	Cash Transfer Payment system	USSD	Feature Phone	Payment system
Eco-Farmer	Micro-Insurance for crops against drought	USSD	Feature Phone	Weather information, farming tips information on when and where to sell, and the best price for their produce
Social media i.e. Facebook, WhatsApp, Twitter, Instagram etc.	Social networking, information sharing	Web-based / App	Smartphone	Information dissemination/sharing (e.g. social groups)
Dial-A-Mudhumeni	Extension services	Call in charged	Smartphone/Feature Phone	Best Agricultural Practice
Kurima Mari	Digital extension	USSD/Calling	Smart Phones	Best Agricultural Practice

The majority of digital innovations in developing countries such as Zimbabwe being developed for agriculture and/or developmental purpose are relatively in the initial stages surviving largely on donor funds. As a result of donor funds, these digital innovations often target only specific areas. Further to this, the development of most Apps is driven by existing ideas as well as being driven by the ‘need to develop an app which people will like’. As a result of this, most Apps being developed for rural communities are not customised for the rural communities (Rathod et al., 2016) resulting in these Apps failing to deliver value.

7. RESEARCH FINDINGS

7.1. Digital Innovations and Livestock Markets

Mobile phones have been credited extensively for enabling smallholder farmers in rural communities to access market information, alternative markets and also market prices. In Beitbridge, livestock marketing is conducted mostly through formalised markets (auction),

locally known as *showa*⁷. During the auction, buyers make bids for livestock until a price is agreed upon between the selling farmer and payments are handled by the local authority who facilitate the auction. The auction process observations made in Beitbridge are similar to those made in Ethiopian markets (Kocho et al., 2011). The auctioneers represent an independent third party only facilitating the buying and selling⁸. The process of livestock selling also involves several governmental departments e.g. police to verify livestock ownership (considering high livestock theft cases), veterinary to inspect the animal health as well as traditional leadership. Livestock without proper details, supporting documents and suspected of diseases are left unsold similar to those for which buyers and sellers fail to agree on prices for.



Figure 1. Livestock Auction in Progress (Photo credit: Paradzai Munyede)

During the auction, price discrepancies were observed between prices offered by buyers and those expected by farmers. The smallholder farmers *always* felt that they were being paid sub-optimal prices for their livestock and buyers justified prices based on their perception of livestock quality as well as market dynamics (Kocho et al., 2011). It is prudent to indicate that smallholder farmers in Beitbridge were found to be vulnerable to exploitation at auctions for several reasons. These smallholder farmers lack access to market information e.g. prevailing prices. Further to this, there are no readily available alternative markets and during auction visits, it was noted that the same buyers were relied upon. Buyers are well aware of the farmers' vulnerability and take advantage of the lack of competition to offer extremely low prices. These vulnerabilities, therefore, push smallholder farmers to sell their livestock even if they are not fully satisfied with the prices being offered. In all, the Beitbridge livestock market represents a classical thin market. The overall impact of this characteristic is that farmers always end with less disposable income for household needs and impacting also on household food security.

⁷ Showa directly translated from animal showing

⁸ Even though the auctioneer is an independent part, questions emerged when it was established that auctioneer is remunerated 1.5% (one and half percent) per sale. The objectivity and independence of auctioneer may be impaired.

Table 3: Randomised Observations at Lutumba Auction

Lot number	Live Mass	Farmer Price	Highest Bid	Other	SHF Gender
1	240kg	\$300 ⁹	\$260	N/A	M
2	300kg	N/A	N/A	No proper details ¹⁰	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

On the prices offered by buyers at the auction, smallholder farmers indicated that they were not satisfied but at the same time had no option. For instance, one smallholder indicated that,

“If you come with your livestock, you will be hoping for a *fair* price¹¹. 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.”

Of the total livestock brought to the auction, at least 40% remain unsold by the end of the auction for several reasons, chiefly among these, a lack of buyers. Apart from the failure to agree on prices with buyers, another challenge which farmers face is the lack of proper documentation for livestock. During the auction, livestock details i.e. 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. However, due to poverty and subsequently desperate need for income, smallholder farmers who fail to sell during 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 (McDermott et al., 2010). Often, smallholder farmers are forced to negotiate with buyers using “eye-ball” pricing in order to ensure that they secure a sell (Kocho et al., 2011).

Further to the above challenges, the cash crisis situation in Zimbabwe was another challenge faced by smallholder farmers during the time of conducting this research. 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

⁹ All currency in USD

¹⁰ A farmer should have livestock card with adequate details which are verified by police, veterinary and traditional leaders. The manual nature of the process provides potential problems which DTs (information storage) can also play a key role towards curbing.

¹¹ I probed to understand why the smallholder farmer was not optimistic about the best price and he indicated to me that smallholder farmers are now used to the pricing and came to the auction knowing what to expect.

field work, the country was experiencing cash shortages and this impacted smallholder farmers also. 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, 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. However, in an era of digital innovations e.g. mobile money transfer, digital payments, these innovations can be tapped into to overcome the challenges within the livestock systems cognisant of the limitations and challenges embedded in innovations.

DTs and more recent innovations can be used by smallholder farmers to overcome the challenges which they face in marketing their livestock and thus, improve the entire livestock system. Karippacheril et al. (2013) report that positive impacts were recorded relating to market efficiencies and market participation as a result of the introduction of mobile phones in India and Uganda respectively. Through GIS systems, locating additional buyers and selling points can enhance the diversity of selling options for livestock farmers. Also, conducting trade online can be critical in significantly reducing the transaction costs which are currently exorbitant for the smallholder farmers in most rural communities. During the livestock auction, smallholder farmers' mindset is also psychologically impacted on by the auctioning approach e.g. the approach of the auctioneer "... \$100, \$150 Any takers? \$200 going once, going twice Selling at \$200? ...Sold!!" Thus, some decisions made during the livestock auctioning are not well thought out and these can be avoided if the buying and selling were to be done online or in a more relaxed environment. The success of online trading in different industries mainly retail provide an indication of what could be coming to the livestock system in the near future.

However, even though DTs are thought to provide smallholder farmers with new approaches to livestock markets, Dearden and Tucker (2016) warn against the unintended consequences of technology. The livestock auction in Beitbridge is much more than buying and selling – it is a social event. This has been in existence for over a decade. 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, have the ability to revolutionise the livestock system, it is critical to consider the other disruptions which may occur within the system.

7.2. Digital Innovations, Livestock and Biophysical Risks

Apart from the political economy challenges, the livestock systems in rural communities are highly susceptible to biophysical risks and vulnerabilities – global environmental changes (GEC) (Herrero & Thornton, 2013). Climate change has become a major concern for both developing and developed communities. In rural communities relying on agricultural systems, the effects of climate change are highly visible. Over the years, agricultural output has dropped extensively leaving millions without food and sources of income. The livestock systems also have not been spared from the impacts of climate change. Climate change, in particular, has affected livestock in several ways e.g. lack of feed, water and emergence of new diseases. Over the years, smallholder farmers and other actors within the livestock system have devised approaches to overcome and deal with the impacts of climate change. Even though there are many scientific deliberations on dealing with climate change, these are poorly communicated to those at the Bottom of the Pyramid (BoP). The majority of smallholder farmers rely on traditional knowledge to deal with climate change.

However, the advent of DTs has brought revolutionary approaches to dealing with climate change which can also improve the resilience and sustainability of the livestock systems. Smallholder farmers and other actors within the livestock system can take advantage of new technologies such as remote sensing, crowdsourcing and mobile technology (Enenkel et al., 2015; Antle et al., 2016). There are new DTs which are being used to make a prediction of seasonal and weather forecast, communicating climate change information e.g. early warning systems and even dealing with the impacts of climate change (Eakin et al., 2015; Hearn et al., 2014). Further to this, DTs can be used to help communities to adapt to climate change for instance, through social interactions with others e.g. through social media (Stevens et al., 2016). There is extensive use of DTs in developing models to predict the future of climate change. Long lasting solutions for challenges within the systems require “structural transformation” which include technology advances (GSDR, 2015). Further to this, ICTs and recent innovations such as social media have potential to connect people in real time providing platforms for discussions and collaborations (Hearn et al., 2014). Often, communities struggle ‘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 farmers groups.

Against the increasing impacts of climate change, smallholder farmers in rural communities are in need of insurance options. However, similar to 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 in 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” (Econet, 2000). There are also other initiatives across the African region e.g. Index based insurance in Kenya which are leveraging on DTs to assist smallholder farmers to overcome the many risks and threats they are facing.

It is critical therefore to indicate that DTs are providing smallholder farmers and other actors within the system a massive opportunity to develop new approaches to solving traditional problems. In the African context, smallholder farmers use traditional knowledge mostly and DTs can be critical in the profiling and archive of that traditional knowledge. There is need however to develop mechanisms through which communities can accept DTs as some reject these DTs on the basis of conflicting values since DTs are characterised as bearing Eurocentric resemblance.

7.3. DTs, Livestock & Women

In attempting to address the challenge of food security and food systems’ sustainability, Odame et al. (2016) indicate that it is important to also consider gender. In African societies, culture often dictates the involvement of women in certain social activities and it has been noted that this practice often leads to underestimation of women’s potential, if not exploitation (Patel et al., 2016). However, it is undeniable that women play a critical role in ensuring households’ food security. The roles which women play in contributing towards household food security range from gathering to preparing indigenous foods to conducting petty trades to generate extra income to support the household. It is also inevitable that if societies are to achieve and maintain sustainable and resilient food systems, women must also be involved. For this reason, and considering earlier discussions on the role of DTs in transforming food systems, it becomes essential to also understand how women interact with DTs in rural communities.

In sub-Saharan, women constitute a significant portion of the smallholder farmers. The challenges which women face in agriculture are many and well-documented (Ogunlela & Mukhtar, 2009). As a result, the concept of gender in agriculture is critical to address (Nagothu, Kolberg & Stirling, 2016). DTs have many affordances and this also includes ‘giving voice to the marginalised’ (Poveda, 2016). Sharma and Maheshwari (2015) report that there is evidence of ‘women overcoming the fear of ICTs’ in many African communities. It is encouraging that even illiterate individuals in communities are embracing technologies. As indicated in Figure 2, it is evident though that the majority of rural communities have access to feature phones. Access to DTs is providing an opportunity to empower women – thus ability to makes choice and also, having the choice available to them (Said-Allsopp & Tallontire, 2015).



Figure 2: ICTs in Rural Communities

Therefore, based on improved ICTs 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 at home. However, DTs can overcome this challenge through instant messaging or even social networking. Even though this is anticipated in the near future, there is a need for efforts to educate women on the use of ICTs and also provide necessary support (see for example elements of Agriculture Innovation System, AIS).

8. DISCUSSION

8.1. Digital Technologies and Livestock Futures

This research is premised on the research questions outlined in the introduction and the conclusions are also drawn based on these questions. Therefore, the discussion part of the paper is structured as follows; firstly, I discuss the question Can DTs fit in the livestock systems, how and where? This is followed by a discussion on the potential impact of integrating DTs into the livestock system on the livestock systems’ sustainability. Finally, the section ends by exploring the opportunities and challenges which exist to integrate these DTs in the livestock systems.

8.2. Can DTs Fit in the Livestock Systems, How and Where?

The focus of the Committee on World Food Security (CFS) at the 43rd convention was on roles of livestock towards sustainable development for food security and nutrition. The critical importance of livestock was outlined at this convention cognisant of the threats facing the livestock systems. During the convention, India's major contribution also echoed by other countries was centred on the use of ICTs in tackling the diverse challenges within the livestock systems (CFS, 2016). As a result, the proposition to use ICTs in livestock systems was adopted as one of the many final outcomes of the 43rd convention of CFS and this provides a firm foundation to draw conclusions that *DTs can fit within the livestock systems*. However, generalisations cannot be drawn as DTs appropriateness is context specific and co-shaped by society (William & Edge, 1996). Even though CFS's recommendation is one major global decision of note, there are several studies which have long established and advocated for the relevance of DTs in livestock systems (Debsu et al., 2016).

The researchers adopted the value chain analysis approach¹² to understand the 'how and where' DTs fit in the livestock systems. The livestock system is made up of value chains and within these value chains, there are many inefficiencies and opportunities to integrate DTs. The livestock systems comprise of production, processing, marketing and consumptions and DTs can be applied at any stage. There are many types of DTs (see for example list in Table 1) including those aimed at production and others aimed at other parts of the livestock value chain (Tendall et al., 2015). In Beitbridge, the researchers are specifically developing a set of digital tools (ussd, mobile app and web-based services) aimed to the livestock sector. The development of these tools is need driven design.

Table 4: Exemplifying DTs Integration in the Livestock Value Chain

Value Chain Component	Technology Affordance	Example of DT/ICTs
Production	Information Access, Consulting, Forecasting, Input Distribution	USSD, Internet Computer, Phone
	Disease surveillance	Same as above
	Veterinary services	Same as above
Marketing and Distribution	Linking with buyers	Same as above
	Market Price information	Same as above
Policy	Women participation	Same as above
	E-government (online participation)	Same as above

In all, DTs can fit within the entire value chain of livestock systems (Chen, White & Holden, 2016; Singh et al., 2016; Waters-Bayer, 2016). In the production stages, DTs are already playing key roles in livestock monitoring, health and diseases diagnosis as well as communication (social networking) with extension workers (ibid). Further to this, DTs are transforming the distribution systems in agriculture creating shorter value chains. Also, relating to marketing, DTs are providing smallholder farmers with critical information such as market prices (Aker & Ksoll, 2016). The majority of smallholder farmers are also considered as illiterate and have less knowledge (poorly educated) due to many reasons. However, DTs are able to facilitate knowledge transfer services through e-learning. The

¹² Value chain defined as "the full range of activities which are required to bring a product or service from conception, through the intermediary phases of production, delivery to final consumers, and final disposal after use." (Kaplinsky, 2000). The value chain analysis helps "... highlighting the constraints and opportunities at and between stages of the chain and can thus be used to develop integrative policy recommendations that target chain inefficiencies and address distributional issues" (Rich et al, 2009).

advent of drones, mobile phones, the internet and several other DTs are revolutionising the entire livestock systems. However, the adoption of technologies in different areas or context are profound. Smallholder farmers in most developing countries are yet to access most of the emerging DTs and only have access to mobile phones. As such, even though DTs have the potential to transform livestock systems, the majority of DTs' affordances remain inaccessible to most rural smallholder farmers in developing communities such as Beitbridge. For instance, one farmer noted that,

“At my age, I find it difficult to learn new technologies and also, I do not know about nor have access to the latest technologies. However, the technologies we have [mobile phones and radios] provide us with the limited information we need - even relating to livestock e.g. disease outbreak.”

But other stakeholders have a different perspective as one of the livestock technicians indicated 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 were 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”

In addition to that, there are many limitations in applying DTs to livestock systems especially in developing countries and rural communities such as Beitbridge. The majority of rural communities have poor supporting infrastructure e.g. in Beitbridge, the research participants indicated that they relied on South African mobile networks and not the Zimbabwean networks. Therefore, even though new innovations which support livestock systems such as mobile apps, there is need to improve connectivity within these rural communities. There are other innovations which are developed to operate even offline e.g. *Kurima Mari* (Table 1) but this takes away other privileges such as real-time access to information. There is no dispute on the importance of network/broadband in supporting DTs. Even during the CFS 43rd convention, it was suggested that there is a need for public investments in infrastructure.

Another concern with DTs is how these DTs fit with social norms and practices (Davies, 2014, p. 192). Food systems are inherently social and the majority of rural communities still hold on to cultural beliefs. The perspective that DTs are inherently Eurocentric is common in the elderly population, the majority whom stay in rural communities. In the same strand of culture, the issue of gender and DTs still persists and if cultural protocols are to prevail, women's access and use of DTs may be compromised in most rural communities. They need to be developed based on everyday experiences and 'lived realities' of target users (Davies, 2014).

8.3. DTs Impact on the Livestock Systems' Sustainability

The sustainability of the livestock system is multi-dimensional and no single approach can guarantee it. Livestock systems are vulnerable from socio-economic, environmental and political factors and for the systems to be sustainable, these issues need to be addressed (Godber & Wall, 2014; Martin & Magne, 2015; Thornton et al., 2014). Even though DTs can be integrated into the livestock system, creating the desired impact is a totally different issue. Toyama (2011) caution that technologies only work as amplifiers of human intent and this provides a critical standpoint to question the intent of the actors within the livestock system. Closely aligned to Toyama's remarks is the concept of technology affordance. The concept specifies that technology has specific affordances but for the desired impact to be created,

there is a need for mutuality of actor intentions and technology capabilities (Abhari et al., 2016).

From an environmental sustainability perspective, livestock systems contribute extensively to environmental degradation and climate change (Thornton et al., 2009). At the same time, livestock systems are impacted upon extensively by climate change. DTs can be used to provide climate-related information, predictions and early warnings systems. However, DTs' capabilities are only limited to providing information and are unable to coerce a smallholder farmer into 'taking action' or making a decision using the information received through DTs. Therefore the success of DTs in creating and maintaining resilient and sustainable livestock systems much depend upon convergence factors. Also, there are instances when smallholder farmers are unaware or not knowledgeable enough to take initiatives. However, DTs such as video streaming – enable smallholder farmers to learn new and advanced livestock management practices and approaches. Improved capabilities of farmers (Chen & Kates, 1994, p. 200). There is a need for support from relevant institutions e.g. Beitbridge RDC is working towards e-government which will redefine how they provide services to their stakeholders including smallholder farmers.

Further to the above, DTs are being credited with 'giving a voice to the voiceless' for instance through social networks. CFS has suggested that to ensure sustainability of livestock and food systems, there is need to empower and give voice to all stakeholders within food systems (CFS, 2016). However, it is critical to indicate that even though new DTs are considered to be empowering the marginalised, in some countries, marginalisation even persists on DTs. The majority of rural communities are excluded from major processes even those which affects their livelihoods. However, DTs are bringing new ways for marginalised groups to participate in a democratic process (Schuppan, 2009). Smallholder farmers are located at the bottom of the value chain but it can be prudent to conclude that DTs are critical in bridging the gap and empower smallholder farmers.

Another form of marginalisation affecting smallholder farmers is financial exclusion. Smallholder farmers face major challenges in trying to access loans and insurance. However, in recent times, it has become possible to profile smallholder farmers i.e. mobile phones are now being used to collect, store, analyse and share data. Through user profiles, smallholders are now being profiled in relations to demographics and socio-economic data. This profiling is providing an opportunity for credit providers to assess the creditworthiness of the smallholder farmers, previously regarded as an extremely challenging exercise. Smallholders are expected to be able to receive credit based on the profiling. Network service providers are already using small but innovative approach to extending airtime credit to mobile phone users. There are other several financial products which are being offered to smallholder farmers through mobile phones improving in the financial inclusion of these smallholder farmers (Aker & Ksoll, 2016).

The nature of the impact of DTs on livestock systems is a complex aspect to study since each smallholder farmers may experience different impacts. However, Amartya Sen's (2014) capability approach which advances "development as freedom" can be a useful starting point for discussion. In the current livestock system in Beitbridge, there are many 'unfreedoms' which are being experienced by smallholder farmers e.g. lack of choice for price, alternative markets and critically, decision making information. DTs afford smallholder farmers with the agency, which helps them have the power and freedom to choose. Through DTs, it would be possible that in future, smallholder farmers will be able to locate alternative markets, be knowledgeable about real time prices and also, have access to information about climate. However, before all these can be enjoyed, there are many challenges relating to DTs such as poor connectivity in rural communities which need to be addressed.

8.4. Appropriating DTs - Opportunities and Challenges

DTs have been and continue to be applied extensively to the development agenda of and in rural communities across the globe. The relevance of DTs in the development process of rural communities has long been debated but Walsham et al. (2007) gave remarks to this effect, trying to resolve this debate by indicating that absolutely, ICTs were and are relevant to development. The only concern which remains according to Walsham and others is to understand how ICTs can benefit development (Walsham et al., 2007). Even though Walsham and others suggested so, van Stam (2012) cautions against the *acceptance* of this considering that we need to explore the contextual relevance of Walsham and co-authors' remarks.

The success and/or impacts of DTs on a community and/or system such as the livestock system need to be examined from a holistic perspective. This implies that research should consider a wide array of preconditions and ultimately, the 'convergence of conditions' rather than one aspect of ICT in society. For instance, if DTs are well designed and yet the targeted people lack prerequisite soft skills of using the DTs, the likely result is little to no impact. As such Underwood provides a subset of pre-conditions which need to converge for DTs' success in transforming and/or impacting systems within communities in the following quote,

“.... with projects and people in place, the challenge is to overcome local constraints including a lack of ICT infrastructure, inadequate and unreliable power supplies, and a paucity of skilled, and sometimes literate, local people. Also, mind-sets need to be challenged and visionary plans created, particularly in developing countries that are limited by their own political or economic constraints.” (Underwood, 2008)

In the context of Zimbabwe, similar to many developing countries, there are emerging policies driven by governments to promote the adoption of ICTs. The government has embarked on the provision of ICT equipment in rural communities as well as developing ICT centres in these communities (see for example Musiyandaka et al., 2013). Further to this, there are many initiatives by start-up companies, Non-Governmental Organisations e.g. Catholic Relief Services as well as community initiatives (see Murambinda Works!) which are also aiming at making DT accessible to communities.

Even though there are efforts to make DTs accessible to marginalised communities, poverty traps remain key barriers to accessibility and use of DTs. In Zimbabwe, many households have extremely limited income generating opportunities and are not able to afford the cost of using DTs. For instance, recharge vouchers (airtime) costs - USD1, USD5 or USD10 – are significant amounts when considering that these households live off less than USD2 per day. In Zimbabwe, the cost of mobile services (voice and data) remain exorbitant which also inhibits the adoption of DTs, especially by the poverty-stricken households. In the same strand, while DT artefacts e.g. mobile phone handsets are increasingly becoming cheaper, some households still fail to afford these. Rey-Moreno et al (2014) suggest that low-cost community networks may present a viable option to lower the costs (voice and data) of mobile services in rural communities. However, even though the government has embarked on several ICT projects, some of the policies and restrictions imposed by government departments negatively impact the success of ICTs. In Zimbabwe, one of the popular cases of politics' impact on DTs is the government battle with Econet during set up (Takavarasha & Makumbe, 2012). The history of Zimbabwean government and DTs' is tainted and if DTs are to be appropriated, this has to be ratified (Takavarasha & Masunungure, 2014).

Similar to comments made by Underwood (2008), Buchanan, Sainter and Saunders (2013) agree that the uptake of DTs is affected by many factors. In recent years, several enterprises have emerged to offer ICT services and products resulting in significant decrease

in costs. Even though the issue of the digital divide is widely discussed in the literature, ICT artefacts are increasingly becoming affordable and rural communities have access to such artefacts (Hussain, 2015). At the same time, research and development on ICTs in societies is increasing. Therefore, there are many opportunities which can be exploited to usher in DTs in rural communities. However, contextual differences will always be present and need to be considered.

From the study, it emerged that the study area, Beitbridge rural communities, face many more challenges compared to opportunities to appropriate technologies. The general infrastructure, including mobile network base stations, is simply non-existent, the demographic characteristics (less educated) and poverty status all impact the adoption and use of DT. For those who have adopted DT, they are yet to fully exploit the affordances of these especially in relation to livestock systems and many other critical sectors such as health.

9. CONCLUSION

The discussions of DTs in rural communities and specifically on ‘development’ have to a larger extent acknowledged the rural digital divide. This research study has profound findings that it can only be a matter of time before rural households find it necessary to overcome the limits promoting digital divide. The rapid change in the biophysical and political economy (e.g. digitisation of man processes) means rural communities’ households also need a reaction – especially relating to technology adoption and use. Firstly, there is a need for a reaction relating to attitudes towards use and acceptance of DTs to think beyond DTs as colonial tools but rather as potential ‘life aides’. Overwhelming evidence indicates how the rural population has gradually accepted the mobile phone and even enjoyed the benefits. This same attitude will be required to accept emerging DTs which will be developed to counter the mutating societal challenges. However, critical technology assessment will be required to ensure that only appropriate technologies are accepted and not overlook the unintended negative impacts of these DTs.

The nonmechanistic perspectives (non-determinism) is a critical aspect when considering the likely impact of DTs on the resilience and sustainability of the livestock system. Using this nonmechanistic approach entails considering DTs not as an autonomous ‘thing’ but rather as complex interconnection. For DTs to contribute towards the resilience and sustainability of livestock systems, there is a need for a connection between a households’ desire to achieve resilience and sustainability, adoption and use of DTs (compatibility with culture, socio-economic and political issues) and application of DTs (skills and knowledge). In this case, the origins of these DTs also play a role. DTs will continue to emerge and transform as efforts to discover and develop solutions to overcome challenges faced by humanity continue. The transformation of DTs will be premised on several facets including but not limited to socio-economic, cultural, political and even environmental factors. As a result, it can be expected that DTs will be transforming and/or be developed to better suit ‘context’ and thus, deliver improved outcome. The result of DTs’ transformation will be the application of these DTs in diverse sectors and as presented in this research, even the food systems. Even though DTs will continue to be applied in diverse sectors, it is no guarantee that DTs will automatically result in positive outcomes, which most researchers look for. Rather, the critical assessment will be needed to also consider the unintended consequences of DTs in systems such as the food systems (Majchrzak et al., 2016). Furthermore, research will need to consider how DTs play a role in amplifying socialities within systems.

It is not a secret that DTs hold so much promise in positively transforming livestock systems and food systems at large for instance, changing the way actors interact within the system (Choi & Graham, 2014). In the near future, if not already, DTs will overcome many

barriers including but not limited to geographic, cultural and even political barriers (Chen & Kates, 1994). However, the utopian approach can be misleading as in rural communities there remains a considerable population not using DTs and who will continue not using these DTs. Therefore, it is critical for future research to investigate how non-users of DTs within the livestock systems also contribute towards the sustainability and resilience of livestock systems against the political economy and biophysical challenges (Selwyn, 2003). However, it is concerning that despite DTs holding so much promise, the realisation of such promise remains a major challenge in most rural communities (Ponelis & Holmner, 2015). Among the many challenges of realising the promises of DTs, Chowdhury (2001) indicates that bringing affordable DTs to communities especially in developing countries remain one of the key challenges.

In conclusion, DTs have the potential to be central to the achievement of a sustainable and resilient livestock system in rural communities such as Beitbridge. However, there are many factors which influence the success of these DTs in doing so and these need to converge if the DTs are to have positive impacts. Further work needs to be conducted to be able to determine as well as accurately quantify and qualify the impacts of DTs on socio-ecological systems such as livestock systems as currently there are no standardised options to compare to. Also, many more studies can help to reveal the various ‘contexts’ in which DTs are introduced to understand how ‘caveats’ of context can be overcome. This study has set the ground work for more studies to venture into marginalised communities and explore the communities’ own imaginations, aspirations on specific systems such as the livestock systems establish how DTs plays a role in facilitating or inhibiting the realisation of these imaginations and aspirations.

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