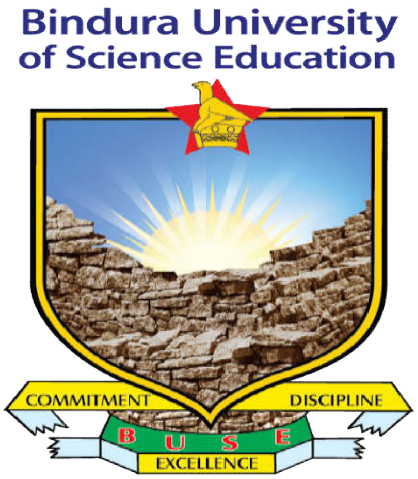

ECONOMIC ANALYSIS OF THE SORGHUM (*Sorghum bicolor* L. Moench) VALUE CHAIN IN THE MID ZAMBEZI VALLEY OF ZIMBABWE

BY

JOSEPH P. MUSARA

R9917227

A THESIS SUBMITTED IN FULFILMENT OF THE REQUIREMENTS OF THE BINDURA UNIVERSITY OF SCIENCE EDUCATION, FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURAL ECONOMICS AND MANAGEMENT

2020

DECLARATION AND APPROVAL

I, the undersigned, hereby declare that the work contained in this thesis is my own and was conducted under the supervision of Dr. L. Musemwa, Dr. M. Mutenje, Professor A. Mushunje and Professor C. Pfukwa. I also declare that this thesis is original and has not been submitted elsewhere for a degree. Assistance towards the production of this thesis and other scholars' works referred to here have been duly acknowledged and referenced in the respective sections.

…….……. ……..

Joseph Persevearance Musara Date

SUPERVISOR

I, the undersigned, have read this thesis and am satisfied that it meets the requirements of Doctor of Philosophy in Agricultural Economics and Management Degree. I approve the thesis report for submission towards award of the degree.

…….……. ……..

Dr. L. Musemwa Date

LIST OF PUBLICATIONS

The following publications form part of the research presented in this thesis.

Publication 1: Forms part of Chapter 2 of this thesis
Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. (In press). From not-working to net-working: Conceptualizing a sorghum sub-economy for livelihood security in arid and semi-arid regions of Zimbabwe. Accepted for publication in *Journal of Sustainable Development.*

Publication 2: Chapter 4 of this thesis
Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. (2019). Sorghum value chain analysis in semi-arid Zimbabwe. *South African Journal of Agricultural Extension,* 47(1): 164-178. http://dx.doi.org/10.17159/2413-3221/2019/v47n1a497

Publication 3: Chapter 5 of this thesis
Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. (2019). Determinants of sorghum adoption and land allocation intensity in the smallholder sector of semi-arid Zimbabwe. *Spanish Journal of Agricultural Research,* 17(1): e0105. https://doi.org/10.5424/sjar/2019171-13115

Publication 4: Chapter 6 of this thesis
Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. (2018). Market participation and marketing channel preferences by small scale sorghum farmers in semi-arid Zimbabwe. *Agrekon,* 57(1): 64-77. https://doi.org/10.1080/03031853.2018.1454334

Publication 5: Chapter 7 of this thesis
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The data analyses and discussion of empirical results for the above-listed four publications were conducted in their entirety by J.P. Musara with technical advice from Drs. Musemwa and Mutenje and Professors. Mushunje and Pfukwa. All the figures and tables were produced by the same, unless otherwise referenced in the respective publications.

LIST OF CONFERENCE PAPERS

Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. *Household welfare impacts of sorghum land allocation differentials in semi-arid Zimbabwe: Towards climate change adaptation.* Presented at the 12th Zimbabwe International Research Symposium, Harare, Zimbabwe. 13-15 February 2019.

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Musara, J.P., Musemwa, L., Mutenje, M., Mushunje, A., and Pfukwa, C. *Dynamics of constrained sorghum comeback in the smallholder sector of Zimbabwe*. Presented at the 2nd Regional RP-PCP-RenCare Conference, Palm Tree Place, Chiredzi, Zimbabwe. 24–27 May 2017.

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LIST OF ABBREVIATIONS

AGRITEX	Department of Agricultural, Technical and Extension Services
AIS	Agricultural Innovation System
AR4D	Agricultural Research for Development
ATE	Average Treatment Effect
ATT	Average Treatment effect of the Treated
CBI	Crop Breeding Institute
CSF	Critical Success Factor
CSI	Coping Strategies Indicator
ESAP	Economic Structural Adjustment Programme
EPZ	Export Processing Zones
FAC	Farmer Associations and Cooperative
FARA	Forum for Agricultural Research in Africa
FAO	Food and Agriculture Organisation of the United Nations
FGD	Focus Group Discussion
FIML	Full Information Maximum Likelihood
CIRAD	French Agricultural Research Centre for International Development
FSR	Food Security Ratio
FTLRP	Fast Track Land Reform Programme

GDP	Gross Domestic Product
GOZ	Government of Zimbabwe
GMB	Grain Marketing Board
GVC	Global Value Chain
HDDS	Household Dietary Diversity Score
HFIAP	Household Food Insecurity Access Prevalence
HFIAS	Household Food Insecurity Access Score
ICP	Innovation and Communication Platform
IMF	International Monetary Fund
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ITKS	Indigenous Technical Knowledge System
LR	Likelihood Ratio
MNL	Multinomial Logit Model
NEPAD	New Economic Partnership for Africa's Development
NGO	Non-Governmental Organisation
NNM	Nearest Neighbourhood Method
NARS	National Agricultural Research System
OLS	Ordinary Least Squares
PSM	Propensity Score Matching

SADC	Southern African Development Community
SNA	Social Network Analysis
SNTA	Social Networks for Technology Adoption
SEZ	Special Economic Zones
SMIP	Sorghum-Millet Improvement Program
SVC	Sorghum Value Chain
TFCA	Trans-Frontier Conservation Area
TT	Treatment of the Treated
TU	Treatment of the Untreated
UNIDO	United Nations Industrial Development Organisation
US$	United States Dollar
VCA	Value Chain Analysis
VIF	Variance Inflation Factor
ZIM-ASSET	Zimbabwe Agenda for Sustainable Socio-Economic Transformation
ZIMSTAT	Zimbabwe National Statistics Agency

ABSTRACT

Economic Analysis of The Sorghum (*Sorghum bicolor* L. Moench) Value Chain in The Mid Zambezi Valley of Zimbabwe

By

Joseph P. Musara

Efficient sorghum value chains are integral for sustainability of small scale farmers' subsistence, social and economic livelihoods in semi-arid communities of southern Africa. There is however, a dearth in quantitative evidence on the determinants which are crowding out stakeholders from participating in the sorghum value chain activities. The study added to new knowledge in this realm by analysing the sorghum value chain pillars in the mid-Zambezi Valley of Zimbabwe. Using five Wards from Mbire District, mixed approaches were used to collect cross-sectional survey data from 380 smallholder farmers. Secondary data were collected from Agritex, NGOs, agro-dealers, traders, processors and retailers to triangulate the primary data.

Mapping techniques identified relationships, constraints, opportunities and marketing margins accruing to selected sorghum value chain actors. Results from the data show that input supply systems are underdeveloped and production is stalled by the low uptake of improved seed varieties and low fertilizer application. There is limited production, marketing and processing of sorghum due to constrained access to production factors, biased extension services, erratic supply of grain to centralised markets by farmers, limited value addition activities and low producer prices. Determinants of sorghum production and land allocation intensity decisions were examined using double hurdle with probit and censored tobit regression respectively. Frequency of contact with relatives, subsidy access and affiliation to

associations influenced the sorghum production decision. Market access, availability of storage facilities and number of buyers whom the farmer interacts with in the market influenced intensity of land allocation towards sorghum.

Factors influencing farmers' market participation and marketing channel choices were identified using probit and multinomial logit respectively. Three exclusive marketing channels were isolated as local (44.7%), traders (34.2%) and a combination of the two (17.1%). Payment time, number of buyers with whom the farmer relates, age of principal decision maker and distance to market influenced ($p<0.05$) market participation. Using local market as the referent category, weighted average market price, number of buyers whom the farmer interacts with in the market, distance to the market, dependency ratio and household income are robust determinants of marketing channel selection. Though variables influencing the two decisions are different, showing independence in the decision making processes, information access through interaction with more buyers influenced both decisions. Welfare impacts were then examined using propensity score matching and endogenous switching regression. Household dietary diversity score and household food insecurity access score were adopted as proxies for food security. Sorghum grain physical productivity and net income gains were also used as indicators of household welfare. Counterfactual analysis showed that farmers who allocate more land towards improved sorghum varieties are better off in food diversity, food access, productivity and net returns.

Contrary to the hypothesis, the study concludes and adds new knowledge by identifying that, even if stakeholders may have binding backward relationships, they do not necessarily have forward linkages among themselves. The study also concludes that, the various aid dimensions which have not been widely explored, including source, value and the number of beneficiaries are emerging as important factors influencing sorghum production and intensity

of production among small scale sorghum farmers. It can be concluded that, household specific, institutional and market factors are important in determining the marketing and marketing channel choices by sorghum farmers in the study area. In line with the hypothesis, there is evidence from the data that, the farmers who adopted and allocated more land towards improved sorghum varieties had higher income, productivity and food security status. It is therefore important to strengthen policies that foster local networks of kinships, cooperative production and marketing and access to aid packages. Investment in appropriate storage facilities in partnership with private players can also reduce post-harvest losses. This allows for sales during market windows of the lean season which usually exhibit higher market prices and help to generate higher returns. Additional research needs to be done with panel data and in other similar semi-arid areas of Zimbabwe over larger spans of time to have a spatial and temporal understanding of the value chain processes.

DEDICATION

To my beloved wife, Tendai

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CHAPTER 1

INTRODUCTION

1.1 Background

Agriculture is one of the strategic sectors in most economies of southern Africa and has immense potential for enhancing food security, strengthening income generating prospects, and alleviating extreme poverty. In Zimbabwe, small scale agriculture remains important in sustaining household food supplies and income, creating employment and generating foreign currency (Baudron *et al.,* 2012). There is wide held consensus that going forward, market oriented and diversified agricultural systems which embrace '*orphan crops*'[1] are a prerequisite to economic development (Mazvimavi & Twomlow, 2009).

Inspired by this drive, sorghum (*Sorghum bicolour* (L.) Moench), which is the fifth most important world cereal, has the prospects of making in-roads into production, processing, marketing and consumption systems in Zimbabwe. The crop has multiple uses including domestic consumption, an important ingredient in stock feeds, generation of environmentally friendly energy, cultural ceremonies and commercial beer brewing. The versatility of sorghum across these multiple value chain nodes, and its ability to grow well under unfavourable climatic conditions makes it a potentially strategic cereal crop among resource constrained decision making units (Ahmed, Sanders, & Nell, 2000). Surprisingly, Maize (*Zea mays* L.) still dominates as the staple cereal crop even in semi-arid and arid Zimbabwe where sorghum has competitive advantage. However, sorghum is widely distributed and supported as an important crop in the arid and semi-arid parts of East and West Africa (Smale *et al*., 2018).

[1]This term refers to a number of crops which have been neglected by stakeholders including mainly small grains.

In southern Africa, agricultural development practitioners have for long marginalised sorghum in strategies which are aimed at enhancing welfare and reducing extreme poverty. The consequences of these decisions are evident especially among resource constrained small scale farmers who are domiciled in the drier areas (Sultan *et al.,* 2013; Taylor, 2003). In Zimbabwe, this paradox is specifically worrying since the crop performs relatively better than other cereals such as maize in agro ecological regions IV and V[2] where it is the third mostly grown summer cereal (Rukuni *et al.*, 2006). In limited response to this reality, there is an emerging dispensation in the agribusiness revolution which demands innovativeness and diversity in all facets of strategic agricultural value chains. Fundamental drivers are aimed at strengthening pillars including agricultural research for development (AR4D), development and adoption of appropriate production technologies, beneficial market networking, affordable processing and overall institutional transformation (Tefera, Dahlberg, & Smale, 2012; Torero, 2011).

This matrix, if appropriately coordinated, offers prospects for sorghum value chain development and is important for small scale sorghum farming households to attain food and income security. Considering the importance of agriculture in semi-arid Zimbabwe, to achieve these milestones, there is need for active and collaborative stakeholders' participation in strategic sorghum commodity value chain nodes (Rukuni *et al*., 2006). This effectively implies improved access to affordable production factors, increased market driven production of sorghum by many farmers at considerably higher scales of land allocation, higher productivity and market participation by many players in multiple marketing channels (Dalipagic & Elepu, 2014). This study will contribute to new knowledge regarding the aforementioned concerns from a more coordinated framework of the value chain.

[2]These are the arid and semi-arid areas of the country and experience low, erratic and poorly distributed rainfall coupled with extreme temperatures in the greater part of the year.

Surprisingly, food security policies in Zimbabwe have remained inclined towards maize production, processing and consumption support regimes even in the arid and semi-arid areas where the crop does not perform well (Mango *et al.,* 2014; Mutenje *et al.,* 2010). Worryingly, the demand for cereals is expected to significantly increase in the foreseeable future due to increasing population and changes in consumption patterns. On the other hand, maize production as the main staple is expected to significantly fall due to climate change and persistent disease outbreaks. In this scenario, strengthening the sorghum value chain provides numerous alternative avenues for enhancing food and income security in semi-arid areas. Experiences in Zimbabwe show that, the evolution of agricultural intervention instruments has continued to crowd out most small scale sorghum farmers from binding downward and upward market oriented relationships (Government of Zimbabwe, 2013; Rukuni *et al.,* 2006; Jayne & Chisvo, 1991).

Studies in similar contexts has attributed this scenario to multiple challenges emanating from risky production conditions, unbalanced marketing environments, dynamic processing and consumption patterns triggered by socio-cultural changes, economic transformations and generalised policy shifts (Sarris & Morrison, 2010; Aduguna, 2007; Ortmann & King, 2007). Specifically, the small scale sorghum farmers are inherently invisible in strategic and rewarding markets, have limited marketing channel options and are food and income insecure. This is due to reduced and biased[3] spending on public and private sector support initiatives such as subsidies, stiff intra and inter-enterprise competition for limited resources, unfavourable market prices and prohibitive standard requirements in markets (Tefera, Dahlberg, & Smale, 2012). The cascading effects of these realities are observable in a system where the number of sorghum producers remain relatively low and the proportions of land allocated towards the crop follows the same pattern (Adegbola *et al.,* 2013).

[3]This is relative to other crops such as maize and emerging cash crops such as sugar beans and tobacco.

At this stage of the debate for sorghum value chain development prospects in arid areas, it is important to also acknowledge that globally, agricultural market reforms and liberalisation has occurred at different times and with wide-ranging implications to agriculture (Azam, Imai, & Gaiha, 2012; Poulton, Kydd, & Dorward, 2006). In Nigeria for example, Asogwa, State, & Okwoche (2012) reported on sorghum marketing dynamics in rural farming households as positively influenced by broader policy changes. Burke, Myers, & Jayne (2015) also reported on the impact of policy re-orientation on the marketing of dairy products in Kenya. Exploring the issues of sorghum market participation and marketing channel choices in Zimbabwe therefore becomes inevitable when designing policies for developing marginalised farming communities.

There is evidence that multiple signals point towards the untapped potential of social inclusion and partnerships in strengthening the sorghum value chain through effective market participation and unlocking of multiple low transaction costs marketing channel alternatives (Makindara *et al.,* 2013; Poonyhth, 2006; Taylor, 2003). In the small scale sector of Zimbabwe in particular, this simultaneously entails lack of cooperation among strategic stakeholders along the value chain nodes in production, processing and marketing related investments. Successful implementation of market and marketing coordination strategies were for example reported with sorghum by Aduguna (2007) in Ethiopia and by Rohrbach & Kiriwaggulu (2007) in Tanzania. Osebeyo & Aye (2014) also made similar conclusions with Nigeria's smallholder tomato farmers who also produced cereal crops on parts of their plots.

The revolutionary perspectives of agribusiness are evolving towards demand driven philosophies which are to be supported by accommodative and responsive market conditions. There is need to realign strategies towards simultaneously addressing a broader spectrum of fundamental drivers rooted specifically in the production-processing-marketing interfaces

(Maina, Lagat, & Mutai, 2015; Loureiro & Hine, 2002) of the sorghum value chain. This seems to be the current missing link in efforts towards attaining sorghum based food and income security status driven by small scale producers in arid Zimbabwe. In light of these observations, multiple consequent actions in the private and public domains have occurred either in direct or indirect response to these challenges. For example, a number of mechanisms including farmer driven cooperatives and contracts have emerged across spatial and temporal scales while expanding into traditionally excluded so called non-cash crops[4] such as sorghum (Mutami, 2015). Of note is the vital role played by private-public networking arrangements and farmer inclusive programmes targeting their participation in sorghum markets and ultimate success of the value chain.

In light of this, there is urgent need to design and sustain innovations which should address both the means and the dimensions along the sorghum value chain towards attaining food and income security in Zimbabwe. Guided by market liberalisation recommendations made by Makamure, Jowa, & Mazuva (2001), results from a women mainstreaming study in market integration platforms by Navarro *et al*. (2001) in Mozambique and a cowpea market integration study by Moussa (2011), one move towards achieving this is the beneficial integration of small scale sorghum farmers into commercially oriented value chain systems with the aim of unlocking net value from viable marketing channels. Mutenje *et al.* (2016) also report that a cocktail of attitude and institutional transitions focusing on adoption and scaling up of physical and economic productivity enhancing innovations and linkages to rewarding low transaction costs markets can offer a break through.

Worryingly, in Zimbabwe agricultural market linkages aimed at effective functioning of orphan enterprises such as sorghum and millets has remained in the confines of agribusiness

[4]There is widespread perception among value chain stakeholders that small grains such as sorghum cannot generate enough income to justify investment into its production, processing and marketing.

rhetoric for some time. Based on studies by Chemionics International Inc. (2009); Dalipagic & Elepu (2014) and Giuliani, Pietrobelli, & Rabellotti (2005), with cereal crops, this naturally creates disincentives even along potentially catalytic trajectories which can propagate rural entrepreneurship towards off-farm and non-farm sorghum driven businesses along the value chain. To encourage participation by multiple stakeholders along strategic value chain nodes, there is need to examine and report on the welfare impacts of sorghum production and enhanced land allocation towards the crop.

In the midst of the sorghum re-embracement drive, significant challenges of fragile social and market networks and unbalanced support still exist. This is mainly evidenced by unhealthy relationships among value chain stakeholders (Scoones *et al*., 2011). Of note, along most sorghum value chain nodes in Africa, there has been inequity in the distribution of benefits among stakeholders with farmers getting the least share of value (Rohrbach & Kiriwaggulu, 2007). It is therefore imperative to interrogate the extent to which household specific, market related and policy wide variables have impacted on the ability of small scale farmers in the mid-Zambezi Valley of Zimbabwe to participate in, and get their share from the sorghum value chain.

This study acknowledges that there is still rhetoric on most discussion platforms about the potential of sorghum as a livelihood enhancing crop in arid areas. However, there have not been concrete economic based analyses to help stakeholders make decisions of participating in the sorghum value chain. The study therefore aims at contributing to new knowledge by using econometric analyses techniques to empirically examine how challenges and opportunities identified in pillars of the sorghum value chain can be transformed to enhance participation and networking towards improving overall functioning of the chain and ultimately welfare of stakeholders.

1.2 Problem Statement

Previous studies show that, in the arid and semi-arid areas of Zimbabwe, sorghum can perform relatively better than other cereals such as maize (Mukarumbwa & Mushunje, 2010; Rukuni *et al.,* 2006). However, the production of this coarse cereal has been on the decline in most areas due to limited access to appropriate information, inaccessibility of inputs, low output market prices, limited marketing channels and high transaction costs. Baquedano, Sanders, & Vitale (2010) and Rohrbach & Kiriwaggulu (2007) report that, this set of determinants compromises the commercialisation prospects for sorghum as they filter into the whole value chain.

Additionally, this sorghum production-marketing paradox has been exacerbated and sustained by the availability of more reliable, relatively cheaper and subsidised[5] substitutes especially maize. Since sorghum is an undervalued crop, lack of participation and coordination among stakeholders along the sorghum value chain remains an important but missing ingredient in the agribusiness development discourse (Smale *et al*., 2018). As the effects of climate change and economic underperformance filter into the agribusiness system, the need for a more realistic and informed decision making matrix becomes unavoidable.

Going forward, re-acknowledging the space of orphan crops such as sorghum in the food and income security framework should take centre stage among value chain actors' strategies. However, due to lack of information on the production, marketing, quantified income and food security benefits, poorly developed linkages are keeping cheaper and nutritious sorghum products away from markets thereby worsening livelihoods of producers and consumers alike. Yet potentially competitive domestic small scale producers of sorghum exist in under-developed rural communities in the mid-Zambezi Valley of Zimbabwe.

[5]Most production and consumption subsidy programmes in Zimbabwe are channeled towards maize. In times of food shortage, the government, NGOs and in some case the private sector provides affected communities with maize grain through food relief initiatives.

Addressing household, market and policy wide failure sustaining the poor state of development for an otherwise commercially viable commodity value chain is essential for inclusive socio-economic development of marginal farming regions of Zimbabwe. Small scale sorghum farmers need to be linked to the rest of the value chain actors so as to reduce incidences of poverty in their localities. It therefore becomes important to analyse the value chain activities from production through marketing and the general linkages that exist among stakeholders. This will help to design specifically targeted interventions for improving the welfare of farmers and the overall efficiency of the sorghum value chain.

1.3 Objectives

The broad objective of the study was to examine the determinants of the sorghum production decision, enhanced land allocation towards the crop, marketing and welfare impacts of differential high yielding sorghum varieties production scales in the small scale sector of the mid-Zambezi Valley of Zimbabwe.

The specific objectives were to:

1. Analyse the sorghum value chain by mapping the various existing and missing nodes while tracing the movement of the grain from the farm gate to end markets.
2. Determine how subsidy programs, networks and market related variables affect the decision of households to produce sorghum and differentially allocate land towards the crop as a livelihood strategy in the small scale farming areas;
3. Evaluate how household and market specific determinants influence the decision for sorghum market participation and preferences for specific marketing channels by small scale farmers; and
4. Determine the contribution of different improved sorghum varieties production scales to household food and income security in the small scale farming areas.

1.4 Hypotheses[6]

The hypotheses to be tested were that:

1. Stakeholders have both forward and backward linkages among each other along various sorghum value chain nodes;
2. Subsidy programs, networks and market related variables affect the decision of households to produce sorghum and differentially allocate land towards the crop as a livelihood strategy in the small scale farming areas;
3. Household and market specific variables are determinants of sorghum market participation and preferences for specific marketing channels by small scale farmers; and
4. Small scale intensive improved sorghum varieties producers are relatively better off in terms of household food and income security than their non-intensive counterparts

1.5 Justification

Substantial work has been done with maize as the main staple crop in Zimbabwe by for example Mutami (2015); Baudron *et al.* (2012); Rukuni *et al.* (2006); Eicher (1995) and Jayne & Nuppenau (1993) based on the food security argument. Yet, in arid and semi-arid zones, sorghum can perform relatively better and hence need to be comprehensively researched on and reported as well. Improving support and networks along the sorghum value chain from production, processing, marketing up to consumption can offer opportunities for farmers in the marginal areas to benefit[7] from the crop. This study adopts the value chain approach as a useful tool for catalysing commercial-oriented development of small scale agriculture since it facilitates examination of holistic relationships among different players.

[6]Hypotheses are presented as research hypotheses

[7]Specifically, facilitating efficient linkages and offering support in the sorghum commodity value chain systems can be fundamental in attaining food and income security for these small scale farmers.

To understand the sorghum value chain, this study captures and reports on the household, market and institutional issues which need to be incorporated into strategies for unlocking the potential of the crop. Focusing on multiple stakeholders including researchers, input suppliers, farmers, buyers and processors involved in the sorghum commodity value chain offers collaborative opportunities for enhancing production, marketing and its subsequent functionality since there will be comprehensive buy-in. In the past, there have been arguments based on the crop's tolerance to adverse conditions which has been put forward by researchers such as Mazvimavi & Thomlow (2009); Rukuni *et al.* (2006) and Taylor (2003) for some time. Despite these research outputs, the uptake of sorghum has been reported to be low in the marginalised communities due to household, market and policy wide factors (Mukarumbwa & Mushunje, 2010) whose interactive effects have however not been explored.

It therefore becomes important to conduct in-depth research which uses econometric approaches to understand the effects of these drivers on the sorghum production decision, differential land allocation preference towards the crop, marketing channel choices and the quantification of sorghum's contribution to household income and food security. Understanding these will ultimately facilitate development of strategies which create an appetite for sorghum production by small scale farmers and opening up of more accommodative and accessible marketing channel options. This will in turn help small scale sorghum farmers in the semi-arid areas to increase area under sorghum production, increase sorghum productivity, generate higher incomes and improve their food security status. The benefit and contributions from the study is therefore anchored on bridging information and knowledge gaps regarding the production, marketing and potential welfare impacts of sorghum as an inadequately untapped livelihood strategy.

CHAPTER 2

REVIEW OF LITERATURE

(Part of this review has been accepted as a review paper by *Journal of Sustainable Development*)

2.1 Introduction

Globally, sorghum ranks fifth as an important cereal after rice (*Oyza sativa* L.), maize, common wheat (*Triticum aestivum* L.) and barley (*Hordeum valgure* L.). Kerr (2014) reports that as at 2013, globally the crop accounted for about 42 million hectares with an aggregate output of close to 62 million metric tonnes, thus averaging 1.5ton/ha. In sub-Saharan Africa however, the cereal comes second after maize (Proietti, Frazzoli, & Mantovani, 2015) with an average yield of 0.9ton/ha. The major sorghum producing countries are the USA, Nigeria, Mexico, India and Ethiopia. In these countries, effective strategic partnerships have been developed and sustained along the value chain in food products, stock feed and commercial beer brewing. Zimbabwe grows sorghum as the third most important summer cereal with national yields averaging 0.5ton/ha. The crop takes up approximately 15% of the total cropped land, with 11% being accounted for by the subsistence oriented small scale farmers who are predominantly domiciled in the arid and semi-arid areas.

In the small scale sector of southern Africa, effective participation and mutually beneficial coordination of activities among actors in strategic sorghum value chain nodes remain the missing link in the agribusiness development drive (Sultan *et al.,* 2013; Jayne, Mather, & Mghenyi, 2010; Chemionics International Inc., 2009). Of note, limited initiatives have been developed to strategically position small scale sorghum farmers as integral participants in the value chain. As such, the net benefits accruing to them remain worryingly low due to multiple and persistent factors emanating from the household decision making processes on

enterprise choices and associated land allocation, unfavourable production conditions, skewed market environments and continuous changes in policies (Chepng *et al.,* 2014; Hamukwala *et al.,* 2010; Poonyth *et al.,* 2000). In Zimbabwe, this is specifically so for small scale farmers in the marginalised arid and semi-arid areas whose inclination towards production and marketing of sorghum as a potential avenue out of food and income insecurity has been compromised by factors highlighted above.

This review discusses challenges and opportunities faced by small scale farmers and other stakeholders, patterns and trends of various functions along the sorghum commodity value chain. The current state of knowledge, emerging discussion points and milestones in efforts towards strengthening small scale driven sorghum value chains are herein presented. Fundamentally, this review anchors on exploring philosophies, principles, practices and mechanisms that have been adopted in isolating, structuring and scaling up (and out) sorghum based agribusiness development pathways. A reflection of methodologies adopted towards placing small scale famers in the vicinity of viable and self-sustaining partnerships with other value chain stakeholders is also done.

The essential components of this literature review include a reflection on sorghum value chains in sub-Saharan Africa, trends in sorghum production and marketing in Zimbabwe, sorghum production and marketing obstacles and drivers, strengths and/or weaknesses of current market linkage arrangements in sustaining sorghum value chains. This section also presents experiences of the welfare impacts of sorghum in the small scale farming communities. This is critical for gaining lessons and insights on the contribution of the crop to household food and income security in arid and semi-arid Zimbabwe.

2.2 An overview of small scale sorghum systems in sub-Saharan Africa

Developing countries in Africa and Asia contribute 90% of the total sorghum cultivated area and about 70% of the aggregate global output (Smale *et al.,* 2018). Sorghum accounts for about 25% of the total cereal production in Africa and approximately 20% in southern Africa. The top producers of sorghum in sub-Saharan Africa are Tanzania, Mali, Botswana, Zambia and Namibia with a significant number of countries in the region including Zimbabwe also producing the crop in the small scale farming areas. In these communities, the crop is generally grown for subsistence as food and fodder by the resource constrained small scale farmers who are labelled as '*poor'* (Rukuni *et al.,* 2006). As also reported by Sultan e*t al.* (2013), sorghum production is mainly done in the region's drier areas of West Africa as is the same case with southern Africa. This is because sorghum grows well in areas were other crops such as maize may fail completely since it is highly tolerant to droughts and persistent high temperatures (Laico *et al.,* 2011). The crop is also adaptable to poor soils which are common in these arid and semi-arid areas offering great scope for food and income security in communities where livelihood options are limited and uncertain (Labeyrie *et al.,* 2014).

Worryingly, in Zimbabwe, regardless of sorghum's comparative advantage over most cereals in marginalised areas, there is a generalised persistent trend where the proportion of farmers producing the crop, the cropped area allocated to sorghum and productivity has declined. A number of catalysts including poor breeding strategies (Haussmann *et al.,* 2012), fragmented, biased and misplaced policy initiatives (Coulibaly *et al.,* 2014), unresponsive community sustained Indigenous Technical Knowledge Systems (ITKS) (Mukarumbwa & Mushunje, 2010) and weak or absent markets (Rohrbach & Kiriwaggulu, 2007) have perpetuated this. In order to reposition sorghum as a strategic crop, there is need to examine and understand how these drawbacks impact on decisions by farmers to produce sorghum and have proclivity towards increasing land allocation towards the crop in the small scale sector of Zimbabwe.

In studies conducted by Di Falco and Bulte (2013) for adoption of risk mitigating strategies in Ethiopia and technology adoption by Shiferaw *et al.* (2015) in Uganda, they used double hurdle models which factored the inherent differences between desired and effective demand for an innovation to understand adoption and intensity of adoption decisions. This strategy was also used in other studies for example by Amare, Asfaw, & Shiferaw (2012) in a maize-pigeon pea intensification study in Tanzania. Kreitler, Stoms, & Davis (2014) and Aldana *et al.* (2011) also used the random utility framework with multiple covariates to examine the adoption decision by households and communities. Based on a review done by Ragasa (2012), this analytical orientation, if adopted and appropriately modified, will help in designing strategies for redressing the failure of sorghum value chains.

The argument is that the aforementioned determinants are assumed to have weakened both intra-actor and inter-actor linkages from the supply-side and demand-side of the chain. This study aims to add to this debate through understanding the production-marketing interface among small scale sorghum farmers. There is consensus that this current matrix does not support enhancing of household welfare in the marginalised areas where enterprise diversification options are limited since it creates breeding ground for severe food and income insecurity (Asfaw *et al.,* 2012). The same conclusion can be made with sorghum (Chepng *et al.,* 2014). Neither does the arrangements encourage and create space for investment into and coordination of functions by other stakeholders (Trienekens, 2011) even along the sorghum value chain in Zimbabwe (Munyati *et al.,* 2013).

Going forward, it is therefore inevitable to strike a healthy balance between inward and outward looking approaches which acknowledge the currently untapped space and dynamic nature of sorghum value chain in unlocking its development prospects. For example, it maybe a misplaced hypothesis that failure by small scale farmers and other value chain actors

alike to participate in sorghum production is entirely due to lack of information on its benefits. Instead, evidence from Tanzania (Mmbando *et al.,* 2016; Amare *et al.,* 2012), Mali (Coulibaly *et al*., 2014; Baquedano *et al.,* 2010) and Zambia (Hamukwala *et al.,* 2010) show that the main problems are lack of inputs, prohibitive transaction costs and exploitation in limited marketing channels. Power asymmetry along sorghum value chain nodes and unbalanced sharing of benefits has also led to the elimination of sorghum from most stakeholders' evoked sets over time (Munyati *et al*., 2013).

It is therefore important to emphasise on designing and supporting appropriate local level platforms which incentivise sorghum production and establish external linkages that expose small scale farmers to all available markets at the least cost and highest returns as enshrined in the value chain methodologies (Smale *et al.,* 2018; Adegbola *et al.,* 2013). This can only be possible through inclusively formulated measures which re-align the broader agricultural policy with attitudes, potential and expectations of sorghum producers, marketers and consumers. Worryingly, most countries including Zambia, Botswana and Zimbabwe have attempted and failed[8] to sustain small scale farmer driven sorghum value chains by adopting inadequately structured and biased explicit subsidy packages. Scoones *et al*. (2011); Rukuni *et al.* (2006) and Eicher (1995) observed that, experiences in Zimbabwe also show that the government and Non Governmental Organisations (NGOs) have continuously supplied subsidised maize inputs and grain in potentially dominant sorghum producing areas.

There is evidence that this has further dampened the prospects of sorghum production, processing and consumption as the policy induced culture imposes additional skewness towards maize products and services by facilitating research, financing, infrastructural development and supported marketing platforms. Hamukwala *et al.* (2010) weigh in and

[8]This extreme term has been adopted in this instance to reflect that output, productivity and welfare have not improved among beneficiaries of subsidy packages. In most instances, the farmers have become so dependent on subsidies over time thereby exerting excessive pressure on the public budget.

argue that even though there were efforts in most southern African countries to enhance sorghum productivity through adoption of high yielding varieties, the benefits have been dwarfed by high transaction costs in the seed markets, unreliable supply of grain by farmers and suppressed consumer demand for final products due to prohibitive prices. In response to this array of drawbacks, farmers have in the short to medium term responded by shifting market oriented production from sorghum to other perceived commercially viable enterprises regardless of the former's potential in their localities (Mazvimavi & Twomlow, 2009; Juana & Mabugu, 2005). In some isolated cases, the ability of small scale irrigation schemes to bridge the dry spells in drought prone ecologies make crops such as soybean (*Glycine max* L.), wheat and maize more lucrative.

Interestingly, in southern Zambia and West African countries, sorghum has remained dominant in production mixes for small scale farmers due to the increased market demand for healthy food and fodder. This is because stakeholders have embraced the reality of the adverse climatic conditions which make economic substitution with other cereals technically impossible. Depending on the variety, Proietti, Frazzoli, & Mantovani (2015) and Mason (2010) report that multiple viable uses including human consumption, making stock feed and commercial beer have been identified, supported and commercially tapped into. This basket of potential marketing channel options has therefore created sustainable incentives for the government and the private sector to include sorghum grain in strategic food security programmes thereby increasing farmer participation in production (Adegbola *et al.,* 2013).

In this vain, research into the seed value chain dynamics has been propelled as an integral ingredient for sustaining the overall sorghum value chain. This pattern has also been observed in a commercialisation study in Tanzania done by Rohrbach & Kiriwaggulu (2007), where they reported notable competitiveness of sorghum as a substitute ingredient for baking,

manufacture of stockfeed and beer brewing. They noted that for this status to be sustained, appropriate seed varieties need to be developed in addition to greasing information dissemination networks regarding the multipurpose uses including nutritional value of the crop. MacInnis (2004) further noted that, the uncertainties which characterise supply in the potential marketing channel options can be resolved by collaborative investments in innovations geared towards specific market oriented production.

In light of the above observations, there is evidence of the need to re-align production, marketing and consumption strategies with the ever changing ecological, socio-economic and institutional conditions (Teklewold *et al.,* 2013; Tittonell & Giller, 2013; Goodman & DuPuis, 2002). This should increase the number of sorghum farmers and the sorghum market size as multiple value chain nodes are unlocked to satisfy varied consumer preferences. This dispensation can be finalised by designing production-marketing development models advocating for consistent delivery of high quality grain into a chain which then processes and satisfies multiple consumers. As alluded to by Josephson, Ricker-Gilbert, & Florax (2014); Ndiritu, Kassie, & Shiferaw (2014); Amare *et al.* (2012); Barnes & Poole (2012) and Faltermeier & Abdulai (2009), at the heart of these efforts should be programs which continuously examine and report the challenges, opportunities and welfare impacts along the commodity value chain of choice.

2.3 Small scale sorghum production and consumption for food security in Zimbabwe

Sorghum production in Zimbabwe has for long been viewed as the privy of resource constrained farmers with the crop being labelled a '*poor man's crop'* (Rukuni *et al.,* 2006). This discriminatory mentality consequently pushed support programmes away from the crop towards more preferred cereals such as maize and cash crops such as tobacco (*Nicotiana tabacum* L.), soyabean and cotton (*Gossypium herbaceum* L.) (Baudron *et al.,* 2012; Masuka,

2012). Studies show that small scale farmers who produce sorghum mainly do so as a far-fetched cushion against failure of the aforementioned mainstream crops even in the fragile semi-arid and arid areas. In these small scale production systems, activities are characterised by use of retained low yielding seeds, low land allocation averaging 15% of total cropped land, input use averaging 10% of total farm budgets, limited investment in mechanisation and peripheral visibility in rewarding markets. This is excessively compounded by limited access to appropriate production and marketing information emanating from a biased extension framework which generates and disseminates distorted information (Mutami, 2015).

Unresponsive networking structures at various nodal links have also weighed in and created long term failures along the sorghum value chain pillars (Maina *et al.,* 2015; Thierfelder e*t al.,* 2015). It is therefore important to interrogate the production and marketing platforms with the view of unpacking the critical push-pull factors affecting the small scale farmers. There is hope given that in the low rainfall and high temperature areas of Zimbabwe, sorghum still remains an enterprise with immense potential to improve the food and income security status of households. Food security is defined as an important indicator of welfare (Cafiero *et al.,* 2014; Maxwell, Caldwell, & Langworthy, 2008) and is a state when at all times, everyone has access to healthy, affordable and adequate food. In most previous studies such as Dewi *et al.* (2014); Reyes (2009); Maxwell *et al.* (1999), the most commonly used indicators of household food security revolve around consumption and income. Other studies by Mabuza *et al.* (2016) and Mango *et al.* (2014) have used the Coping Strategies Indicator (CSI) to examime household welfare impacts within the food security framework.

The Food Security Ratio (FSR) was also used in a study by Silvestri *et al.* (2016) to show how own food production and purchases can adequately satisfy household energy needs. However, this indicator is usually inaccurate since determining the exact values of the two

aforementioned inputs is a challenge with most social science based non-experimental studies. Musemwa *et al.* (2015) adopted the Household Food Insecurity Access Prevalance (HFIAP) in examining the level and causes of food insecurity in the Eastern Cape Province of South Africa. The household dietary diversity score (HDDS) and the household food insecurity access score (HFIAS) have widely been used as proxies for food security (Ngema, Sibanda, & Musemwa, 2018; Musemwa *et al.,* 2015; Fielden *et al.,* 2014; Lo *et al.,* 2012; Kennedy *et al.,* 2010). These two latter indicators were adopted for the current study due to their comprehensiveness in capturing detail with a number of food stuffs.

In Zimbabwe, regardless of the positives, sorghum has been neglected by researchers, input suppliers, extension agents, financiers, producers, processors, marketers and consumers. This compromises the crop's production and productive capacities leading to declining trends over time (Scoones *et al*., 2011). Figure 2.1 shows the generalised declining trends[9] in aggregate national sorghum production and consumption from 1990 to 2016. Figure 2.1 shows that, generally there was a balance between consumption and production in the 1990s. However, fluctuating and declining production capacity among the small scale producers led to deficits in the 2000s. This shows some unsatisfied positive changes in consumer tastes and preferences[10] towards sorghum related products in recent times, mainly driven by the '*healthy eating'* calls being made globally.

[9]The negative regression coefficients for both production and consumption show the declining pattern

[10]Consumers are now re-awakening to the need to consume sorghum for health related benefits, its high crude protein content in stock feed and as a viable ingredient in the beer industry.

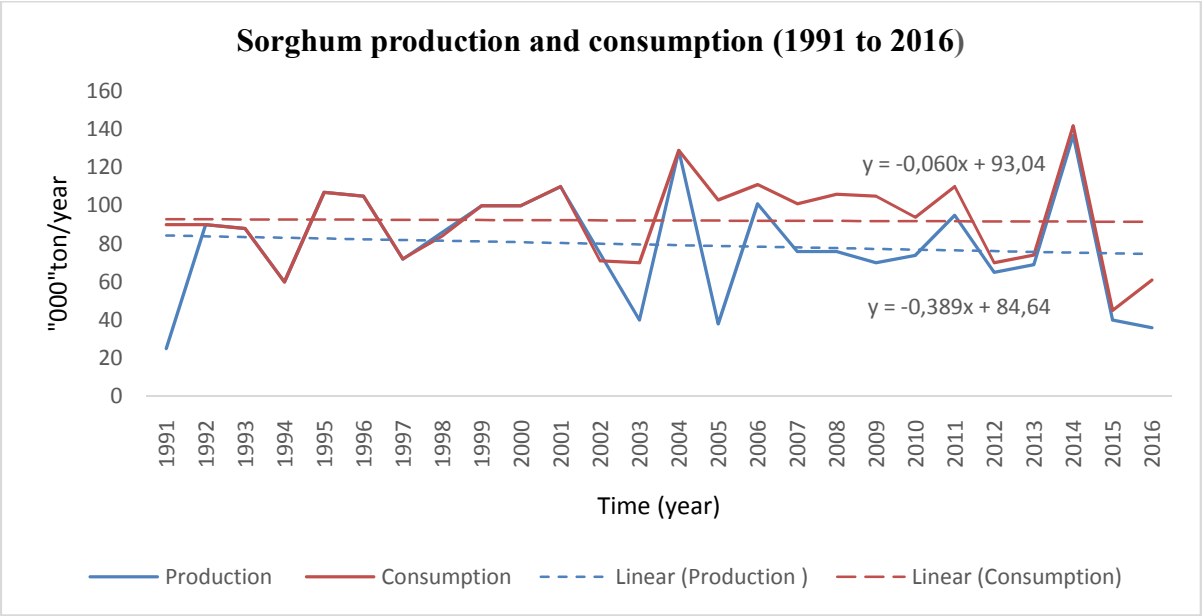


Figure 2.1: Sorghum production and consumption trends in Zimbabwe (1990 to 2016)

Source: Adapted from FAOSTAT (2017)

In Zimbabwe, the observed trends in sorghum production can be attributed to multiple changes in local level production conditions and practices, support policy instruments, processing investment and fluctuating tastes and preferences in sorghum markets (Jayne & Nuppenau, 1993; Jayne & Chisvo, 1991). For example in the early 1990s, the increase in sorghum production can be ascribed to changes in government policy which directly promoted the production of small grains (Rukuni *et al.,* 2006; Makamure *et al.,* 2001). Consumption subsidies were also channelled via the Grain Marketing Board (GMB)[11] with multiple depots being scattered throughout the country supplying sorghum grain at subsidised prices especially during the 1992 drought. This view is supported by evidence from West African countries where for example Sultan *et al.* (2013) reported observed increases in production and consumption of small grains. Post the region's drought of 1982-85, the governments focused on supporting the crop as a food, income and nutrition security hedge.

[11]GMB was the sole official buyer and seller of cereals in Zimbabwe at this time.

To sustain the increases in sorghum production, governments in most countries adopted subsidy based strategies (Coulibaly *et al.,* 2014; Eicher, 1995) which where blended with different forms of market liberalisation[12] (World Bank, 2006; Pinckney, 1993). The private sector also weighed in by providing contractual platforms where mainly small scale farmers where accommodated so as to stimulate production of the crop. With a reliable supply, consumers increased their demand for the grain and related products along various value chain nodes. It is therefore necessary to examine the key determinants of sorghum production and land allocation decisions towards the crop by small scale farmers so that informed decisions can be made to support them.

Scoones *et al.* (2011) are however of the opinion that, the policy space in Zimbabwe has for decades rhetorically encouraged production, processing, marketing and consumption of sorghum, hoping to reduce food shortages in low rainfall areas of the agro ecological zones IV and V where most small scale farmers are located. Mukarumbwa & Mushunje (2010) weigh in and postulate that, the production and consumption of sorghum has been on the decline in Zimbabwe due to policies that favour maize across all geo-economic boundaries. They further noted multiple weaknesses in the government's response strategies towards attempting to induce sorghum production and consumption[13]. Key among these is the lack of a coherent and sustainable policy which has failed to address the unique technological, institutional and socio-economic needs of farmers who are located within adverse and diverse agro ecological conditions of the arid and semi-arid areas (Munyati *et al*., 2013). This matrix could explain the spikes and downs in sorghum production and consumption (refer to Figure 2.1) as government frequently changed focus from small grain production to maize and back, albeit in a preferential manner for the latter.

[12]For example in Zimbabwe, Economic Structural Adjustment Programme (ESAP) was adopted in the early to mid-1990s.
[13]For example in recent years when droughts were experienced, the major cereal crop imported was maize.

The sustained decrease in sorghum production in the early 2000s could be as a result of the fast track land reform programme (FTLRP). Rukuni *et al.* (2006) attribute this decrease to the degenerating agro-based economy after the international community including International Monetary Fund (IMF) and the World Bank stopped balance of payments support to the government in 2001. They also observed the negative effects of FTLRP to farming in general caused by partitioning land into small pieces which made it administratively difficult to finance, provide seed and fertilizer and stalled international trade space. Fluctuations in sorghum supply and demand in the early 2010s can also be attributed to the various changes in government monetary and fiscal policies which switched resources across farm enterprises as well as across sectors depending on global market signals.

This is in agreement with Coulibaly *et al.* (2014) who reported that government policies are key determinants for agricultural development in Mali and Mishili *et al.* (2009) in a study on consumer preferences along cowpea value chain conducted in Nigeria, Ghana and Mali. Matshe (2009) and Ortmann (2000) also weigh in with the same viewpoint in their studies conducted in South Africa and the greater southern Africa. A number of other studies by Gandhi & Namboodiri (2002) in India and Giuliani, Pietrobelli, & Rabellotti (2005) in Latin America also follow a similar pattern. It is therefore important at this stage to explore the determinants of sorghum production and land allocation intensity towards the crop. This can help to shape the decision making processes among stakeholders along the sorghum value chain as they tap into the utilisation of sorghum.

2.3.1 Trends in area planted and sorghum yields

Experiences in Zimbabwe show that there is an inverse relationship between area planted to sorghum and aggregated country yield as shown in Figure 2.2. The increase in area under cultivation was due an increase in the number of small scale farmers getting into sorghum

production. However, this coincided with a decrease in commercial farmers growing sorghum as they lost their land to fast track land reform hence there was a general decline in productivity. Sorghum value chain development practitioners should therefore understand the drivers of the decision to produce sorghum and the associated land allocation by the small scale farmers who constitute the major proportion of sorghum producers in Zimbabwe.

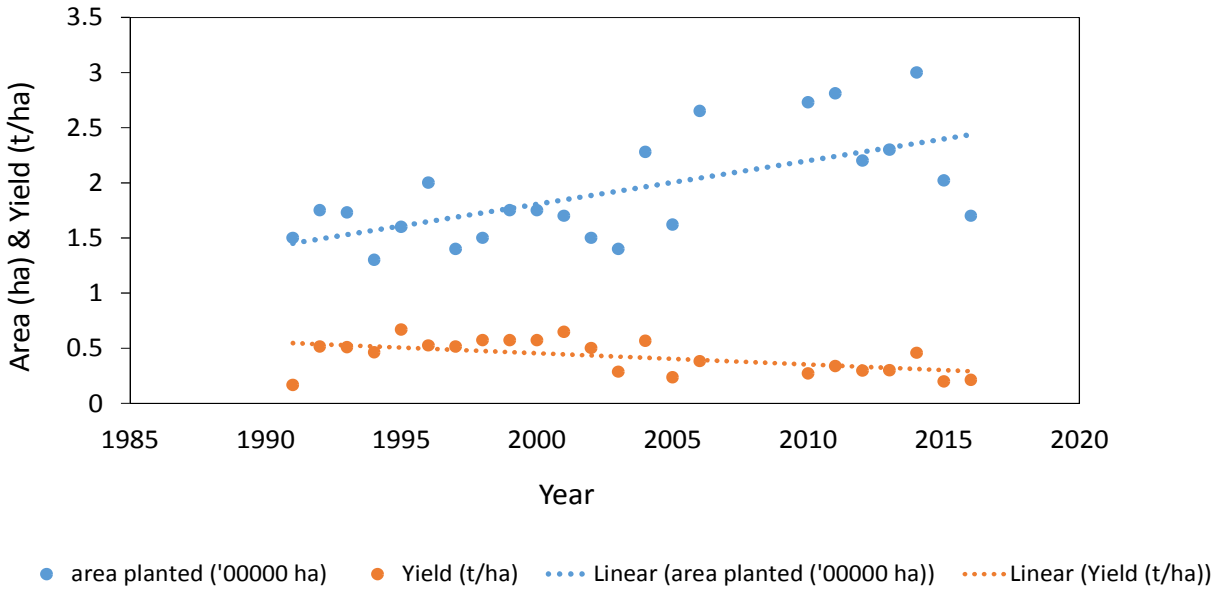


Figure 2.2: Sorghum yields versus cropped area

Source: Adapted from FAOSTAT (2017)

The generalised low sorghum yields are compounded by the problem of reduced investments by value chain actors including farmers in terms of standard input use, limited varietal improvements from research centres and lack of appetite for market infrastructure developments by processors and the government (Sultan *et al.,* 2013). In Tanzania however, Rohrbach & Kiriwaggulu (2007) report a different scenario where significant strides have been made to commercialise sorghum. This has been achieved by supported investments and appropriate innovations being disseminated on a mutually beneficial platform which accommodates the public and private sector players. To understand this matrix better in the Zimbabwean context, it is important to interrogate the relative productivity patterns. Figure

2.3 shows a comparison of maize and sorghum productivity levels in Zimbabwe between 1994 and 2013.

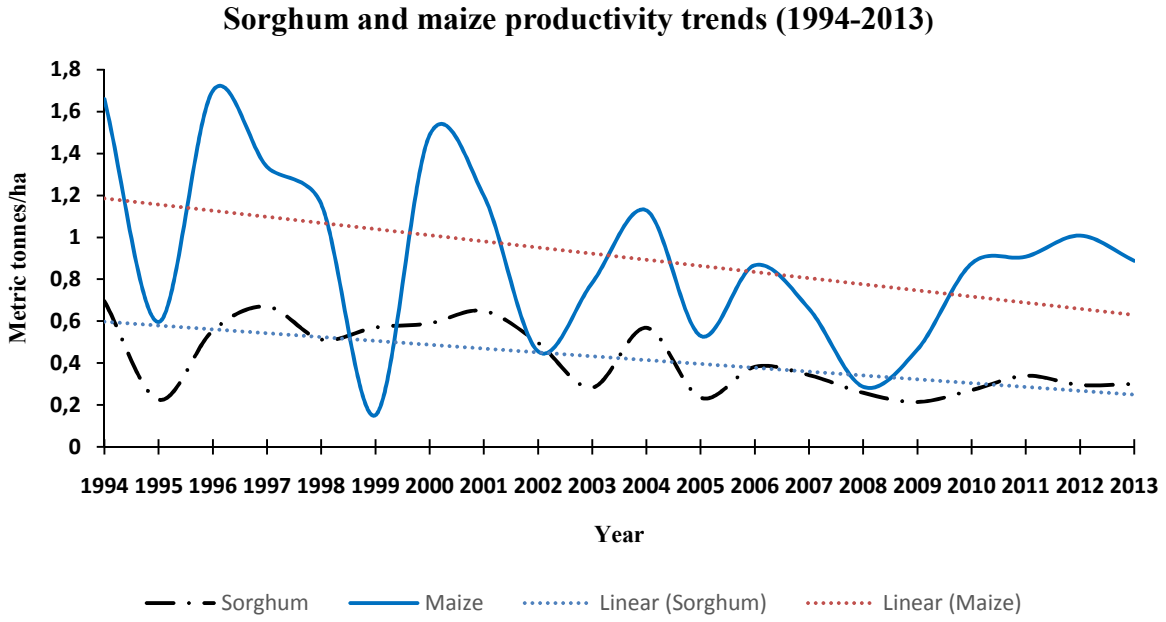


Figure 2.3: Sorghum and maize yields from 1994 to 2013 in Zimbabwe

Source: Adapted from FAOSTAT (2017)

For the past two and half decades, sorghum yield levels in Zimbabwe have averaged 0.5ton/ha compared to potential yields of about 5ton/ha. As highlighted in Figure 2.3, sorghum yields reached a peak in 1997 at 0.67ton/ha and the lowest level of 0.21ton/ha recorded in 2009. During the same period, maize was however reported to have averaged significantly higher at 1.0ton/ha, almost double the sorghum average. This is because small scale sorghum farmers who constitute the greater proportion of producers experience multiple challenges ranging from limited access to input markets to inadequate and appropriate institutional support by other value chain stakeholders. A similar pattern was reported by Amare *et al.* (2012) in their intensification study in Tanzania and Zeng *et al,* (2015) in Ethiopia.

The low sorghum productivity levels are mainly attributed to farmers' adherence to farm saved seed as the main source for the next planting season, the limited application of fertilisers, minimal discussion of sorghum related issues in farmer groups and dis-incentivising market prices (Coulibaly *et al.,* 2014; Baquedano *et al.,* 2010). Faced with production systems that are not efficient, the potential of the whole sorghum value chain is compromised since primary production is the cornerstone of the chain. It is therefore important to examine the welfare impacts of sorghum land allocation and productivity differentials among small scale producers so as to inform and incentive effective participation by multiple stakeholders in the value chain.

Technical efficiency is also a major challenge for small scale farming communities in southern Africa. Nyanga (2012) however found that even though small scale sorghum producers in Zambia were producing about 34% of their potential output, they were more efficient than their non-sorghum producing counterparts. Of major concern however, was that this level of efficiency was much lower than maize produced under similar conditions (46% in Malawi) and cowpeas (87% in Nigeria). The underperformance of these small scale producers has limited the potential of other non-sorghum producing farmers to have proclivity for the crop as well as the current producers to allocate more land towards the crop. This is worsened in an operating environment where there are insignificant investments being done towards institutional transformation to increase the productivity levels through research for development (R4D), extension and market reforms. Similar observations were made in a study by Chepng *et al.* (2014) in Kenya. The current efficiency levels in small scale farming communities of Zimbabwe therefore present opportunities for initiatives to improve sorghum production, productivity, marketing and welfare.

Tefera *et al.* (2012) reported that there is potential to double productivity of resources and income levels for sorghum farmers through adoption of appropriate technologies and improved farm management practices. Poonyth *et al.* (2000) concurred and noted that increasing land allocation towards sorghum and enhancing productivity are important ingredients in improving welfare and stakeholder participation along the value chain. Adegbola *et al.* (2013) also argued that without appropriately structured and favourable incentives and effective extension services which groom networking, resource constrained farmers can hardly benefit from sorghum production and marketing innovation platforms. This is the case even in areas of low, erratic rainfall and relatively high temperatures where the crop has great potential to do well. Understanding the determinants of sorghum production and associated land allocation decisions in these contexts becomes an inevitable exercise towards unlocking the prospects for sorghum value chain development.

2.3.2 Seed systems and agronomic practices

Access to improved and affordable sorghum seed by small scale farmers remains a challenge imbedded in production systems of southern Africa (Asfaw *et al.,* 2012; Haussmann *et al.,* 2012; Howard, Rusike, & Kelly, 2000). Southern African Development Community (SADC)/International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)'s Sorghum-Millet Improvement Program (SMIP) attempted to redress this by distributing over 130 000 genotypes of sorghum and pearl millet to SADC national programs. This intervention strategy was aimed at assisting the beneficiary countries to develop and distribute new varieties appropriate for their own localities. Over the past decade and half, about 30 sorghum varieties were released by 8 SADC countries[14] but this output is way below potential for these countries combined (Hamukwala *et al*., 2010).

[14]Botswana, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe.

A report by Sarris & Morrison (2010) point towards governments' reluctance to embrace sorghum as a significant cereal crop in their food security strategic plans. It is however reported that the improved National Agricultural Research System (NARS)/SMIP varieties have increased yields by up to 20% as compared to conventional varieties in the areas where they have been taken up (Hamukwala *et al.,* 2010; Eicher, 1995). Of note is their early maturity characteristic of up to one month earlier than traditional varieties which significantly reduces risk of drought-induced crop failure. Despite all these positives, the uptake of improved varieties by small scale farmers in the semi-arid areas of Zimbabwe is still low.

Another worrying reality is that sorghum seed multiplication programmes are minimal in Zimbabwe (Juana & Mabugu, 2005). For example, the collaborative national breeding programme between ICRISAT and Crop Breeding Institute (CBI) which dates back to the 1950's has resulted in a limited number of locally appropriate variety releases. Observations are that currently there are low volumes of high yielding seed varieties from research centres which are complimented by insignificant community based seed production initiatives. In response, small scale farmers have resorted to using retained seed which is susceptible to pests and diseases and has low yield potential averaging 0.35ton/ha (Rukuni *et al.,* 2006). This has led to low aggregate sorghum grain output, affected food and income security in these areas which have little economic diversity and compromised the viability of multiple functions along multiple value chain nodes. Table 2.1 shows the varieties that have been developed in Zimbabwe between 1987 and 2004.

Table 2.1: Sorghum improved varieties in Zimbabwe (1987-2004)

Variety Name	Variety Type	Year of Release	Grain Colour	Maturity
SC Sila	OPV	2004	White	Late
SC Macia	OPV	----	White	Early
SV-1	Hybrid	1987	Brown/Red	Medium
SV-2	Hybrid	1987	Brown/Red	Medium
SV-3	Hybrid	1998	Brown/Red	Medium
SV-4	Hybrid	1998	Brown/Red	Late
NS-5511	Hybrid	----	Red	Early
DC-75	OPV	----	White	Late
PAN-88	OPV	----	White	Late
ZWSH-1	Hybrid	1992	White	Medium

Source: Rukuni *et al*. (2006)

The sorghum seed development scenario is at deviance with what prevails with maize, and mainly driven by private seed breeding companies such as Seed Co and Pannar. Tefera *et al.* (2012) also reported the same pattern in most Eastern and Western African countries and advocates for the need to establish closely knit and binding partnerships aimed at developing sorghum seed systems in Africa if meaningful productivity gains are to be attained. Following this line of thought, it becomes unavoidable to trace and examine, within the participatory value chain framework, the various sorghum seed multiplication, distribution and pricing approaches that have been adopted with particular focus on small scale farmers' contexts and capabilities. This will enable practitioners to identify methods which are appropriate and successful in these domains thus encouraging the participation of small and medium scale commercial seed companies in the sorghum seed system (Kerr, 2014; Ahmed *et al.,* 2000).

Additionally, there is immediate need to enhance efficiency of the seed system through developing an all-inclusive platform for complementary inputs provision including appropriate research, financing and comprehensive extension services. Mazvimavi & Twomlow (2009) suggested that the *'community seed bank'* mechanism coupled with seed fairs can be tried with sorghum and possibly offer a gateway out of the current sorghum seed access challenges while at the same time strengthening local networks for generating and sharing information. There is evidence from previous studies that, the choice of an enterprise and associated agronomic practices influences the temporal economics of farm production. Short term concerns of decision making units revolve around farm costs structures, attainable yields, net returns and the potential for crop-livestock integration (Hosu & Mushunje, 2013). The long term fundamentals are centred on protecting and improving the natural resource base for attaining sustainable incremental productivity levels. Baudron *et al.* (2012) reported that, there is an intricate relationship between these two facets. The long term viability of farming is significantly influenced by short term practices which ultimately determines the condition and productivity potential of the natural resources.

Guided by these phenomenal preconditions, regardless of observed generalised low adoption levels, new sorghum varieties have been widely adopted in the top end of the social spectrum in arid Zimbabwe. If coupled with proper agronomic practices, Labeyrie *et al.* (2014); Mafuru, Norman, & Langemeier (2007) and Rohrbach & Kiriwaggulu (2007) observed that, there are clear indications that sorghum yields in areas with below average rainfall are at least double for those who use improved varieties and allocate more land towards the crop. Moreover, these farmers experience additional benefits of greater production flexibility, lower production costs, more reliable yields, higher incomes and hence better protection of natural resources in the semi-arid to arid areas (Coulibaly *et al.,* 2014).

Taylor (2003) also noted that, the success of sorghum enterprises is determined by the ability of agricultural markets to facilitate farm level access to seeds. As such, decisions on seed access and utilization cannot be underestimated in the value chain development debate. Becerril & Abdulai (2010) further argued that, if there is to be a comprehensive understanding of the decision making processes by farmers regarding the choice of crop varieties, policy practitioners need to grasp the following issues:

- What are the seed varieties available to and affordable for the farmers via formal and informal marketing channels?
- Do the seed varieties that are offered by markets actually reflect and satisfy the different needs of the heterogeneous farmers within particular operating environments?
- To what extent do the output markets influence the varieties grown by the farmers and consequently the seed type and quantities they demand from input markets?

In Zimbabwe, given the importance but weaknesses of seed supply and pricing mechanisms and guided by the above fundamental questions, there is evidence that the absence of sorghum seed value chain revival strategies will continue to compromise functioning of the overall sorghum commodity value chain. In response, Ali & Abdulai (2010); Cirera & Arndt, (2008) and Poulton *et al.* (2004) noted that rational profit maximising decision makers are pulled towards embracing alternative enterprises such as maize, cotton and tobacco, albeit even in areas where the crops might fail in times of bad weather. In efforts towards strengthening the scope of sorghum commercialisation, it is therefore important to examine the marketing arrangements that characterise the sorghum value chain. This should help to re-shape the relationships among the stakeholders and improve production, marketing and overall welfare.

2.4 Sorghum marketing and institutional arrangements

Efficient marketing of agricultural commodities is a pre-condition for enhancing welfare among farmers (Mmbando, Wale, & Baiyegunhi, 2015; Sarris & Morrison, 2010; Abdula, 2005). In Zimbabwe, the marketing of sorghum grain is mainly done through informal channels which accounts for approximately 80% of the traded volume. These transactions are mainly concluded in the localities of production. According to Rukuni *et al.* (2006), small scale sorghum farmers trade with other members within their communities (villages and wards) and rarely transact with external traders or brokers. The limited visibility and accessibility of formalised marketing systems is therefore a major disincentive for market participation and marketing channel selection by small scale sorghum producers. This is worsened because they are positioned at the periphery of decision making structures along strategic value chain nodes.

In Zimbabwe, the brewing industry has been active in providing contracts, albeit to a limited number of small scale farmers to produce especially red sorghum thereby offering a potentially ready market for the produce. Challenges have been reported in these arrangements with most farmers failing to supply the required volumes and quality of the output on time. This has led to premature termination of the contracts, leaving the farmers exposed to the market participation and marketing channel choice challenges (Rukuni *et al.* 2006). Comparable patterns have been observed by Mujeyi (2013) and Masuka (2012) with cotton in similar agro-ecological regions. Interestingly, in more recent times, the stockfeed producers have also been actively involved on the sorghum marketing platforms. The main sticking issue among small scale farmers is the mismatch between pricing regimes and the transaction costs structure which farmers feel is not viable. Schaner (2016) and Mason (2010) argue that faced with these major challenges which diminish their marketing margins, prospects for sorghum commercialisation remains a far-fetched welfare enhancing trajectory.

To understand the marketing channel choice decisions, studies have traditionally adopted auto regressive modelling techniques to show the influence of social, economic and institutional factors on market choice and the associated welfare impacts. Schneider & Kubis (2009) used the grouped conditional logit approach to understand migration flows in Germany, but this significantly limits the scope of factors affecting a particular decision. Grouping the individuals into specific categories does not allow the researcher to understand the heterogeneity which inherently characterises the individual decision making entities. A multinomial logit modelling approach was used by Mutenje *et al.* (2016) and Langyintuo & Mekuria (2008) to explore the determinants of uptake of particular agricultural innovations for food security. Mmbando *et al.* (2016) also used a multinomial logit approach to examine the determinants of marketing channel choice in Tanzania and isolated transaction costs, extension and household wealth as having a bearing on choice of marketing channel. Maina *et al.* (2015) weighed in and also adopted a multinomial logit to understanding the effect of transaction costs in Kenya and reported similar results.

Apparently, in Zimbabwe and the sub-region, minimal efforts have been made to develop effective sorghum marketing systems which are appropriate for small scale farmers. The proclivity for sorghum marketing is still relatively low and so are the volumes of the grain being produced and traded in the sparse markets (Rukuni *et al.,* 2006). In Zambia, a study by Hamukwala *et al.* (2010) also observed that the low adoption of this potential food security hedge was due to lack of adequate support services and erratic and variable performance of the production and marketing techniques. However, Lundy *et al.* (2007) report that, in addition to understanding how farmers and agro-firms relate in markets, it is also pivotal to consider the expectations of the final consumers of the products. The argument is that it will not be efficient to produce without understanding the needs of the targeted end markets in terms of, for example, pricing, standard requirements, payment arrangements and volumes

required. They proposed the use of a critical success factors analysis framework as a useful tool in understanding consumers-suppliers relationships.

The above complex scenario which is also experienced in southern Africa may therefore be explained by the limited information and knowledge about the characteristics of various marketing channels (value chain nodes) in which farmers can effectively participate. Explicitly, the absence of strategic and locally designed market networks is a hindrance to production, flow and consumption of sorghum products. Birachi *et al.* (2013) and Pye-Smith (2013) further observed that in most modern agricultural markets, it is not a matter of, for example, price or quality that dominates but a combination of both and more factors acting simultaneously or antagonistically. In trying to understand these intricate relationships, Sebatta *et al.* (2014) used a two-stage Heckman model to investigate the potato market participation decision in Uganda. They reported that distance to the village market and household income had significant effects on the market participation decision.

In addition, Burke *et al.* (2015) investigated the effect of expected income and standard requirements in private markets on the decision to participate in dairy markets in Kenya. Guided by these findings, household decision makers therefore need to make a trade-off among multiple critical success factors in niche markets before making a decision on whether they will participate or not (Barrett *et al.,* 2012) because consumers may, for example, not be willing to pay more for a high quality product but require reliability of a lower quality commodity in multiple and visible marketing channel options. Dialogue and coordination by both consumers and suppliers should be expedited in efforts to synchronise both groups' demands and expectations as this facilitates development of sustainable linkages in commodity value chains (Drost, van Wijk, & Mandefro, 2012).

2.4.1 Trends in real and nominal prices of sorghum in Zimbabwe (US$)

Figure 2.4 shows the trends in nominal and real sorghum prices in the domestic markets. The associated price elasticity of supply is presented in Figure 2.5. In Zimbabwe, the real price of sorghum grain in competitive markets was low as shown by patterns during the 1990s and early 2000s. As observed by Brown & Kshirsagar (2015) and Moussa (2011), this can act as a major disincentive for market participation by small scale farmers and influence the specific marketing channel choice.

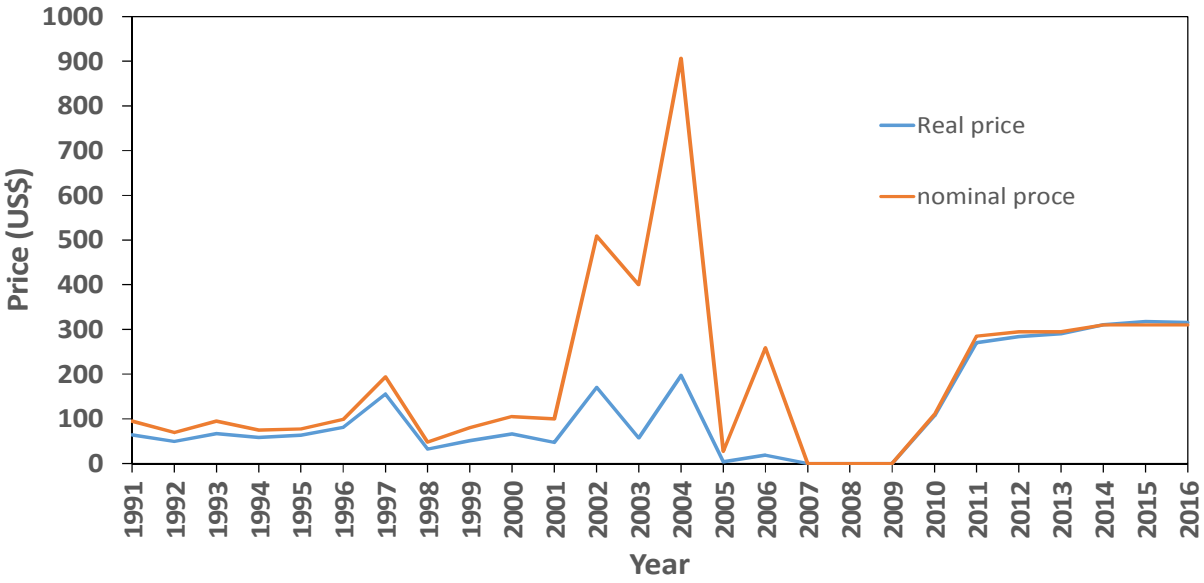


Figure 2.4: Sorghum nominal and real prices
Source: Adapted from FAOSTAT (2017)

However, the status quo is that, in semi-arid environments of Zimbabwe, farmers have not embraced sorghum production and marketing regardless of the cereal's economic potential and its historic role as a major component of their diets. This similar pattern has been reported by Chepng *et al.* (2014) and Laico*et al.* (2011). There is evidence that these farmers are insightful in selecting crops as guided by the relative market prices, the aggregate market size and distance to the market. In this operating atmosphere, it then becomes inevitable to engage the stakeholders in policy changing dialogue regarding the appropriate price support

regimes to be developed and implemented. As in response to these signals, recently, the government of Zimbabwe has gazetted a supported producer price of 390 US$/ton which is anticipated to incentivise sorghum production, marketing and consumption.

Lessons from a study conducted in Mali by Coulibaly *et al.* (2014) show that, the prolonged and persistent decline in sorghum prices rationally pushed farmers towards expanding the next best alternative enterprise, maize, in areas where the former crop previously dominated. They reported that, efforts to redress the scenario by providing subsidised sorghum seed and fertiliser as incentives had a marginal effect on the farmers' net incomes. This initiative however was postulated to have a larger effect on increasing household sorghum consumption, thus reducing the need for food purchases especially in low harvest years. As such, effectively implementing a seed and fertiliser subsidy package, as is the case with NGOs in Zimbabwe, implies that decision makers need to blend this with more direct sorghum pricing related marketing strategies (Scoones *et al*., 2011). This would enhance farmers' income and encourage sorghum re-uptake in land allocation decisions. In essence, this points towards the need for implementing a more holistic technical-marketing approach which should be driven by development of and penetration into new rewarding markets. This strategy should offer favourable prices in addition to the traditional approach of isolated supply of new productivity enhancing technologies[15]. Similar observations on the need to interlink production and marketing spaces were reported by Mmbando *et al.* (2016) and Hill & Vigneri (2011).

2.4.2 Annual trends in prices and price elasticity of supply

The sorghum price elasticity of supply in Zimbabwe has been on the decline since 1990 with a generalized inelasticity tendency as shown in Figure 2.5.

[15]Such as high yielding sorghum seed varieties and fertilisers

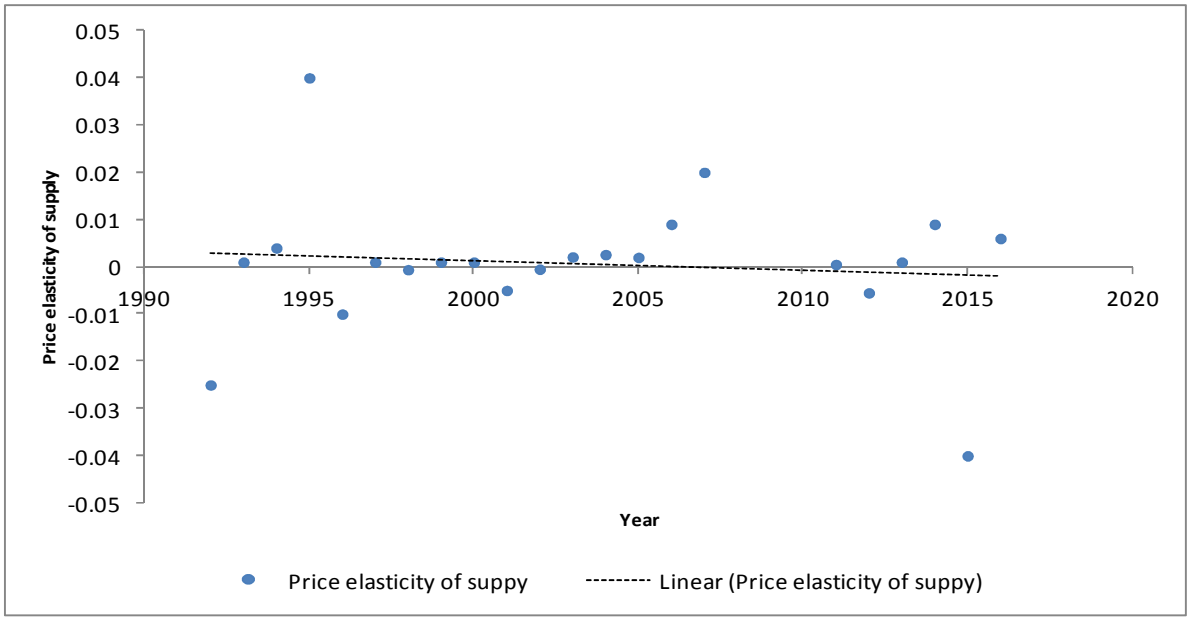


Figure 2.5: Annual trends in sorghum price elasticity of supply in Zimbabwe

Source: Adapted from FAOSTAT (2017)

Benfica & Tschirley (2012) noted that generally, supply response to price with agricultural commodities is inelastic. In a study on price and non-price factors, Moussa (2011) found that cowpea supply elasticity was inelastic in both short run and long run analyses. Figure 2.5 shows that sorghum producers in Zimbabwe are not sensitive to sorghum market price variability. This seems counterintuitive since it conflicts the economic theory that producers are positively responsive to the variances in prices. To understand this better, it is important to examine the effect of price and related variables on the decision to produce and market sorghum in different marketing channels by small scale farmers.

In response to the above reality, the government of Zimbabwe has recently adopted a double-edged approach of both market and technology driven incentives to catalyse sorghum production and marketing in arid parts of the country. Unsurprisingly, there are still notable differences in prices between rural and urban sorghum markets with prices relatively lower in the former as justified by the transaction costs argument. This is mainly because sorghum

supply is relatively higher in the areas of production and become more expensive as traders incur additional transaction costs in getting the produce to the urban market. There is evidence that sorghum prices in the both markets are highest between October and March, which is the lean season. Coulibaly *et al.* (2014); Misselhorn (2005) and Pinckney (1993) reported a similar movement of price throughout the season. This is attributed to the tendencies of agricultural commodity prices to be at the peak immediately after harvesting. There is therefore need for an analysis of the specific determinants of market participation and marketing channel choice so that producers are informed on whether to transact within a given market.

2.4.3 Governance structures in sorghum production, marketing and processing

There is limited information on whether it is purely policy bias that has kept sorghum grain by-products out of viable markets or it is a combination of household specific decision making processes and sorghum value chain governance systems that are not accommodative. Studies show that within the framework of product-income flow processes and networks, there is a notable distinction among a number of value chain governance regimes (UNIDO, 2009; Gulati *et al.,* 2007). The defining differences across these chain patterns is the trade-off that has to be made between the benefits and risks involved when decisions regarding how outsourcing of key ingredients such as information and production resources is made. These fundamentals decisions are the key drivers of commercialisation prospects across crop and livestock enterprises in the small scale sectors of southern Africa. The governance patterns fall along the spectrum of power asymmetry and explicit coordination mechanisms bounded by the pure market based governance (lowest) and hierarchy (highest). For stakeholders to understand where sorghum has fallen short, there is need to trace the dominant existing governance practises in rural small scale sorghum markets of Zimbabwe, as is the case in this study.

Unpacking the characteristics of the arm's length market relations shows that it is the simplest form of value chain governance (Gibbon, 2004). It would have been expected for small scale sorghum farmers in Zimbabwe to embrace, participate in and benefit from this arrangement because buyers and suppliers do not necessarily need to be closely related as the product involved is presumably naturally standardised (Trienekens, 2011). However this has not been the case because in literature there are reports that farmers and sorghum grain processing firms alike have not been able to easily meet the demands of customers in various dimensions including quality, pricing and reliability of supply. This can therefore be attributed to land allocation decisions which do not accommodate sorghum thus creating artificial scarcity of the product in potential markets, while at the same time negatively impacting on food and income security.

As such, if any challenges manifest with the product, then buyers cannot easily switch to a new different supplier in the production zone since the supplier is not available or will need significant time to provide the sorghum grain. This has created a disincentive for sorghum utilisation by processors especially stockfeed manufactures as it becomes risky since farmers can easily have an upper bargaining hand using price as the central governance instrument (Rohrbach & Kiriwaggulu, 2007; Poonyth *et al.,* 2000). Experiences in Zambia show a different picture where small scale farmers in the southern and drier parts have strong direct linkages with processors of stockfeed and beer (Hamukwala *et al.,* 2010).

Given experiences in Zimbabwe, can value chain stakeholders therefore advocate for modular (network-style) networks with sorghum? As noted by Giuliani *et al.* (2005) in Latin America, in this set up, the firms tend to develop information-intensive linkages with clearly delineate essential competences among themselves. The buyer determines what is to be produced in terms of the design and product specifications. This provides an opportunity for

the highly competent suppliers to provide the product at the shortest notice since they have a cluster of product specifications readily available at their disposal. Small scale sorghum farmers in arid and semi-arid zones of Zimbabwe have failed to capitalise on this attribute of consumers through networks which foster information sharing intensity and allowing buyers to gain confidence in their competence as suppliers of sorghum grain. According to Angelucci & Conforti (2010), examples of modular linkages are successfully exhibited in financed value chains where buyers are committed to few suppliers such as in contractual arrangements. Sadly, embracing this approach has manifested in the form of sorghum processors opting for lowly priced and reliable imports from neighbouring countries such as Zambia, Malawi, Namibia and Botswana. This has a negative bearing on the sustainability of domestic sorghum enterprises as farmers end up having no reliable markets to supply their produce.

There is evidence that the realities among small scale sorghum producers is that there are high chances of them not providing differentiated products in the marketplace due to their complexity and varied quality demands. This is for example done by stock feed in Nigeria (Asogwa *et al.,* 2012) and commercial beer processors in Tanzania (Makindara *et al.,* 2013). Ultimately, this has led to unsustainably dense interactions being developed whereby knowledge cannot be easily generated, codified, transmitted within the chain or learned by all stakeholders. Studies by Lundy (2012) and Tchale & Keyser (2010) show that, the way forward is for the small scale farmers to develop links with a few distinct markets with whom they develop long term relationships characterized by some risk sharing practices such as contracting or cooperative farmer groups.

It can therefore be argued that, given the prevailing scenario in the small scale sector, the best way is to migrate towards captive networks which embrace and scale out practices such as

out-grower contractual arrangements such as those offered by Delta Beverages Pvt Ltd and Profeeds Pvt Ltd in Zimbabwe. Alternatively, a hierarchical platform which is characterised by various forms of vertical integration can be adopted. The strategy will be to isolate some lead firm which takes overall control and ownership of some strategic production operations given that competent farming households cannot easily be found or it is difficult to codify desired products such as sorghum grain or seed. In the medium to long term, this transition will have direct implications on domestic and international trade along multiple sorghum value chain nodes (Kerr, 2014; Chemionics International Inc., 2009). This will naturally trigger changes in consumer tastes and preferences for this coarse staple and have a net effect on land allocation decisions towards the crop and its marketing along many channels.

2.4.4 Organisation and performance of agricultural value chains in southern Africa

Sorghum was traditionally a major source of food among small scale farming communities of Zimbabwe (Mutami, 2015) and sub-Saharan Africa (Taylor, 2003). Going forward, the crop is, therefore, critical when strategies for fighting against rural poverty are to be designed. The government of Zimbabwe and other development institutions have been and are currently to some extent assisting sorghum stakeholders to improve their sorghum sector performance. This is being done through a series of programs and projects supporting organization in investment as well as through policy and institutional reforms (GOZ, 2013).

In sub-Saharan Africa, many countries have been implementing or are seriously considering implementing reforms of their sorghum systems from production through to consumption (Smale *et al.,* 2018). The end goal of these reform strategies is to strengthen the competitiveness of sorghum production, processing, and exports in an increasingly demanding and diverse world market. This should also ensure long-term, sustainable, and equitable growth for this potentially important sector in many African economies. At the core

of these interventions are decisions regarding realigning the role of the state in decision making practices; facilitating greater involvement of the private sector and establishing collective farmer organizations. For organizational and performance efficiency, it is also important to pay particular attention to ensuring greater and fair competition in input and output markets which can lead to improved productivity through research and development. Rohrbach & Kiriwaggulu (2007) also allude to these dimensions and add that for improved performance of the sorghum value chain, there is need for technology dissemination and comprehensive value addition programs which re-hinged on product and market development. The desired outcome, as reported by Poulton, Kydd, & Dorward (2006), should be the processing of sorghum grain and by-products to competitively service multiple value chain nodes.

There is consensus that, understanding the structure of the sector is critical in designing and sustaining reform programs since it has the potential to either promote and/or impede fair competition along value chain pillars. However, Aduguna (2007) reports that, relatively little continuous attention has been paid to the precise structure that sorghum sectors could take after some reform intervention for sustainability benefits. There is work by Makindara *et al.* (2013); Hamukwala *et al.* (2010) and Mafuru *et al.* (2007) that confirms that the sorghum sector structure greatly matters to the overall performance and to the various types of the approaches needed to improve its physical and economic performance. Ahmed *et al.* (2000) concurs and adds that the developments taking place in other competing or complementary sectors have a strong bearing in the performance outcome of the primary sector.

An immediate case as presented by Asogwa *et al.* (2012) in sorghum marketing performance shows that for stakeholders to remain competitive and increase market share and market diversity, there has to be extensive effort that acknowledges the need to enhance productivity

and quality management. This, as agreed to by Chepng *et al.* (2014), will be integral in building and sustaining competitive advantage in value chain nodes. Mukarumbwa & Mushunje (2010) report that, in Zimbabwe and extending to a number of southern African countries, the recent experience in relation to policy dialogue, shows that in most cases, the models for supporting the sorghum value chain is based on reference to countries such as Zambia and South Africa. Rukuni *et al.* (2006) however postulate that, in order to effectively design reform strategies in more complex business environments, there is need for local level analysis of value chain pillars. The analyses are missing in most countries and restructuring of the sorghum sector becomes a huge challenge (Adegbola *et al.,* 2013). This study aims to bridge this gap and conduct an economic analysis of the sorghum value chain in semi-arid Zimbabwe.

2.5 Challenges in the sorghum value chain

Westlake (2014) and Porter (1985) define a value chain as a systematic value flow of goods and services from inception of the idea until it reaches the final consumer. Hellin & Meijer (2006) concur by recognising that there a number of clusters of chain actors including input suppliers, farmers, traders, processors, retailers and final consumers who execute various specialised functions. These stakeholders should shape the nature, value and direction of benefits emanating from their relationships. Yet, being a member of any cluster does not imply the ability to extract equal and maximum possible value (benefits). Khonje *et al.* (2015) and Mutenje *et al.* (2010) also identify the impact of policy on the crop mix in resource constrained small scale farming systems which often forces farmers to grow crops that they may not have preferred, thus distorting the structure and conduct in value chains. For example, in Zimbabwe, the over dependency on maize even in areas where it is not suitable for cultivation has undermined food security and income gains due to the higher

frequency of droughts in recent years (Bola *et al.* ,2013; Rukuni *et al.,* 2006). This has also persisted in a number of countries in Africa (Di Falco & Veronesi, 2013).

There is wide held consensus that sorghum is a good substitute and/or complementary crop for maize especially in dry land areas (see for example Hassan *et al*., 2016) which are often the sites for Trans Frontier Conservation Areas (TFCAs) and are prone to heat stress and drought. In Zimbabwe, a number of sorghum commodity value chain nodes including domestic consumption, seed, local opaque beer and commercial beer breweries are currently functional to various extents and scale. Others including stock-feed, bio fuel and silage still need to be explored and supported so as to broaden the marketing channel options for farmers. Successful unlocking of sorghum based value chains have been reported by Makindara *et al.* (2013), Mason (2010) and Rohrbach *et al.* (2007). In addition, Dicko *et al.* (2006) also advocate for the use of sorghum grain as human food in Africa.

Learning from these experiences can help to strengthen the currently existing nodes and tapping into potential avenues. This will establish a concrete foundation for sorghum to contribute towards household and national economy of Zimbabwe. More sorghum marketing channels will increase the appetite for production and pricing efficiency due to competition. There is evidence stemming from work by Hamukwala *et al.* (2010) which identifies potential scope for enhancing performance of sorghum value chains in semi-arid southern Zambia and the surrounding sub-region by unlocking the seed systems. This can be achieved by more integrated and direct private sector interventions which grease market linkages across all pillars of the value chain. In Zimbabwe, there is a current gap in research on market linkages that exist in sorghum value chains, the associated challenges, their responsiveness to change and their appropriateness in various contexts.

Abdulai & Huffman (2014) and Ortmann & King (2007) concur that the approach to agricultural research is changing from the conventional linear mode to integrated and more holistic approaches. For example the Integrated Agricultural Research for Development (IAR4D) and the Innovations Systems (IS) philosophies have been adopted over the past years in response to the challenges facing traditionally linear agricultural research methodologies in Africa. These approaches advocate for embracing new mechanisms of stakeholder involvement and empowerment to reduce risks (Drost *et al.,* 2012; Angelucci & Conforti, 2010) and strengthen the '*new agribusiness revolution'*. This shift in attitude will develop and strengthen the production and marketing of small grains such as sorghum especially in semi-arid environments. If appropriately blended with practices which are guided by the value chain approach, this matrix should help to achieve nutritionally stable and reliable stocks of food at affordable prices. In this regard, significant strides have been made to disseminate technologies among agricultural stakeholders as reported by Khonje *et al.* (2015); Diiro (2013) and Mazvimavi & Twomlow (2009). However, there is still need for market linkages to be enhanced in terms of responsiveness to changes in agricultural systems and relational platforms.

The persistent and sustained absence of strong and responsive market linkages among value chain actors is a problem since it has a close relationship with compromised livelihoods (Escobal *et al.,* 2015; NEPAD, 2003). This calls for designing of more appropriate market networks if the value chain approach is to bear fruit especially with currently marginalised crops such as sorghum. In Zimbabwe, the performance of agricultural markets can generally be classified as unhealthy with signals of a decrease in the number of stakeholders in most platforms since 2000 (Poulton *et al.,* 2004; Makamure *et al.,* 2001). There is evidence showing that the underlying problem of weak and unsustainable market linkages, flow of resources and information in value chains for small grains remains engraved in most small

scale farming areas of Africa (Asogwa *et al.,* 2012; World Bank, 2006). In line with Agenda 2064 of The African Union (AU) which advocates for private sector driven rural agribusiness development, crop specific production and marketing arrangements, inspired by mutual benefits need to be designed, sustained and scaled up (Government of Zimbabwe, 2013; NEPAD, 2003).

2.5.1 Production constraints

Small scale farmers in southern Africa including Zimbabwe usually cite the late acquisition and reliability of quality inputs as a major challenge to market oriented production (Mutami, 2015). Most previous studies (for example Ortmann & King, 2007; Rukuni *et al.,* 2006) acknowledge that, production factors such as fertilizers and pesticides are expensive while quality seed of different sorghum varieties are relatively available but have not been adequately multiplied (Haussmann *et al.,* 2012, Ricker-Gilbert, Jayne, & Chirwa, 2011; Eicher, 1995) and distributed to farmers at the right time and quantity for early planting (Twomlow, 2009; Rohrbach & Kiriwaggulu, 2007; Shapiro & Sanders, 1998).

Experiences with the SMIP in southern Africa show that small scale farmers mainly depend on retained seed from the previous season while input support mechanisms such as subsidies for the sorghum enterprise remains unreliable. Consequently, farmers end up planting the crop late. As a result in most semi-arid areas the crop has suffered from extended mid-season dry spells culminating in low yields (Smale, 2018; Bola *et al.,* 2013). In Malawi, there are reported productivity gains from adopting high yielding varieties by small scale farmers (Kerr, 2014). Contracts for the sorghum based stock feed and beer brewing nodes have also gone a long way in ensuring availability of inputs to farmers. A number of studies (Sarris & Morrison, 2010; Ortmann & King, 2007) show the potential of farmer cooperatives in facilitating access not only to input markets but also to output markets.

Agricultural financing also plays an indispensable role in the success of farming activities due to its catalytic effects on access to production factors (Fries & Akin, 2004). The deficiency of reliable rural finance options has derailed sorghum production (and marketing) potential in the arid small scale areas of Zimbabwe, just like any other crop enterprise. Unsustainable financing mechanisms in these communities imply that farmers have to rely on personal savings, loans from friends and relatives and cash from non-farm activities such as selling milk and fruits to finance other agricultural activities. The unreliability of these strategies further compromises timely acquisition of inputs (Coulibaly *et al.,* 2014; Angelucci & Conforti, 2010).

Faced with these challenges and low yields, farmers in arid areas reserve most of the sorghum grain output for household consumption given that there are limited opportunities for other cereal crops such as maize. In these marginal areas, household income contributions from other agricultural enterprises such as livestock are still low regardless of significant livestock numbers being kept by farmers (Mutami, 2015). Income from these alternative sources could be used to strengthen the sorghum value chain in the short term before it can be self-sustaining given the current state[16]. There is evidence that crop-livestock integration practices have been successfully implemented to counter the challenge of limited agricultural finance channelled towards small scale farmers by formal systems in many parts of the world (Hosu & Mushunje, 2013). Studies in Zimbabwe, Kenya and Tanzania show that farmer cooperatives can offer a breakthrough from this challenge and improve access to affordable financing. For example, small scale farmers in most rural communities of sub-Saharan Africa have successfully developed savings clubs which have sustained provision of agricultural finance (Sarris & Morrison, 2010).

[16]Small scale farmers have not embraced the commercial orientation of crop-livestock integration philosophy

In the greater part of Africa, there is a missing link of government allocation of subsidy funds towards sorghum based value chains in semi-arid areas where maize performs poorly (Ricker-Gilbert *et al.,* 2011; Jayne & Rubey, 1993). Notably, in southern Africa, extension service delivery for sorghum is mainly inefficient with limited effective interaction between extension agents and farmers. There is need to find alternative solutions to enhance extension modes with adequate response mechanisms in the wake of evolving value chain indicators including prices and consumer preferences (Mabiso, Cunguara, & Benfica, 2014; Maina *et al.,* 2012; Angelucci & Conforti, 2010). Information related to production practices and associated changes in innovations is an indispensable ingredient in effective decision making on enterprise choice by small scale farmers (Shiferaw *et al.,* 2015; Adegbola *et al.,* 2007). In small scale farming communities, sorghum production is mainly affected by poor and dysfunctional networks at all levels and thus has remained rudimentary, uninformed and subsistence oriented.

Specifically, in semi-arid areas of southern Africa, where sorghum can do well, agriculture practises are still poor and the land use patterns are not always the most suitable in the environments. Mafuru *et al.* (2007) and Poonyth *et al.* (2000) weighed on this and concur that without the right economic environment including accommodative market incentives and effective extension services, resource constrained farmers can hardly benefit from sorghum production and marketing innovation platforms. If this impetus is not injected into areas of low, erratic rainfall and relatively high temperatures where sorghum has great potential to do well, the benefits can never be realised beyond the household food security level at the best.

2.5.2 Post-production challenges

There are fundamental issues of storage, processing and marketing which need to be examined for small scale farmers to attain income and food security. Inappropriate grain

storage facilities in small scale farming set ups is a challenge. This leads to significant post-harvest losses along the value chain as about 60% of the grain deteriorates during storage. Storage facilities need to be affordable, upgraded or built to handle large volumes of grain required by the industry. Mmbando *et al.* (2015) examined the welfare impacts of maize and pigeon pea market participation using consumption expenditure with propensity score matching and endogenous switching. They reported the effect of infrastructure such as storage facilities as an important factor in determined sustained food security throughout the season. To understand this better, more research can be done on grain weathering or alternatively, technologies that are already in the pipe line can be tried and scaled out.

Sorghum producers in most of southern Africa, except South Africa are too small, producing an average of 0.81 ton/ha on an average area of 0.6ha per household. The low sorghum productivity levels in Zimbabwe means millers have to import sorghum from other regions such as South Africa and Zambia where productivity is higher. Problems are also encountered when farmers are constrained in supplying adequate volumes to markets due to stockholding limitations. Faced with this conundrum, there is limited scope for farmers to invest in processing equipment (Proietti *et al.,* 2015) such as mechanical grain threshers which cost on average 2000 US$. This means that farmers end up selling the raw grain which fetch low prices in the markets. Previous studies show that farmers are therefore exposed to unfair trade as they have weak negotiating capacities fuelled by no training on farm management principles such as marketing in competitive environments (Musara *et al.,* 2018; Maina *et al.,* 2015; Benfica & Tschirley, 2012).

In most cases there is evidence that marketing logistics tend to become more complex with traders and middlemen controlling the market thereby creating a breeding ground for exploitation of farmers for prices and standard requirements. In Zimbabwe, this scenario

dominates most sorghum producing zones where no producer and marketing associations represent farmers in these transactions. All this is further compounded by the low purchasing power of Zimbabweans which represents the main limitation for market penetration, expansion and growth. Of Zimbabwe's annual sorghum grain output, about 20% is commercially processed as malt in beer industries.

Rohrbach & Kiriwaggulu (2007) reports that in the greater Africa, there is potential for the animal feed industry to use sorghum but only so if the relative prices are lower than the prevailing maize prices. In the early 2000s, ICRISAT worked on efforts to convince Zimbabwean millers to incorporate sorghum meal in their business portfolios. This was based on the notion that consumers would accept the taste of sorghum meal. However a gap still remains on the quantified relative size of the sorghum market to justify the use of the grain in commercial processing. As such, market participation by small scale farmers remains low due to the uncertainty about the availability of reliable markets. To expand the marketing channels at the disposal of these farmers, Makindara *et al.* (2013) argues that there is urgent need to find alternative markets for the sorghum grain apart from the current dominant breweries into for example stock-feed, biofuel, silage and health products.

Additionally, farmers need to be educated on the different pricing for grain and seed because they seem to confuse the two. In the process, they focus too much on price and not other factors such as quality and reliability as demanded by partners in the value chain (Zerbe, 2001). Experiences have also shown that there is relatively skewed distribution of value chain gains with processors being the highest beneficiaries and primary producers getting the least share (Tefera *et al.,* 2012). This presents a squeeze for small scale sorghum farmers who should be linked so as to be strategically positioned. Currently they are disconnected from other value chain stakeholders especially at the processing and marketing nodes.

2.6 Opportunities to improve the sorghum value chain for welfare impacts

Sorghum is nutritionally superior to other cereals as noted by Adegbola *et al.* (2013) and supplies the basic nutritional requirements for the rural poor whose income levels prohibit acquisition of other relatively expensive source (Proietti *et al.,* 2015). This provides a sustainable safeguard against food and income insecurity. Sorghum provides for the main energy and protein demands for a sixth of the global population located in climate vulnerable semi-arid regions of the world. The crop is also an integral component of the staple diet and income source for over 300 million people domiciled in Less Developed Countries (Taylor, 2003).

Small scale farmers struggle to firmly position themselves in the mainstream economic map especially with the advent of economic integration driven market liberalisation. The benefits of market liberalisation which has facilitated affordable access to information, resources and a variety of products from various local, regional and international markets have evaded them (Oduol & Mithofer, 2014; Poonyth *et al.,* 2006). Interestingly, at the same time, consumers have responded by demanding high quality products in highly differentiated forms at the lowest possible price. This presents an additional challenge for the small scale farmers thus creating a market response lag in terms of production, market participation and marketing channel selection. Three distinct subsystems have dominantly emerged in response to the varying needs of the multiple market segments.

Guided by Aduguna (2007) and Rukuni *et al.* (2006), the '*rudimentary-system*' can be said to be dominant for small scale sorghum in Zimbabwe. This is characterised as the low income chains with inappropriate input sourcing, production and marketing systems. This category dominates practices in rural farming communities which exhibit traditionally '*high-volume'* and '*low-value*' platforms. The main target of these chains is to supply the local markets with

the basic staple food commodities such as grain sorghum and maize. This is the current case with Zimbabwe's small scale sorghum producers who have over time found it convenient to supply the local markets due to lower transaction costs and reduced risks. Angelucci & Conforti (2010) and Trienekens (2011) argue that this is not enough to improve agricultural value chains and advocate for improved market linkages and increasing market sizes. This can be achieved when traders develop direct strategic linkages with farmers who participate in low end markets. However, characteristically, in southern Africa these chains tend to be long and there are high chances that the small scale farmers will not access the benefits from final markets (Sarris & Morrison, 2010). This greatly reduces the share of margins accruing to the sorghum farmers and hence the need to examine market participation and marketing channel selection decisions in these contexts.

The main question currently needing attention is how stakeholders can support a shift from rudimentary systems to the agribusiness notion for agricultural development in Zimbabwe. As noted by Giuliani *et al.* (2005), this has inspired focus on the '*transitionary system*' which comprises of producers in developing communities who target the emerging high value marketing channel options such as supermarket chains. The successful stories with these chains have been reported with the development of local farmer cooperatives glued and based on a series of win-win contractual arrangements with the private players (Barrett *et al.,* 2012; Maina *et al.,* 2012). The reality is that if small scale sorghum farmers meet their end of the bargain in terms of conforming to volumes, quality and time, then their sorghum grain can penetrate niche markets. The case of Delta Beverages Pvt Ltd contracting smallholder sorghum producers in areas such as Matabeleland and Mashonaland is a model example of this system. The catch scenario is that, though these tend to be '*low volume*' networks, they generate '*higher value'* than the '*rudimentary-system*'. Burke *et al.* (2015) and Nyanga (2012) recommends that for this shift to be achieved, it demands a holistic re-alignment of

attitudes and skills of the farmers through training and support with basic resources through for example affordable financing at the take-off stage.

The more complex and highly rewarding '*advanced-system*' is dominated by the export chain (Barrett *et al.,* 2012; Ortmann, 2000). In this arrangement, low quality products rejected in the export market can also be domestically sold. Even though the volumes tend to be the smallest of the three sub systems, the value generated is the greatest. Evidence shows that reduced investments and the setting in of diseconomies of scale among small scale farmers in Zimbabwe has been the major drawback in greasing the potential sorghum market linkages. An example of this subsystem is the Export Processing Zones (EPZs) facilities that were implemented in Zimbabwe around 1994 (Rukuni *et al.,* 2006) and the more recent the Special Economic Zones (SEZ) borne out of Zim-Asset (Government of Zimbabwe, 2013).

Supporting these initiatives, with particular focus on marginalised crops such as sorghum can offer unimaginable breakthrough for farmers in arid and semi-arid production zones. As reported by Asogwa *et al.* (2012) and Angelucci & Conforti (2010), the main challenge is developing a universally acceptable price, quality and standards system to be embraced by all actors in the identified strategic commodity value chains. This can also be compounded by the currently existing weak interconnections that are exhibited within and across the three sub-systems. For example in the Zimbabwean small scale sorghum context, outputs from one sub-system are not being used in another system i.e. activities tend to be too localised. If these linkages are improved then there is likely to be benefits from commercially oriented agro-industrial practices which extensively make use of the '*advanced-subsystem*'.

2.7 Sorghum commercialisation prospects

Sorghum is primarily grown for subsistence in Africa with less than 3% of the yearly output being commercially processed by industry (Adegbola *et al.,* 2013). A number of challenges

characterise commercialisation prospects of most agricultural commodities especially small grains such as sorghum (Rohrbach & Kiriwaggulu, 2007; Ortmann, 2000). In Zimbabwe, there is a parallel frontier where on one hand small scale farmers are unwilling to invest in expanded production of the crop as long as the right seed, fertiliser, subsidies and markets are not readily available (Thierfelder *et al.,* 2015; Twomlow *et al.,* 2006) while processors also avoid the crop due to unreliability and prohibitive comparative prices. Government of Zimbabwe (2013) reported that this has stalled market development initiatives by the private sector leading to the crop being limited to farm household food security. The fundamental constraints to the commercialisation of sorghum include comparatively low productivity levels, high transaction costs and limited awareness of the potential commercial uses of the crop. These dominant challenges have more directly manifested as skewed government (and private sector) support in production and marketing, limited marketing channel options and biased consumer preferences away from sorghum (Sultan *et al.,* 2013). This has had a bearing on the potential of sorghum value chains in the small scale sector of southern Africa in general and Zimbabwe in particular.

The basic theory of agricultural marketing states that individuals are faced with distinct choices of either participating in a particular market and gain income or consume all that they produce (Azam *et al.,* 2012). The former group are those who have evolved from subsistence to commercial and market oriented agricultural practices. Therefore the rationality framework of producers and consumers has formed the foundation of most analyses of how and why individual households make a choice to commercially produce a particular crop, enhance land allocation towards the crop and participate in a given marketing channel with the surplus (Mmbando *et al.,* 2015). Studies by Trienekens (2011) and Ortmann (2000) show that, most information disseminating linkages have not evolved in response to the shift from agriculture to agribusiness and as such still depend on static and localised peer linkages.

Burke *et al.* (2015) and Escobal *et al.* (2015) also observed that most value chain actors fail to access new market opportunities because the peers they depend on are also not appropriately networked. Tefera *et al.* (2012) noted that, it is therefore important to promote linkages which connect actors not only within their cluster but across multiple groups.

Given the above limitations, an integrated mentality by societies which can be catalysed through changes in knowledge, attitudes and skills will in future drive networking and grease the wheels for easy access to factor and product markets. This will inspire a new revolution in agricultural marketing whereby actors can fully exploit their advantages through bargaining for higher shares. Ortmann & King (2007) note that guided by this vision, in recent years there has been significant investment in research towards how the small scale farmers can become an integral participant in the food value chains of southern Africa. However, no significant results have been observed for the small grain domain of agriculture which encompasses sorghum and millets.

Rohrbach & Kiriwaggulu (2007) and Shapiro & Sanders (1998) postulate that in small scale farming areas, different forms of farmer support and cooperation arrangements have existed for a long time as an effort to commercialise agriculture. The practices have been premised on the need for coordination of small scale agricultural production and processing by agribusiness companies. These involve contracts where arrangements between farmers and a firm specifying one or more conditions of production and marketing of an agricultural product are entered into. These relations are premised on committing the grower to produce a certain commodity at a certain time for an agreed quantity and price while in return, the firm undertakes to provide a market for the commodity. In some instances the contractor may provide extension services and other facilities to producers in order to satisfy its quality and quantity production requirements.

There is evidence that, adopting contracts towards commercialisation prospects works well where production organised in platforms such as cooperatives dominate and formal marketing systems are still underdeveloped. Barrett *et al.* (2012) observed that in most cases contracts can offer increased incomes for producers and higher profits for investors thereby reducing risk and uncertainty for both parties. Interestingly, in the commercialisation drive, contract farming offers opportunities for new market opportunities including export markets of non-traditional export products which small scale farmers would otherwise not be able to participate in since it introduces value-added production activities (Trienekens, 2011). Worryingly, previous studies have shown that, cash crops such as cotton, tea and tobacco have dominated contracts and other farming support portfolios. In Zimbabwe, contract based cash crop production has had positive spill over effects on food crop production and development of services in most small scale zones (Rukuni *et al.,* 2006).

Commercialisation of sorghum in these areas is a challenge because most cereals are considered to be of relatively low value and high risk to the sponsoring company due to widespread household retention for food and present unlimited opportunities for side selling within local informal markets. As such, the holistic perspective to the value chain approach has not infiltrated semi-arid farming peripheries of TFCAs in Zimbabwe where sorghum can do well. Therefore, this socio-economic and institutional transformation approach remains with undocumented and unquantified potential to commercialise small scale sorghum systems. However, this myth can be broken if an econometric evaluation of the production, marketing and welfare impacts of sorghum in small scale households can be done. Makindara *et al.* (2013) and Rohrbach *et al.* (2007) argue that the migration towards more interlocked and mutually beneficial arrangements inspired by the value chain philosophy is therefore critical to commercialise small scale sorghum practices. This specifically implies tackling issues such as input prices and access, network structures at the local level and beyond,

product prices, increasing market size and access to low cost marketing channels among other key variables.

2.8 Guiding framework for value chain analysis

Value chain analysis is guided by a framework showing procedures and points of attention for enhancing activities and networking. For example Giuliani *et al.* (2005) and Taylor (2003) argue that it is important to begin by unpacking the constraints before studying the opportunities available for the chain. Most studies have however adopted a more descriptive analytical approach thereby missing the intertwined nature of these factors. Experiences from Zimbabwe as reported by Mango *et al.* (2014) show that these constraints cannot be treated as mutually exclusive draw backs. The main constraints in developing countries include market access and orientation, resources and infrastructure and institutional factors. Trienekens (2011) concurred and noted that:

> *"…getting access to markets is not a sufficient condition for developing country value chains to be able to sell their products. Supporting infrastructures, resources including knowledge and capabilities are conditional for these chains to be successful…".*

For effective interventions to be developed, it becomes important to adopt a more econometric[17] orientation in order to understand these fundamental determinants. Understanding these is the underpinning precondition to guide how the sorghum value chain in the mid-Zambezi Valley of Zimbabwe may be upgraded.

Evidence shows that, in reality value chain analysis is made difficult since as opposed to the linear representation shown in most schematics, generally value chains are characterized by complex multiple linkages and flows. In these chains, there are a number of intermediary

[17]See chapters 3, 5 and 6 for a detailed explanation of these tools.

producers that can also feed into a number of value chain nodes (Angelucci & Conforti, 2010) creating a complex map[18]. Mostly, these flows culminate in the branches from the main value chain absorbing an insignificant component of the total output but in some isolated cases, chances are that customers are shared almost equally among the nodes. It has been observed that, in the characteristically complex and integrated markets of today, a relatively small or (large) customer or supplier may become a relatively large or (small) customer or supplier in the future. This is a reflection of the value chain's potential to grow. Phiri *et al.* (2013) reported cases where in a commodity value chain, a particular supplier controlled some strategic technology or input in markets. Regardless of whether this may be an insignificant part of the output, this monopoly causes the dynamics of the value chain to become even more complicated and unpredictable.

The evolution of the agribusiness concept has generated a paradigm shift in understanding these complex market interactions. There has been a change from scenarios where the main challenges faced by the producer was to provide volumes of produce that were adequate to a market that was almost always supply constrained. Moussa (2011) maintains that in the present day case, the markets are now characterized by production systems that tend to be '*market-driven'* rather than the traditional '*supply-driven'* value chains that had low competition traits and were inefficient. In light of this new orientation, the focus on the final product market becomes a prerequisite to understanding the functioning of value chains. This calls for the mapping of the market size and market growth potential as important trajectories in value chain analysis. In essence, after the identification of the focal point in any study of this nature, Hellin & Meijer (2006) reported that, decomposing the final market into distinct marketing channel segments with unique characteristics becomes a precondition.

[18] See Figure 6.1 in Chapter 6.

There is evidence of observed variations from low income markets where the price dominates as the key Critical Success Factor (CSF) to high income markets where factors such as quality and branding become important (Ortmann & King, 2007). To understand these issues, UNIDO (2009)[19] proposed a set of guiding procedures when conducting value chain analysis and development. The major challenge in Zimbabwe is to prioritise the selection of context appropriate agricultural commodity value chains. In most cases the sorghum value chain has been side lined from mainstream research due to fragmented policies regarding provision of support for various crop enterprises. As such, there are tendencies for high potential crops to be left out of planning for reasons including political mileage and borrowed policies which are in most cases inappropriate in the local contexts.

2.9 Transaction costs along sorghum value chains in developing countries

Managing transaction costs in agricultural enterprises remains a critical function if meaningful gains are to be extracted in markets (MacInnis, 2004). In most developing countries, sorghum marketing is exposed to multiple exogenous and endogenous push/pull factors which compromise or enhance the interaction of stakeholders. Maina *et al.* (2015) report that farmers sometimes overlook these tranasaction costs and do not account for them in their farm businesses. The major elements left out include the bargaining costs and search costs which ussually present themselves as hidden costs of doing business. Osebeyo & Aye (2014) concur and report that these farmers will then tend to overstate their profit margins thus giving a false impression of enterprise viability. A similar scenario was also observed in the commercialisation analysis of the sorghum enterprise by Rohrbach & Kiriwaggulu (2007) in Tnzania. They noted that transaction costs are an indispensable ingredient into efficient marketing but they can also be excessive to an extent of disincentivising participation in some markets.

[19]These steps guided the current study in value chain analysis.

The reality of most developing countries including Zimbabwe is that in most cases, marketing points are located away from the production zones (Schaner, 2016). The tranasaction costs then become the 'cost of inconvinence' whenever the farmer decides to transact in a particular market. As a strategy to reduce the inconvinience, Takeshima *et al.* (2011) reports that entreprenuers have the tendency of offering the market services, albeit at a fee which can be higher than the case when the farmer would have been physically present at the market. These middlemen have become a common component of marketing channels and in most cases are getting the greatest value from the transactions. Mutami (2015) and Scoones *et al*. (2011) report that among small scale farmers in Zimbabwe, the transaction costs constitute about 65% of the total costs of marketing. Inspired by this observation, this study aims to explore the marketing factors in an effort to identify intervention points which offer opportunities for stakeholders to coordinate marketing activities in a mutually beneficial way which can increase the net benefit accuring to ech of them along the value chain.

Bargaining power in agricultural commodity markets has the cascading effect of increasing the returns through negotiations for contracts, prices and market share (Mmbando *et al.,* 2016). However, Rukuni *et al.* (2006) report that most small scale farmers in Zimbabwe lack the bargaining skills and are exposed to unfavourable marketing conditions such as unfair prices both in open markets and in contractual arrangements. This, according to Diiro (2013) has compromised the adoption of productive innovations at various spatial and temporal scales. The welfare of the farmers with low bargaining power and with limited access to innovations remain poor and most of them will always produce for subsistence. It is therefore important at this stage to explore the welfare effects of intensifying high yielding sorghum varieties as a gateway out of low productivity, low incomes and food insecurity. Infrastructural inadequacies have also had a negative bearing on marketing and market performance in developing countries (Sultan *et al.,* 2013).

In the aforementioned environments, both communication, financing and transaport networks do not offer opportunities for affordable services. Trienekens (2011) agrees and notes that efficiency in agricultural commodity value chain is hinged on the availability of good infrastructure. Taylor (2003) adds to this and reports that storage facilities are another important dimension which has the potential to reduce the transaction costs in most markets. Tefera *et al.* (2012) noted that small scale sorghum farmers who do not have storage facilities incur higher transport costs, sell during periods when the market prices are low, have lower scope for negotiations and are worse off than their counterparts with storage facilities. This study explores the various dimensions of transaction costs including distance to the market and number of accessible buyers in market with the view of identifying options to reduce these costs and increase value from sorghum.

2.10 Summary of literature review

Zimbabwe's semi-arid regions such as the mid-Zambezi Valley have immense potential to produce enough output to meet the demands of the sorghum grain markets across the various potential end users. However, in light of the above observations, the pillars of the sorghum value chain are compromised by challenges including information asymmetry, limited access to strategic input and output markets as well the associated prices in these markets. Additional research will provide more localised, appropriate and responsive interfaces between farmers, extension workers, focal point persons among other key stakeholders to share production and marketing information and experiences on sorghum value chain platforms. This immediate dispensation should go beyond traditional descriptive sorghum production, marketing and welfare studies. The aim is to catalyse the understanding of key determinants which affect these aspects of the value chain through more econometric inclined lenses. Guided by understanding challenges presented here-above, the framework for the present study will be aimed at recommending on deliberations and design of responsive

market related solutions based on realities of the value chain approach for sorghum as shown by the research findings in the mid-Zambezi Valley. This research effort should be able to strengthen the functionality of sorghum value chains as driven by market linkages while facilitating commercialisation of the crop in the small scale farming domain.

CHAPTER 3

METHODOLOGY

3.1 Description of study area

The study was conducted in the mid-Zambezi Valley of Zimbabwe which stretches along Kanyemba at the Zambezi River in the North to the Muzengezi River near Mahuwe in the East. Specifically, Mbire district (Figure 3.1), which is located in Mashonaland Central Province and the youngest district in Zimbabwe with 17 administrative wards was selected for the study.

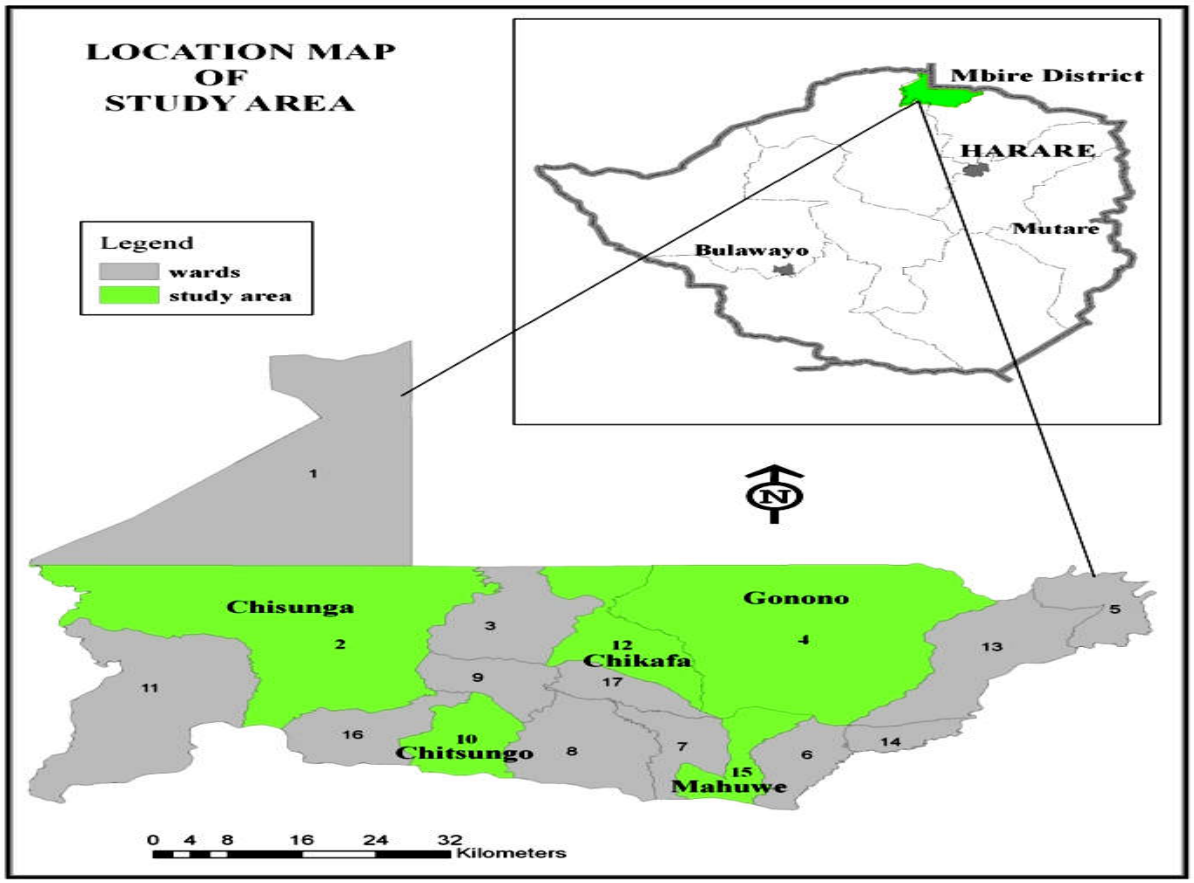


Figure 3.1: Location of the study area

Source: Generated by authors

The district has a population of 82380 inhabitants and a density of 17.54/km^2 which is increasing at an average of 1.09/year. There is a balanced composition of males and females in the area with a 50% representation in the active 15-64 years category. Mbire district is located at Degrees Minutes Seconds (DMS) coordinates -16°09'32" S and 30°34'21" E or -16.11589 and 30.5727 in Decimal Degrees (DD) or Universal Transverse Mercator (UTM) coordinates of 36K 240249.9488 and 8211076.5675. The area lies at an average elevation of 373m and is semi-arid receiving below average and erratic rainfall coupled with high temperatures.

Temperatures in the area average 30^{o}C with no significantly distinct seasonal variations even though winters can be as cold as 8^{o}C in June and July in the mornings and evenings. An annual rainfall ranging from 350 to 550 mm is experienced in Mbire district. Extreme water scarcity is experienced in the long dry season which stretches from April to October. Availability of water improves in the wet season spanning from November to March. Despite the poor sandy soils, erratic rainfall and crop destruction by wildlife, households in the mid-Zambezi Valley still depend on agriculture for subsistence and cash income. Cotton has for long dominated livelihood options alongside sorghum, maize and soya bean. However, due to the global decline in cotton market prices, livestock rearing which has also been practiced in the area mainly with goats and cattle has become a very strong option for income generation. Wildlife ranching[20] also forms a core of the livelihood strategies for the local communities. Communities also depend on informal trade in clothing, fruits and locally produced hardware. These activities are dampened by the limited infrastructural development initiatives in road networks and ICT platforms which tend to isolate these communities from mainstream markets.

[20]Programmes including CAMPFIRE and REDD$^+$ have been implemented in these areas. The Lower Guruve Development Association (LGDA) has partnered with other NGOs such as Action Plan to sustain these efforts.

The region is a blend of different cultures including Korekore, Chikunda, Doma and immigrant Karanga ethnic communities. These have varied livelihood strategies with for example the Doma being nomadic hunters and Karanga known to accumulate cattle and use modern technologies in agriculture (Baudron *et al.,* 2012). These cultural dimensions can have a significant influence on multiple crop production decisions by the households. Flooding is also common in the area and farmers have adopted the retreating approach[21] as a coping strategy. Three major rivers namely Angwa, Hunyani and Monozi cut across the district and people who live along these rivers are usually affected by the flooding which also destroys infrastructure. The area is located away from the main urban trading areas and is 200km North-East of Harare and 100km from Mvurwi. As such, farmers mainly depend on informal local markets with intermittent traders coming into the communities to trade at the farm gate during some marketing seasons.

3.2 Sampling frame and sample selection

The study area was selected purposively as it is a major sorghum producing zone in the LZ-TFCA where the crop has the potential to generate income and food security gains. The study area was selected after comprehensive stakeholder consultations. This was also done in sync with other various government and private sector programmes currently taking place in the mid-Zambezi Valley. Since the area is a long-term government priority area in terms of socio-economic development, then focusing on livelihoods based on the potential of sorghum was important and timely as well. The motivation was that, this would directly feed into local development efforts, ZimAsset, Vision 2030 and the devolution agenda of the government of Zimbabwe. The population was made up of small scale farming households in the mid-Zambezi Valley of Zimbabwe. A multistage sampling approach with purposive selection of

[21]As floods approach farmers retreat to highlands and when the floods have subsided they return to their homesteads to benefit from the moisture and flood debris which usually improves soil fertility. For a detailed explanation of the practice see Bola *et al.* (2014).

five wards which are dominant sorghum producing areas and population based proportionate selection of farmers was used since there was population variability across the sampled wards.

Five Wards namely Chisunga (Angwa), Mahuwe, Gonono, Chikafa and Chitsungo were purposively selected. The first four are dominant sorghum producing areas. Gonono and Chikafa are close to the border with Mozambique and their inclusion offers an opportunity to understand decisions in communities with mixed cultures and relations. Mahuwe is centrally located while Chisunga (Angwa) is at the periphery of the mid-Zambezi region and close to Zambia. Chitsungo is a unique Ward where sorghum production is minimal due to the cultural inclination of the inhabitants who believe that maize should remain the staple cereal crop. This inspired its inclusion in the sample so as to understand the hurdles faced by potential sorghum farmers who can benefit from networking with others in dominant sorghum producing wards.

A representative sample was then randomly selected to get 380 farmers[22] who participated in a survey which generated cross sectional data in April 2016. The sample size calculator with a known population of 14 500 farmers was used to come up with the sample size. This was also validated using a standard sample size table. The specific sample sizes per ward which were calculated proportionately are as follows, with the number of farmers in parenthesis as Ward 2 (80); Ward 4 (79); Ward 10 (50); Ward 12 (70) and Ward 15 (101). These farmer numbers represented the relative farmer populations per ward and by acknowledging the population differences across the wards, the proportionate sampling increased sample representativeness.

[22]A sample size of 252 is reported in the results section of Chapter 7 since the study censored non adopters from the total sampled households (380) and analyses behavior of adopters in terms of their proclivity to either intensify sorghum production or not before examining the income and food security differentials.There was variability in farmer populations across the wards and representative proportions were selected from each ward.

3.3 Data collection procedures

This study made use of both primary and secondary data sources. Primary data on existing networking arrangements, land allocation, crops produced by farmers, subsidy distribution, sources and access and market conditions were collected using a structured questionnaire as the main data collection tool. The questionnaire document consisted of question items that solicited information from a subject to facilitate objective research analyses. The questions were specifically focusing on the demographics of the households, household production patterns, household asset base structures, the marketing decision making frameworks, the food sourcing, consumption and security patterns and perceptions of households on their relationships with various value chain stakeholders. The study invested time and financial resources to understand value chain dynamics through direct interaction with the various stakeholders including seed, chemicals and fertiliser agro-dealers, briefcase traders, processors, wholesalers and retailers. This effort helped to understand why there are low numbers of farmers producing sorghum as their main cereal crop, decisions to market and associated choices of marketing channels by small scale sorghum farmers. Data on the food security and income benefits by sorghum farming households in the areas were also collected.

The effects of questionnaire bias was reduced by asking standardised questions and pre-testing the questionnaire through conducting pilot studies on a few respondents as well as friends. These procedures helped in removing and correcting ambiguous questions prior to the actual administration. The study adopted the self-administration approach so that explanations and clarifications were done when the need arose during data collection. The main observations with the questionnaire in the study, which are also alluded to by Best & Khan (1995), were that there was no way in which increased thoroughness during data analyses could compensate for the imprecision in measurement during data collection.

Furthermore, the tool involved interpersonal relationships of power and this distorted value chain actors' realities by attempting to fit them into some predetermined setups. This reality demanded the adoption of triangulating data collection tools using FGD and key informant interviews.

Six agro-dealers who provided seed, fertilisers and chemicals, fifteen traders, two processors, three wholesalers and ten retailers were also conveniently selected with the help of Agritex officers and farmers. One FGD comprising 8 farmers was initially conducted in each ward. Additionally, one FGD was also conducted with representatives from all the identified stakeholders[23] along the value chain. Facilitation and coordination of the focus group discussions was done so as to ensure that the diverse opinions of participants were brought out constructively and clearly. This instrument was effective in collecting mainly qualitative data on aspects of marketing such as challenges and opportunities from the farmers' perspective. This interaction was important in shaping the stakeholders' relationships and redefining their roles in the various marketing channels. This group discussion approach generated in-depth information and perceptions that were in most cases sensitive. There were however higher degrees of freedom as new lines of thought came up in dimensions not earlier anticipated by the study. A fairly free environment was created where all participants said out their views without fear of later victimisation. Personality however influenced participation in the discussion with some participants defining the tone and direction for the discussion.

The study also made use of the semi-structured interviews with key informants as a triangulation strategy to gather in-depth information from value chain actors. This strategy made use of open-ended questions and allowed probing which went beyond the pre-determined extent of the structured questionnaire format. In-depth knowledge about the

[23]These stakeholders are identified above.

subject matter under investigation was generated in the process. This approach was most appropriate for this exploratory study which was venturing into unknown territory of the sorghum value chain performance and development prospects. The data that were generated from these interviews tended to be more difficult to analyse since more time was invested in comparison of responses generated from the different groups interviewed. For example, interviews to generate data for CSFs and market segmentation were conducted with buyers in retailers, sales managers in producers and consultants. Perceptions of value chain actors were also captured using these interviews.

Secondary data on the other hand were available in different forms and sources from studies that have already been conducted by others. This form of data came in handy especially in situations where primary data were not available or could not easily be collected. The main weakness of this form of data arose when the source was not reliable such as cases of sales volumes and market prices. Furthermore, the data were in some cases summarised in ways that made it unusable for the current study's needs. It was therefore appropriate for the study to augment primary data with secondary data for validation purposes.

The participatory value chain analysis methodology was used to unpack the sorghum value chain. Guided by Lundy (2012) and Lundy *et al.* (2007), the steps that were involved in the study are:

1. Identification of the commodity value chain for which the analysis was needed. The sorghum value chain anchored on small scale farmers in the mid- Zambezi Valley of Zimbabwe was isolated. This was done through a series of Innovation and Communication Platform (ICP) meetings conducted in collaboration with French Agricultural Research Centre for International Development (CIRAD), a research oriented French organisation. A number of potential agricultural chains were discussed

and after a series of consultations with value chain actors, the sorghum value chain was noted to be the most acceptable and potentially viable option.

2. Identification of main stakeholders so that they are brought into the discussion. Guided by literature and experiences in the study area, these were identified as researchers, input suppliers, financiers[24], farmers, handling agents, processors, wholesalers, retailers and consumers. Local leadership was also included in the discussions since they have a direct bearing on success of the sorghum value chain.
3. Organisation and facilitation of participatory workshops where the value chain actors contributed. The study used the FGD approach since it was more flexible, realistic and had the potential to yield results. The FGD also ensured that diverse opinions and positions were brought out constructively. A guide was developed through a series of consultations and literature based orientations. The researcher then facilitated in the discussions as guided by the developed series of questions. Representatives from the value chain actors were included in the discussions forming a group of 9 members who then attended the ICP consultative meetings. Minimum conflicts were observed since there had been prior consensus on the value chain to focus on.

Figure 3.2 summarises the data collection tools for sorghum value chain analysis that were used in the study as suggested by Hellin & Meijer (2006).

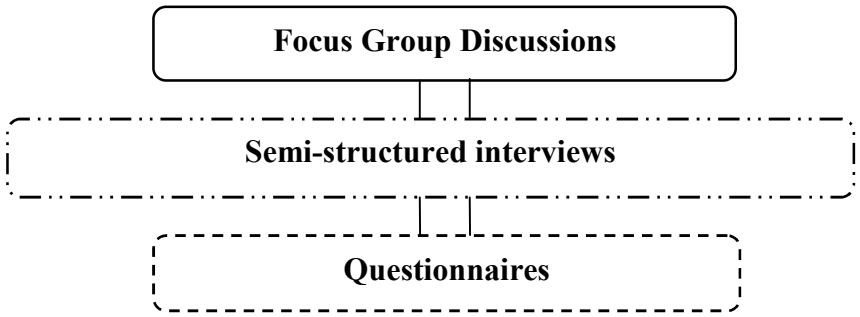


Figure 3.2: Data collection tools ladder for value chain research

Source: Adapted from Hellin & Meijer (2006)

[24]Financiers were not forthcoming to participate in the discussions and were therefore left out.

3.4 Data analyses[25]

The study examined factors affecting smallholder farmers' inclination to produce sorghum and allocate differential land proportions towards the crop. To achieve this, the study used a double hurdle estimation approach with the probit model to understand the decision on whether or not to produce sorghum and a censored tobit model to explain the behaviour of the intensity of production variable. The study also aimed to examine the determinants of market participation and marketing channel preferences by smallholder sorghum farmers. To achieve this, a double hurdle based on probit and multinomial logit regression models was applied to the two decision making stages respectively.

The study estimated the impacts of sorghum improved varieties land allocation differentials on household welfare. Household dietary diversity score and household food insecurity access score were used as proxies for food security. Productivity and net income gains were also adopted for analysis using propensity score matching and endogenous switching regression. The study also used a participatory framework to analyse and map the sorghum value chain in the study area. Various stakeholders and their activities were explored in addition to how they relate to each other.

[25]For detailed explanations of the analytical tools, see the respective Chapters 4, 5, 6 and 7.

CHAPTER 4

SORGHUM VALUE CHAIN ANALYSIS IN SEMI-ARID ZIMBABWE

(This paper was published in *South African Journal of Agricultural Extension*)

Abstract

Strengthening relationships along agricultural commodity value chains remain an important discussion point especially with orphan crops in semi-arid areas. The study uses a participatory framework to analyse the sorghum value chain in mid-Zambezi Valley of Zimbabwe. A sample comprising 380 small-scale farmers proportionately selected from five major sorghum producing Wards was used. Six agro-dealers, 15 traders, 10 retailers, 3 wholesalers and two processors were also sampled. Focus group discussions, informant interviews, questionnaire and reviews of financial records were conducted. Input supply systems for sorghum are weakly developed and production is stalled by inappropriate innovations including seed and fertilizer application. Marketing and processing channels are limited due to erratic supply and low producer prices. Demand for sorghum inputs can be created by making farmers realize the benefits of using improved sorghum seed varieties and fertilizer in sorghum production. Ultimately, this should grease the flow of sorghum products along strategic value chain nodes.

Keywords: smallholder sorghum farmers, value chain networks, marketing margins, agribusiness

4.1 Introduction

Efficient agricultural value chains are important in generating and sustaining wealth for actors (Pye-Smith, 2013; Sarris & Morrison, 2010; Gulati *et al.,* 2007). Asymmetry exists in most value chains with farmers extracting the least share. Smallholder farmers depend on farming for livelihoods and argument this with different forms of off farm income. Sorghum

remains important for sustainability of smallholder farmers' subsistence, social and economic livelihoods in semi-arid and arid communities of southern Africa. Migrating towards market driven sorghum production can catalyse effective participation in the value chain and improve welfare through efficient utilisation of the limited resources and beneficial networking. However, sorghum based livelihood strategies are compromised by multiple household specific and market related drawbacks (Mukarumbwa & Mushunje, 2010).

There is a double pronged challenge where small-scale farmers attain low yields and are exposed to extremely unfavourable market relations thereby reducing net marketing margins. Farmers do not actively participate in rewarding value chain nodes and face low market prices, high transaction costs due to remoteness of prime production zones from the main viable market centres, poor institutional support networks and a biased policy environment (Makindara *et al.,* 2013). In the low rainfall and high temperature areas of southern Africa, agricultural production, processing, marketing and consumption systems are dominated by maize at the expense of potential '*orphan crops*' such as sorghum. The latter has been side lined and remain labelled as a '*poor farmer's crop'* which receive minimal support from value chain stakeholders. This matrix compromises efficiency in executing functions along sorghum value chains by exposing sorghum not only to unhealthy competition among value chain actors but from other livelihood options.

In Zimbabwe, the advent of economic reforms in the early 1990s triggered agricultural diversification based on competitive advantages of productivity gains and emergence of more rewarding markets (Mutenje *et al.,* 2010). There was anticipated to be a stakeholder re-awakening induced reduction in over dependency on maize especially in arid and semi-arid areas where there was excessive need for irrigation if the crop was to perform well. Notably, this phase culminated in temporary support reduction towards maize with some crops such as

sorghum and cotton being embraced by farmers due to guaranteed markets. However, post this era, the government reversed support mechanisms which saw the maize value chain re-dominating (Rukuni *et al.,* 2006). This dampened the commercialisation prospects of sorghum and other small grain crops due to relatively high transaction costs, inadequate and erratic supply, traceability challenges, poor quality and grading. Coupled with the availability of maize from local and regional markets at relatively lower prices, this has continuously pushed sorghum towards extinction from the production, processing, marketing and consumption domains. Studies have shown that there is limited value addition activities with sorghum and this has compromised the crop's potential to generate sustainable margins for actors along multiple value chain nodes (Aduguna, 2007).

The study acknowledges that analysing value chains is a precondition to strengthening and sustaining linkages between farmers and potential users such as seed producers and stock feed processors (Westlake, 2014; Giuliani *et al.,* 2005). The study carried out a participatory based analysis arguing that commercial utilisation of sorghum by markets in the agro-food sector can significantly induce an increase in demand for farm level sorghum production and off farm marketing innovations. The study identifies chain actors, functions, behaviour and compares respective margins as a gateway to isolating points of intervention along the value chain. The major routes for sorghum from local to terminal markets were mapped while identifying the associated challenges and opportunities and estimating the marketing margins for selected value chain actors. This has the potential to become the gateway to unlocking and developing strategies which catalyse improvement of the sorghum commodity value chain.

Value addition is critical in the success of agricultural commodity value chains. Tchale & Keyser (2010) and World Bank (2006) report that, high income countries such as USA add

185US$ of value by processing one tonne of agricultural products. This is as compared to their developing counterparts who add a mere 40US$ for the same volume of raw agricultural commodities. Furthermore, 98% of agricultural production in developed countries undergoes industrial processing with only 38% being processed in developing countries. This variance is attributed to low levels of development in agro-value chains in developing countries which underutilise the full potential of the agricultural sector. In most cases, high potential crops such as sorghum are left out of planning for reasons including political mileage and borrowed policies, which are inappropriate to local contexts and socio-cultural shifts. Additionally, developing countries have chronic shortage of skilled manpower to carry out comprehensive value chain analyses (Dalipagic & Elepu, 2014). This derails attaining economic growth benefits from the value chain approach since information may not be reliable or unavailable when needed for decision making by value chain actors.

Interestingly, lessons from the sorghum value chain in the USA show that, the stockfeed industry has been driven by sorghum. In Mali, reports show significant impacts of stakeholders' collaboration on margins (Coulibaly *et al.,* 2014). In Tanzania, the scope for sorghum commercialisation was reported by Rohrbach & Kiriwaggulu (2001) and encouraging results in a clear beer sorghum based value chain were observed by Makindara *et al.* (2013). In southern Africa, value chains have been analysed for sorghum seed in Zambia by Hamukwala *et al.* (2010); key crops including maize and sorghum in Malawi by Chemionics International Inc. (2009) and fish in Malawi by Phiri *et al.* (2013). In Zambia, between 2008 and 2010 the market prices did not change in the same proportion as the increasing production costs and this significantly reduced the profit margins (Sarris & Morrison, 2010). The main exogenous pushers of production costs in 2010 were the higher international oil price and rise in demand of inputs from large countries which increased the cost of fertilizer compared to the 2008-2009 farming season.

Targeted and recent sorghum value chain analyses in Zimbabwe still remains absent in the body of literature. However, analysis by Rukuni *et al.* (2006) observed that Zimbabwe has weak institutional arrangements and structures which are rigid and marginalise sorghum. For example they reported that research and financial services frameworks used in Zimbabwe are ineffective and unresponsive to the demands of smallholder farmers in the arid areas where sorghum performs well. These conditions, coupled with infrastructural inadequacies that characterize small-scale farming, has reduced value extraction from sorghum value chains at each nodal link. Stakeholders have also turned a blind eye on embracing a double-edged approach of both market and technology driven incentives which would catalyse sorghum adoption and marketing in arid and semi-arid parts of the country.

4.2 Conceptual framework

The study explores sorghum value chain nodes while isolating the actors, activities, associated constraints and opportunities. Value chain success is influenced by short and long term economics of practices. In the short term, stakeholders are concerned with productivity, costs and returns (Gulati *et al.,* 2007). In the long term, binding relationships are important based on who provides the service and who determines the effective demand for the product. Porter (1985) envisaged the intricate relationships of the firm, upstream suppliers and the downstream consumers as the foundation of the value chain concept. A value chain matrix which is fragmented and has no coherence among stakeholders has no competitive advantages and does not generate value. The study was guided by a reversed value chain as shown in Figure 4.1. This schematic helps us understand the flow of income (value) from the markets to primary producers instead of the traditional flow of goods and services. This counter-intuitive way of looking at the market, as alluded to by Hellin & Meijer (2006) shows the demand-pull philosophy characterising today's agricultural value chain activities. Using this approach, we trace and decompose the final market into distinct strategic market

segments with unique success characteristics and compute marketing margins for selected actors.

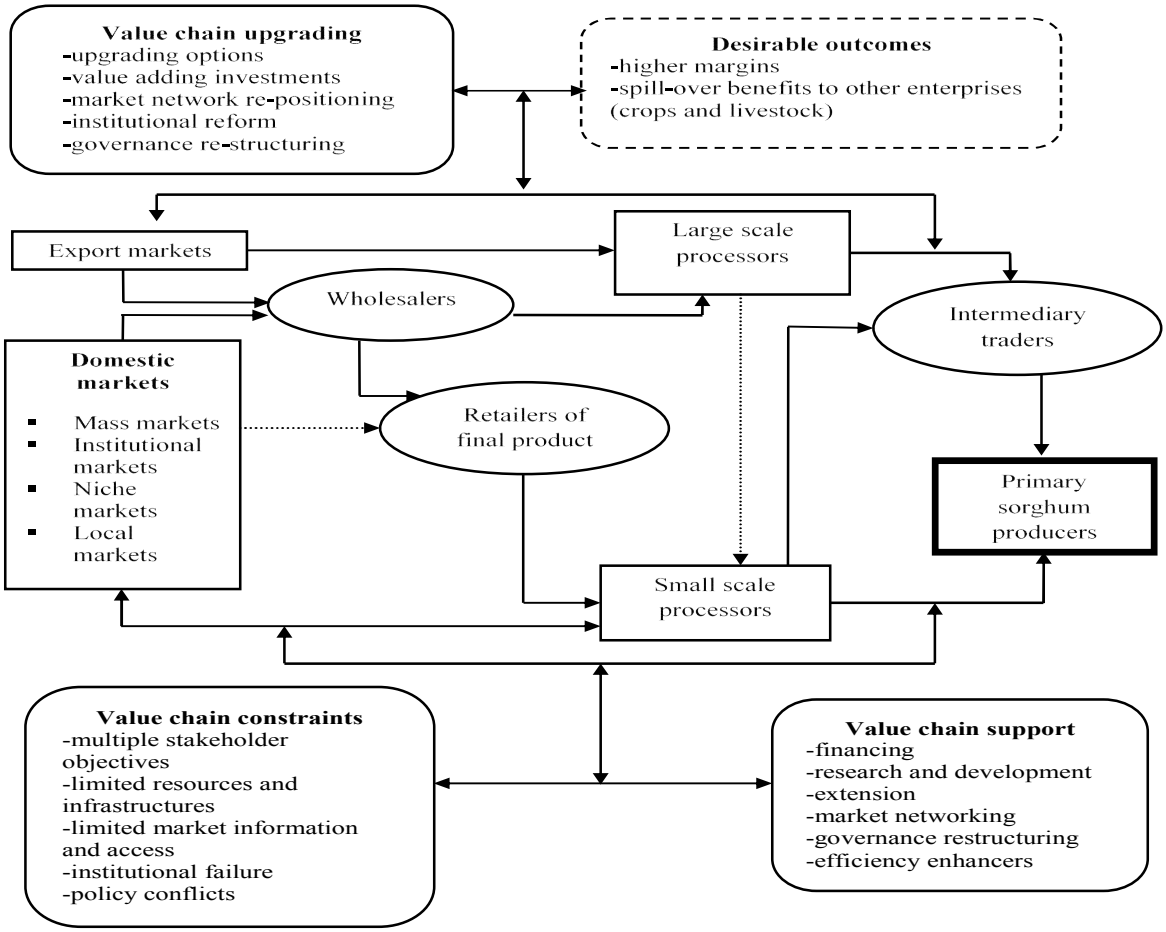


Figure 4.1: Reversed income flow framework

Source: Adapted from Trienekens (2011) and Hellin & Meijer (2006).

Conceptually, value is added to the product at each stage of the chain due to a specialised activity (or a number of activities). Analysing these activities is therefore anchored on a market based philosophy which debunks factors affecting coordination and net benefits for stakeholders. Factors examined include characteristics of sorghum (e.g. price, quantity), existence of formal and informal linkages and the state of an enabling environment including policies and institutions (Drost *et al.,* 2012). This either greases or hinders efficiency of product and/or service movement along the value chain depending on its viability. Identifying specific market segments isolates critical success factors making it easier to

analyse relationships among actors and ultimately economic performance of the chain. Angelucci & Conforti (2010) note that this helps to characterise how actors in the value chain system respond to opportunities and overcome hurdles towards maximising marketing margins. Based on this, insights into formulating agribusiness models as upgrading options for selected strategic value chain nodes are provided.

4.3 Methods

The study was conducted in the mid-Zambezi Valley of Zimbabwe. Agricultural activities are affected by mid-season dry spells which are common in the area. The region is a blend of multicultural communities with different livelihood strategies (Baudron *et al.,* 2012). Five wards were purposively selected as dominant sorghum production areas from where three hundred and eighty farmers were proportionately selected. Six agro-dealers, fifteen traders, three wholesalers, ten retailers and two processors were also selected. Primary data were collected using FGDs, key informant interviews and a structured questionnaire. Secondary data were also extracted from financial records of the value chain actors. The participatory value chain analysis methodology was used. For detailed description of sampling and data collection, see Chapter 3.

4.4 Data analysis

Following the value chain concept alluded to above, the study uses mapping techniques based on network analysis to trace relationships along value chain nodes. This helped us to examine the existing practices and the missing links which may be tapped into for the benefit of defining scaling up strategies. Studies on value chain mapping have sketched the networks among actors and presented pictorial schematics. Completing the map entails estimating marketing margins for respective chain actors (Mishili *et al.,* 2009). In order to understand the share of benefits and costs that accrue to each actor it was imperative to apportion these

per actor. There are various approaches to making this presentation (Nang'ole *et al.,* 2011) and the most effective method is the tabular approach (Trienekens, 2011; UNIDO, 2009).

The Analytic Analysis by Product Table (AAPT)[26] was used for estimating aggregate production costs incurred by selected stakeholders and the associated marketing margins. This approach presents total costs per actor per year showing aggregate scale of the actor's business as opposed to conventional approaches which present costs per unit. Most agricultural commodities tend to have low profits per unit but since sales volumes are large, actors will generate decent incomes. Procedures prescribed by Hellin & Meijer (2006) were useful in estimating variable costs[27]. The variable costs mainly encountered by local traders are storage and miscellaneous costs. Brokers (large scale traders), wholesalers and retailers mainly face transport, labour and post-harvest losses. The value chain analysis effectively made use of actual costs and margins to find out whether any process of the chain is accessible to a particular actor and if the chain is a good source of income for the actor. Due to price and traded volume variations for different marketing channels used by actors, we adopted the weighted average selling price[28].

4.5 Results and Discussion

4.5.1 Sorghum seed supply systems

Seed is an important ingredient to the success of agricultural enterprises (Ahmed *et al.,* 2000). However, farmers reported that currently there are low volumes of high yielding seed varieties from research centres which are only supplemented by insignificant community based seed production initiatives (see Table 5.2). As reported during FGDs, the scenario in

[26]For a detailed explanation see SMEPS & KIT (2009).

[27] Since a unit of production has a unit input requirement, calculation of variable costs was straight forward. Transportation costs had a fixed flat charge assigned by commercial transporters and this affected the marginal unit cost which was then determined by volumes traded. In cases where the real costs were not available from secondary data sources, we used of average costs estimates. Post-harvest handling losses were accounted for.

[28]This is more effective as compared to traditional average price used when evaluating economic performance of value chains.

Table 5.2 is a far cry when compared to maize where about 33 hybrid varieties were used in the same period. One sorghum farmer said:

> "*It [the sorghum seed] is a major challenge as it is expensive and this increases the costs of production. Worse, in most cases the seed is not easily accessible through vendors and agro-dealers so farmers opt for the recycled seed which is readily available. Maize seed is easier to access in all seasons."*

Discussions showed that minimal research and development into sorghum seed production is done by both public and private value chain actors. Rukuni *et al.* (2006) reports that minimal efforts have been done by the government in partnership with ICRISAT who are involved in research, release of new varieties, certification and seed quality control. In the private sorghum seed system, production of improved seed hybrid and open pollinated varieties (OPV) is through large international seed companies such as PANNAR and Seed Co. These institutions have breeding and variety selection programmes which are driven by market demand for seed (Howard, Rusike, & Kelly, 2000).

To support this viewpoint, during the study, an agro-dealer said:

> "*Information and communication sharing on the benefits of improved high yielding seed issues has reduced the risks of production and the associated losses. However, seed availability remains a challenge. Sometime last season, I went to Harare in search of the high yielding seed, unfortunately, the suppliers had run out of stock, so I had to go back home empty handed".*

There are rare cases where the government implements sorghum based farmer support programmes so that farmers can access the high yielding varieties. The government contracts the large seed companies to produce and market certified sorghum seed at subsided rates to

the farmers. Smale *et al.* (2018) reported similar challenges with the adoption of high yielding varieties in West Africa where availability and affordability emerged as key determinants. The findings are in agreement with Humakwala *et al.* (2010), who reported that in Zambia, high yielding varieties are not readily available regardless of efforts by research institutes to release a number of varieties in the past decade.

4.5.2 Sorghum seed sources and common types of transactions

Results show that there are limited options through which smallholder farmers in the mid-Zambezi Valley of Zimbabwe acquire improved varieties of sorghum seed. The most widely accessible source is that of local agro dealers who buy from large seed companies in bulk and re-sell to farmers (Figure 4.7). Hamukwala *et al.* (2010) reports that, in similar environments of Zambia, the agro-dealers are unreliable and the transaction types are mainly concluded on a cash basis. Evidence from FGDs revealed that farmers are exposed to exorbitant prices (Table 4.1) and unreliable supply of seed. Given that demand for sorghum seed by farmers from dealers is minimal, quality of seed is not guaranteed and there are chances of buying expired seed. There is evidence from work by Chepng *et al.* (2014) that farmers have limited alternative channels from which they can acquire seed and participate in these markets because of their proximity which reduces transaction costs.

Another source of sorghum seed are contractual arrangements between farmers and processing companies such as Delta Beverages and ProFeeds where lead farmers are mainly used as agents by contractors. Mujeyi (2013) reports that, under these contractual arrangements, the inputs are provided on an agreement that, farmers should guarantee the right of first refusal to contractors during the marketing stage. The contractor applies the '*deduction at source'* approach and recuperates their investment before paying farmers the balance for produce delivered at an agreed price. Contractors sometimes provide extension

services so as to improve on quality of produce to meet their processing needs. Barrett *et al.* (2012) also reports similar strategies. From the study findings, an extension officer pointed out that:

> *"Limited capacity and lack of agribusiness knowledge are the major challenges that we are facing with small-scale sorghum farmers. Among them, there are some who do not appreciate what market oriented and diversified production is all about. They enter into contracts just because their neighbour has done so."*

The major challenge is that, in most cases, small scale farmers fail to provide the volumes and quality required by contractors (Munyati *et al.,* 2013). In addition to poor management practices, extreme weather patterns have also reduced yields. FGDs show that sorghum contractors have moved to other zones such as Masvingo and Matabeleland where productivity levels are relatively higher and more stable. Guimberteau, Traore, & Baron (2013) also reported on the effects of climate variability on the yield performance of sorghum. They are in agreement with Westlake (2014) who is of the opinion that most contracts are not tailor made for specific local conditions but are universally designed by the contractors for the whole country or region.

Strategic public-private partnerships are critical in the success of value chains (Gibbon, 2004). Results show that the government of Zimbabwe has partnered Non-Governmental Organisations such as Plan International, Action Aid and CIRAD in implementing input subsidy programmes. This is meant to assist smallholder farmers to acquire improved seed and fertilisers which they may not readily get in the open markets. Discussions with stakeholders revealed that though farmers are aware of these programmes they rarely benefit from them since they usually target influential community members. Some farmers have intentionally ignored participating because of missing markets since the organisations do not

provide markets for the produce. This is the case with most '*orphan crops*' in Africa where uptake of subsidy programmes has been low (Ricker-Gilbert *et al.,* 2011). Some farmers in Gonono which is close to the border with Mozambique reported that they sometimes cross the border to acquire improved sorghum seed.

4.5.3 Prices and effective demand for sorghum seed

A survey of sorghum seed sources reflects variations in prices of improved sorghum seed with variety. Table 4.1 shows that the prices of OPV varieties such as Chibuku and Kandevha are lower than for hybrid varieties such as SC Macia.

Table 4.1: Average sorghum seed prices observed in the selected wards

Sorghum variety	Average price (US$/kg)
SC Macia	1.21
SC Silla	1.20
Chibuku	0.88
Kandevha	0.77
Other unspecified local varieties	0.63-0.70

Source: Survey data

Table 4.1 shows that prices of OPVs range from US$0.63-0.77 per kilogram whilst prices of hybrid seed range from US$0.88-1.21 per kilogram. About 87% of farmers in sampled wards use recycled or retained seed and rarely buy improved sorghum varieties because they cannot afford to buy seed from agro dealers and/or vendors. This pattern was also reported by Hamukwala *et al.* (2010). Promotion of using improved sorghum seed varieties is done mainly by NGOs such as Action Aid and Plan International in efforts to boost food, nutrition and income security. The aim is that, through harnessing from indigenous knowledge information sharing systems, demand for new information and improved seeds can be created and sustained (Labeyrie *et al.,* 2014).

Access to working capital remains a challenge in African agriculture (Hosu & Mushunje, 2013; Fries & Akin, 2004). Discussions show that farmers have no access to credit lines from established financial institutions such as banks. Farmers in Mahuwe ward report that there are informal lenders in their communities but the cost of loans are prohibitive and pegged at on average 75% interest rate. Ortmann and King (2007) report the potential of cooperatives in improving access to multiple markets by farmers including financial markets. Surprisingly, faced with this bottleneck, farmers in the study have not formed cooperatives and community based savings clubs so as to generate their own capital which can be used by members and non-members to boost productivity.

4.5.4 Other strategic inputs

For improved productivity, there is need for sorghum farmers to have access to affordable inputs beyond the seed (Mutami, 2015). During FGDs, one old farmer reported that:

> *"Farmers cannot afford fertiliser prices even when subsidized and use is limited among farmers. Farmers also do not use standard fertilizer application rates as they spread available fertilizer thinly to cover a large area'.*

These behavioural tendencies were also reported by Tittonell & Giller (2013). There is also a widely held perspective that sorghum can grow well even with minimal fertiliser application and as such is perceived as a '*low cost crop*' (Mutami, 2015). Guided by this information, farmers rarely invest in fertiliser for sorghum production. This misconception is refuted by Shapiro & Sanders (1998) who argue that inorganic fertilisers are an important input in cereal crops production, including sorghum. The survey with agro dealers show that the most common fertilizer sold is NPK with Urea emerging as an alternative. In practice, however, the major suppliers of inorganic fertilisers are NGOs through various development programmes. They mainly source fertiliser from Zimbabwe Fertiliser Company (ZFC). Due

to excessive competition for fertiliser, a limited proportion reaches smallholder farmers through normal markets. If it happens, prices are expensive and prohibitive to many farmers. Ricker-Gilbert, Jayne, & Chirwa (2011) also observed similar patterns in Malawi where fertilisers where contributing about 63% of the total variable cost of production among small scale farmers. Subsidies have als been used in the studied areas as well as in Mali as reported by Baquedano, Sanders, & Vitale (2010) with varied effects on yields and incomes among targeted farmers.

4.5.5 Constraints on performance of the input sector

The data from the study shows that both structural and institutional constraints affect how the input sector performs in the study area. Government and NGOs input subsidy programmes have the tendency to reduce business available to agro dealers and frequency of transactions in open markets (Ricker-Gilbert *et al.,* 2011). Agro dealers reported that transaction costs are high due to several middlemen between them and manufacturers. Fostering direct access to manufacturers would significantly reduce the selling price. Discussions with stakeholders showed that there is generalised limited growth in markets for sorghum seed and fertilizers. In a study by Zerbe (2001), it was reported that most agro dealers expressed willingness to expand business within current markets and/or into new markets but lack of affordable investment capital is hindering this expansion possibility. Similarly, as noted by Smale *et al.* (2018), due to low uptake of sorghum, general aggregate demand for inputs by farmers is low thus affecting investment proclivity and growth of sorghum input markets. A community leader indicated that:

"The most significant challenge is the lack of capital to purchase high yielding seeds and chemicals to use and the fertilisers, hence resulting in low productivity."

There is evidence of limited access to input markets by smallholder sorghum farmers in southern Africa (Howard, Rusike & Kelly, 2000). Results show that the main markets are found in district centres and provincial capitals which are far from farmers and hence significant transport costs are incurred. During discussions, farmers and agro dealers reported that markets for their products are approximately 100km away. Farmers have to make do with village and roadside markets where they are exposed to unfavourable prices and poor quality from informal traders. Hamukwala *et al.* (2010) report that there is poor reinforcement of sorghum seed quality control since the crop is treated as peripheral in mainstream agricultural development. Zerbe (2001) weighs in and notes that, in most instances, vendors sometimes sell counterfeit seeds thereby eroding farmers' trust. Key informants noted that seed companies sometimes sell poor quality seeds, e.g., some farmers in studied communities bought seed that had poor germination but were not compensated. The seed company responded by recalling the product from the market.

One other major challenge with small scale farmers is that, supply of inputs is not always adequate, continuous and reliable (World Bank, 2006). Results show that, there are periods when agro dealers fail to get inputs from wholesalers on time, thus affecting the availability for farmers. Evidence shows that unavailability of seed and finance are major constraints to uptake of sorghum as a livelihood enhancing strategy (Aduguna, 2007). Due to the dynamic nature of agricultural activities in this arid area, some agro dealers have limited information on what farmers require, at what specific time period, in what form, at what price and quantity. Similarly, Smale *et al.* (2018) confirms this and state that, farmers also have limited knowledge on seed markets, marketing dynamics, different seed products available and prices. A supplier-consumer critical success factor analysis conducted shows this mismatch and expectations as in Figure .4.2.

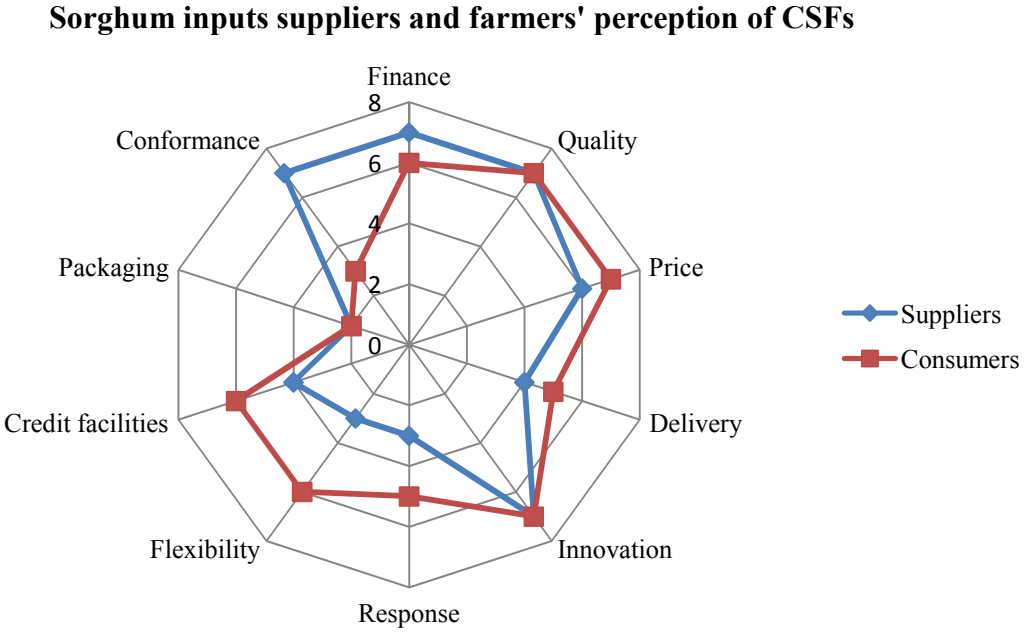


Figure 4.2: Critical success factors analysis for sorghum markets

Source: Survey data

The results show that farmers are mainly concerned with prices, innovations and availability of credit facilities. On the other hand, suppliers are concerned with conformance and financing. In practice, this knowledge is generally missing and this conflict distorts functioning of sorghum inputs markets (Ahmed, Sanders, & Nell, 2000). This study contributes to this gap in information and addition to this new knowledge.

4.5.6 Production of sorghum

An analysis of average land allocated and productivity levels across the sampled wards is shown in Figure 4.3.

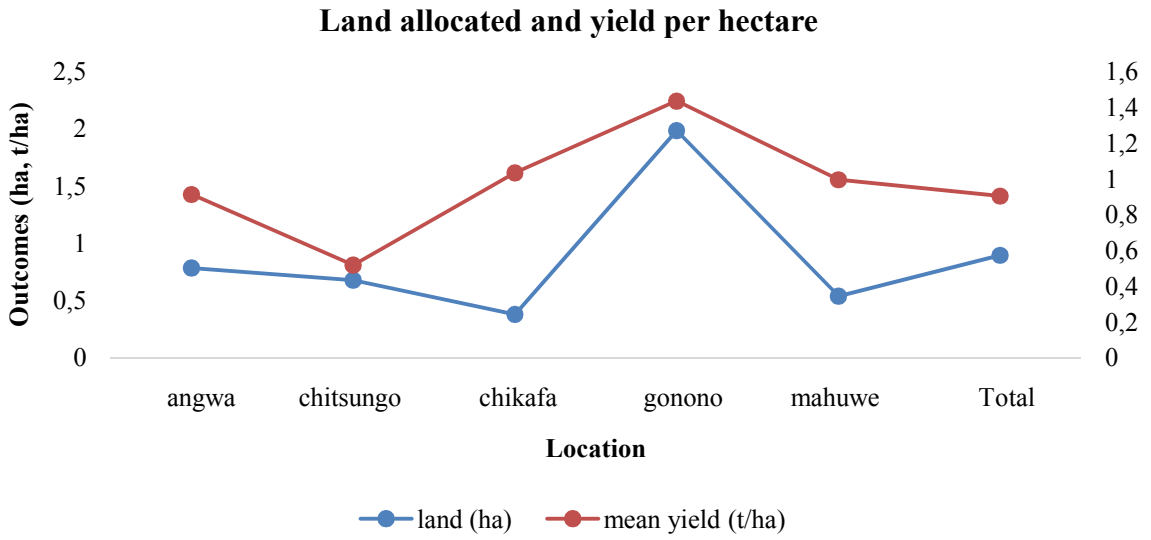


Figure 4.3: Sorghum land allocation and average productivity by ward

Source: Survey data

Gonono is the prime sorghum producing zone in the study area and dominates in both average land allocated to sorghum (2ha) and productivity (1.4 ton/ha). However, these values are still below the potential in similar environments as reported by Rukuni *et al*. (2006). The strength is that, farmers in the area accept that the crop is a core source of livelihood and have configured production and networking practices to harness from its potential. A similar pattern is reported by Kerr (2014) in Malawi were the crop has been re-embraced by communities as a '*lost and found'* crop and is now integral in food and income security.

Sorghum is one of the most important cereal crops in the mid-Zambezi Valley with potential to be included in the main staple basket (Rukuni *et al.,* 2006). Both subsistence and commercial cultivation is done in almost all parts of the zone at different levels using varied resources. Results show that, productivity averages 0.9 ton/ha which is higher than the national average of 0.5 ton/ha as reported by Mukarumbwa & Mushunje (2010). During FGDs, stakeholders concurred that, this can be improved if input markets are developed and use of improved seed varieties and inorganic fertilizer is enhanced. However, GOZ (2013)

report that, resources including land allocated and investments in production innovations remain marginal in these smallholder farming communities where maize still dominates.

4.5.7 Production related constraints

The uptake of sorghum production enhancing innovations in the study area remains low. In these drier parts of Zimbabwe where sorghum can be allocated reasonable land, extreme climatic conditions especially mid-season dry spells affect its performance. These findings are in agreement with Laico *et al.* (2011), who observed that most smallholder sorghum production is done for subsistence. They noted that this is because of the view that sorghum is not economically rewarding due to missing markets, market failure and limited support. During FGDs, farmers reported that in most cases they leave the crop in the field when rainfall is inadequate. They anticipate that sorghum remains dormant and when rains come it will sprout and grow. However significant yield losses were reported was also noted by Tefera, Dahlberg, & Smale (2012). In response, the governments of most countries in Africa and NGOs have initiated projects to promote conservation agriculture with sorghum. This was anticipated to incentivise farmers by providing inputs and linkages to potentially viable markets (Chepng *et al.,* 2014; Adegbola *et al.,* 2013).

4.5.8 Processing and marketing

Three marketing options in the study area were isolated as shown in Figure 4.4. Results show that, a significant proportion, accounting for 44.74% of farmers use local markets, 32.34% market sorghum through traders while 17.11% use a combination of traders and local markets.

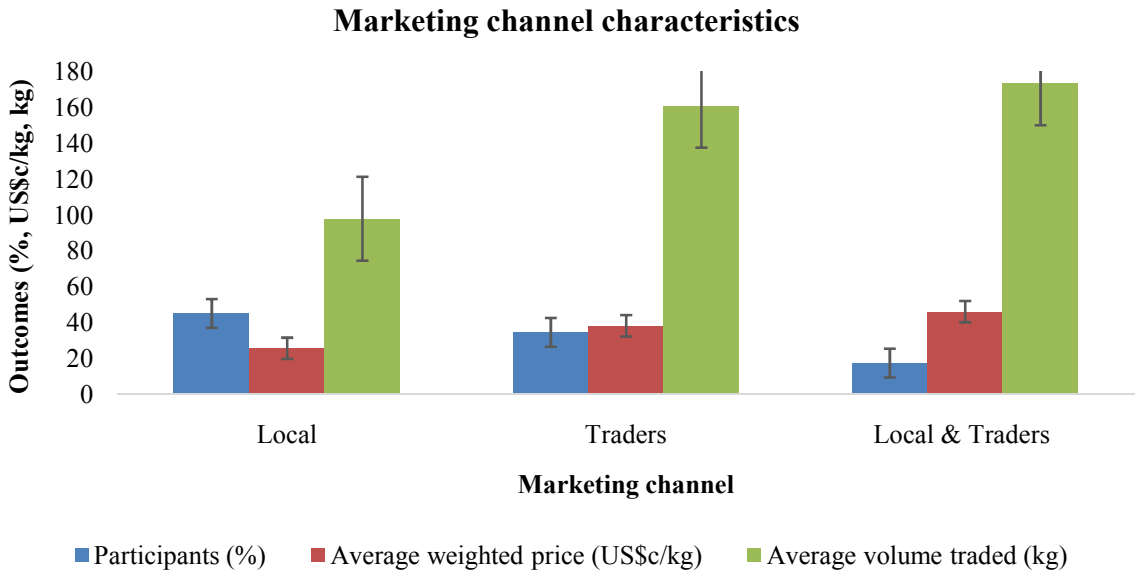


Figure 4.4: Sorghum grain marketing channels and associated attributes

Source: Survey data

There are price variations across these marketing channels. Similar observations were made by Taylor (2003). Farmers who used the combined option enjoyed a relatively higher weighted average price of 0.46 US$/kg followed by those who transacted with traders (0.38 US$/kg). Farmers using local village markets had the lowest price of 0.25 US$/kg. Local marketing channel accounted for the least sales volumes while the combination had the highest value. This is in contrary to Tefera, Dahlberg, & Smale (2012) who reported that the local market dominates in sales volumes in parts of West Africa due to its convinience.

Results show that there are limited channels through which smallholder farmers sell their sorghum produce (Figure 4.4). Farmers mainly sell sorghum to small scale traders who in turn sell to medium scale traders who eventually sell to large scale traders in Mvurwi, Bindura and Harare. Small scale local traders sometimes store sorghum and sell back to farmers during lean periods at higher prices. Limitations in storage facilities by small scale farmers has limited their ability to generate higher returns by selling during periods were market pieces are higher (Poulton, Kydd, & Dorward, 2006). Large scale traders sell to

processors of mealie meal, stock feed and beer. Some farmers sell their sorghum directly to consumers in village or roadside markets. Contracted farmers sell to contractors with reported cases of side marketing due to lower prices compared to the open markets. Rohrbach & Kiriwaggulu (2007) made conflicting findings in a commercialisation study in Tanzania and reported that reducing the number of middlemen is the way out of low marketing margins. During discussions, a farmer said:

> *"Low sorghum market prices still remain one of the critical challenges that we are facing when we are selling our products."*

A further analysis of the market prices as in Figure 4.5 shows the comparative prices for sorghum seed and sorghum grain. Farmers who produce seed enjoy higher market prices as compared to those who produce grain. However in most cases, farmers do not produce sorghum seed due to the numerous demands associated with the production. If seed sorghum production is tapped into, there is scope for improving the seed value chain and the overall sorghum value chain. This was also alluded to by Hamukwala *et al.* (2010) in a sorghum seed value chain study in Zambia.

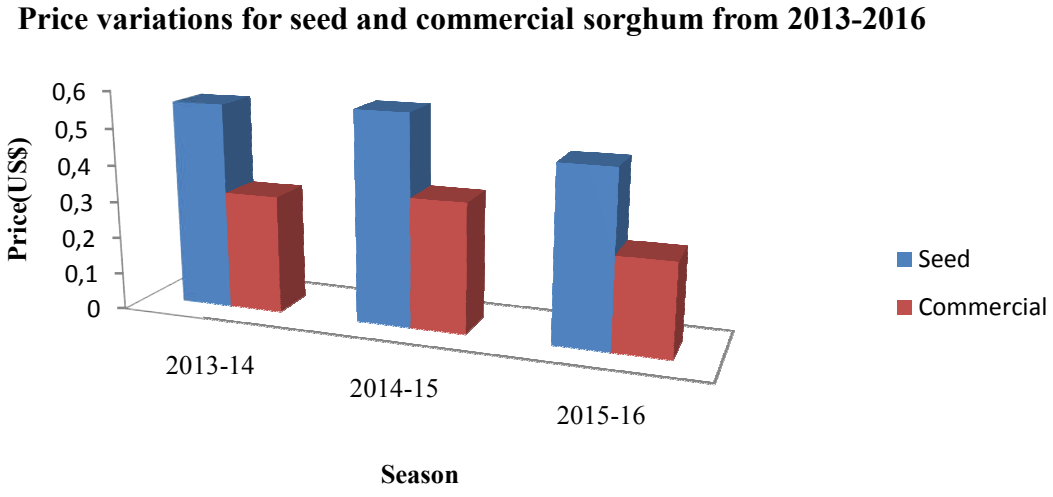


Figure 4.5: Sorghum seed and grain prices

Source: Survey data

Looking beyond the market prices, market linkages are also critical in sustaining the smooth movement of goods and services in agricultural value chains (Angelucci & Conforti, 2010; Tchale & Keyser, 2010). Results in Figure 4.6 show the existence of backward and forward linkages between various actors and their respective markets as a way of reducing risks.

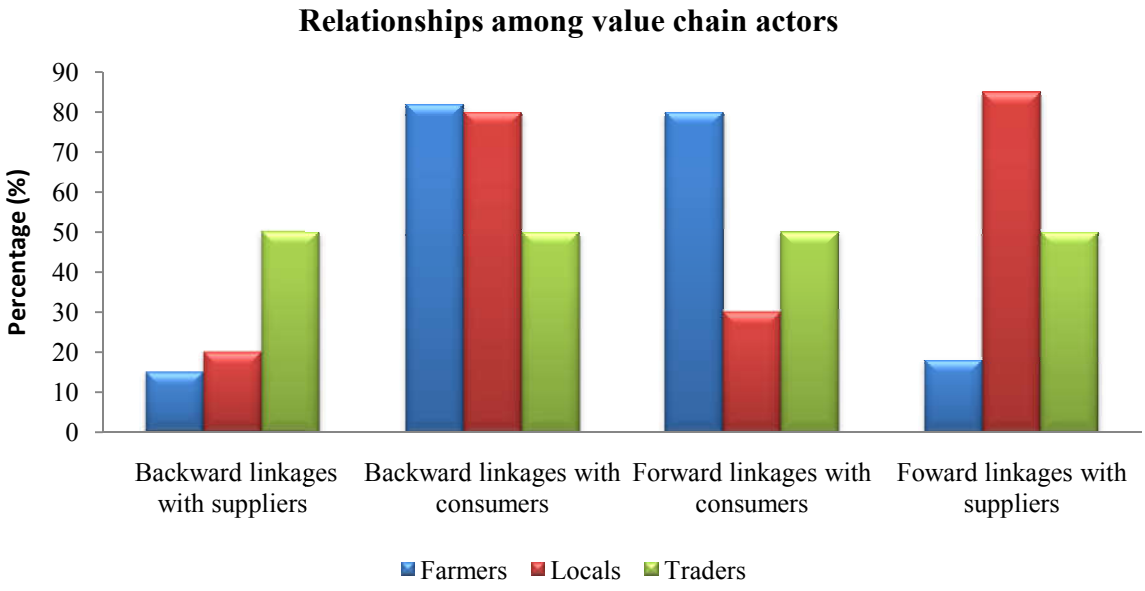


Figure 4.6: Mean percentage of actors with linkages to markets

Source: Survey data

Since direct contracts are not common with sorghum, mechanisms such as trade diversion and long term binding trust has been developed amongst value chain actors. This is in agreement with Barrett *et al.* (2012) who reported that low value crops such as cereals are ussually excluded from contracts by the private players who feel that they are risky with low returns. Makindara *et al.* (2013) were of a different view and noted that the success of the beer value chain in Tanzania was based of concerete contracts with small scale producers.

Results in Figure 4.6 show that farmers are not adequately networked with input suppliers but are more connected to the local markets. About 80% of trading agents have backward linkages with their provider markets who are mainly farmers but only 10% have forward

linkages with processors who are the end markets. This picture shows that there is limited networking along the sorghum value chain. As alluded to by Juana & Mabugu (2005), this fragmentation increases risks associated with doing business and pushes potential entrants and existing actors out of the value chain. It is evident from the study that there are no comprehensive networks among the identified stakeholders.

4.5.9 Sorghum grain processing and marketing constraints

Results from FGDs showed that the major constraint to sorghum grain marketing is low and variable producer price which fluctuates between and within markets depending on progression of the marketing season. Prices are lowest immediately after harvesting and can peak during lean season periods (Baquedano, Sanders, & Vitale, 2010). These prices do not support sorghum production as a reliable source of income. Farmers and traders alike also reported challenges in sorghum grain storage which also affects marketing decisions. Farmers are unable to keep grain for longer periods until price in markets has improved because they do not have proper storage facilities and/or cannot afford to buy pesticides to fumigate their produce. Benfica & Tschirley (2012) also noted a similar scenario where farmers rush to market the produce even if they would have wanted to do so at a later stage and take advantage of market windows. Agro dealers also have the tendency of storing the grain in the open air or warehouses that are not properly ventilated suffer losses and physical deterioration of produce during storage. Sarris & Morrison (2010) support this practice and postulate that the physical loss is mainly as a result of pest and rodents while quality deterioration is caused by humidity.

Figure 4.7 shows that, there are several players involved in sorghum processing including millers, beer brewing companies and stock feed manufacturing companies. Small scale millers own grinding mills and process sorghum grain into mealie meal as and when

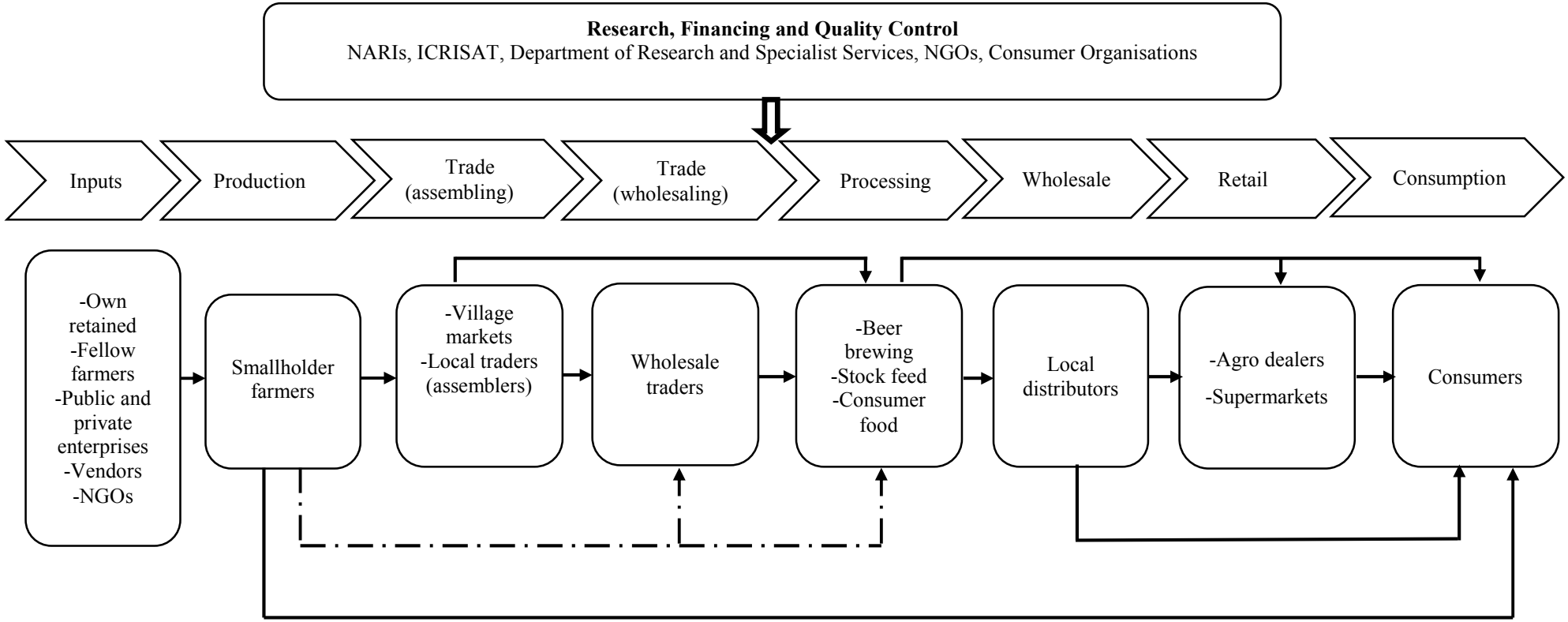
required. Poonyth *et al.* (2006), report that, in urban centres of South Africa, there are relatively more organised and large scale actors involved in processing and packaging of mealie meal and stock feed for onward sale to wholesalers and retailers. A retailer sampled from the study indicated that:

> *"Taking advantage of the business potential from scaling up capacity of the sorghum enterprise, one can be able to make appropriate decisions on how the demand and supply patterns of the grain and inputs are moving. This determines when, how and of how much of the commodity to buy, pricing and promotion. This is of economic importance because it saves time and other resources'.*

In Zimbabwe however, due to unreliable and low supply of sorghum grain, most stock feed processors shun using the grain as a raw material regardless of its high crude protein content (Mutami, 2015). Reports during FGDs show that, retail of sorghum grain is limited in supermarkets or formal shops but is dominant in urban open markets such as Mbare Musika where grain is bought by individuals for onward processing into mealie meal or as raw stock feed especially for poultry. A sampled trader said:

> *"Tapping into the scaling up potential of the business in high yielding varieties and fertilisers is useful to me because it helps me to get viable profit margins".*

Figure 4.7 shows a complete sorghum value chain map with the various networks which are currently utilised as well as those which are missing.



Key:

Existing relationships

Missing relationships

Figure 4.7: Value chain map for sorghum in mid-Zambezi Valley, Zimbabwe

Source: Survey data

4.6 The role of extension in strengthening the sorghum value chain

Discussions with stakeholders pointed towards a weak extension system in the study area. Rukuni *et al.* (2006) concurs and reported that extension agents play an integral role in linking farmers with various actors along agricultural commodity value chains. Rohrbach & Kiriwaggulu (2007) also postulate that in small scale farming areas of sub-Saharan Africa, different forms of extension driven farmer support programmes and cooperation arrangements have existed for a long time as an effort to commercialise sorghum. Mutenje *et al.* (2016), argue that, the practices have been premised on the need for extension agents to coordinate small scale sorghum production, processing and marketing through linkages with agribusiness companies. An extension agent said:

> *"Scaling up prospects for the sorghum enterprise makes the administration of sorghum farming easier and facilitates getting information about marketing and pricing of the products from suppliers."*

Given the above observations, an integrated and extension oriented mentality by sorghum value chain stakeholders needs to be urgently adopted. Stakeholders in the study area agreed that, his can be catalysed through changes in knowledge generation and dissemination structures, attitudes and skills development. In future, this should then drive networking and grease the sorghum value chain wheels for easy access to factor and product markets by stakeholders (Hamukwala *et al.,* 2010). Ultimately, this will inspire a new revolution for coordination in various sorghum value chain nodes whereby actors can then fully exploit their competitive advantages through execution of activities and bargaining for higher shares. Guided by this vision, key informants concurred that there is need for significant investment in research and extension services delivery systems along the sorghum value chain.

Mennecke *et al.* (2007) notes that this should help the small scale farmers to become an integral participant in small scale beef markets. The processes can also be effectively borrowed, modified and infused in the sorghum value chain if appropriate determinants are identified and well coordinated by multiple stakeholders.

A summary of marketing margins for two sorghum trading channels is shown in Table 4.2 (see Table S2 for more detail). There is evidence stemming from work by Makamure, Jowa, & Mazuva (2001) which shows that in more liberalised markets, the margins accruing to each stakeholder depend on the type of trader and end products which they sell in markets.

Table 4.2: Marketing margins for a sample of sorghum output traders

Budget Parameter	Local traders	Assemblers
Total quantity sold (kg)	16000.00	13000.00
Average weighted selling price (US$/kg)	$0.35	$0.50
Gross income (US$)	**5600.00**	**6500.00**
Total quantity purchased (kg)	16615.00	13270.00
Purchase price (US$/kg)	0.25	0.35
Purchase cost (US$)	**4153.75**	**4644.50**
Total marketing cost (US$)	**325.00**	**393.00**
Total variable costs (US$)	**4478.75**	**5037.50**
Gross margin (US$)	**1121.25**	**1462.50**
Gross margin as % of costs	**25.03**	**29.03**
Cost per unit (US$)	**0.28**	**0.39**
Marketing margin (US$)	**0.07**	**0.11**

Source: Survey data

Both channels have positive and marginally different marketing margins. For the trader's channel, the marketing cost is higher for empty bags and packaging hence the lower margin.

This shows that, there are variations in the CSF models used by these businesses in sustaining competitive edge and extracting value. This contradicts findings by Hill & Vigneri (2011) who reported that the main cost is the acquisition of the primary commodity (such as sorghum grain). Channel 2 is an assembler and has a higher marketing margin. These traders take the risk of storage and make profit from seasonal price variations. Cirera & Arndt (2008) are also of the opinion that, storage and transport networks can help reduces transaction costs and boost the margins among value chain actors.

4.7 Conclusions

Input supply systems for sorghum are weakly developed with evidence of limited active coordination in research. Private seed companies play a passive role in production of foundation seed and commercialization of improved sorghum seed varieties. Farmers have limited options of improved hybrid and OPV sorghum seed varieties available in markets. There are limited agro dealers involved in marketing of sorghum seed. Given this dominantly unorganised and informal seed system, the sorghum input value chain is characterized by limited demand and use of improved sorghum seed. More land is put under sorghum but not necessarily because of high productivity levels. Sorghum is a pseudo-staple food and hence is cultivated by more than 70% of farmers. Sorghum yields average 1.1 ton/ha. Production constraints include limited use of fertilizer, extensive use of recycled seed, lack of agricultural equipment, natural hazards. Farmers have limited options for marketing sorghum produce with a few active actors in the sorghum output markets who dictate prices. The farm-gate price for sorghum is low and discourages uptake of sorghum as an income source. Farmers' participation in high value sorghum markets is limited and market through several intermediaries who benefit producer surplus. Farmers lack knowledge on markets and prices,

do not have transport and are constrained by inability to store grain for longer periods and thus cannot benefit from seasonal price movements. The combination of these factors result in farmers being exposed to a low price for sorghum grain soon after harvest and during lean periods they buy the same sorghum from small and medium scale traders at about twice their selling price.

4.8 Implications for policy

There is potential to improve the sorghum input value chain in the arid areas of Zimbabwe. The most important strategy is create demand for sorghum inputs by making farmers realize the benefits of using improved sorghum seed varieties and fertilizer. Promotion of improved sorghum seed varieties in target communities by extension agents is critical towards attaining the potential yield of about 3.5 ton/ha. Extension agents can conduct on-farm demonstrations and field days which can create the much needed awareness. Government can explore input subsidies to encourage adoption of improved sorghum seed varieties. It is important to promote contract farming through organizing farmers into cooperatives or associations. This will also assist with group marketing of produce. Agro dealers should be supported with funding mechanisms to grow their business and expand into new markets. Such mechanisms can be linked to promotion and use of improved sorghum seed varieties. Significant volumes of sorghum are informally sold in the region and in such transactions farmers are not protected by existing policies and face risks of losing their produce or money in botched deals. It is important to formalise farmers' participation in markets in such a way that benefits all value chain actors. If a value chain is linked and efficient from inputs, production, marketing and processing then it is not difficult to increase production of targeted crops through use of recommended inputs because there is guaranteed value for all actors.

CHAPTER 5

DETERMINANTS OF SORGHUM PRODUCTION AND LAND ALLOCATION INTENSITY IN THE SMALLHOLDER SECTOR OF SEMI-ARID ZIMBABWE

(This paper was published in *Spanish Journal of Agricultural Research*)

Abstract

Sorghum is important for sustaining small scale farmers' subsistence, social and economic livelihoods in semi-arid and arid environments of southern Africa. However, production of the crop has been on the decline in the small scale communities of semi-arid Zimbabwe. The study examines factors affecting smallholder farmers' inclination to produce sorghum and allocate differential land proportions towards the crop. The paper uses a double hurdle estimation approach with cross-sectional survey data from 380 sorghum farmers in the mid-Zambezi Valley located in Lower Zambezi Trans-Frontier Conservation Area. Results show that frequency of contact with relatives, duration of receiving subsidies and number of groups to which household members belonged had a robust influence ($p<0.01$) on the sorghum production decision. Market frequency, availability of storage facilities and the number of buyers in the market significantly ($p<0.01$) influenced the land allocation decision. Variables influencing the two decisions are not necessarily the same showing independence in the decision making processes. However, information flow from networks and conditions of market platforms remain important variables in the two decisions. It is therefore important to decentralise sorghum markets, strengthen local networks of kinships and increase the scope of improvements in infrastructure including roads and communication channels which could lure more buyers to the lower Zambezi valley. Affordable and appropriate storage facilities

can also be developed in partnership with private players to allow for sales during off market windows which generate higher returns.

Keywords: double hurdle; sorghum systems; small scale farmer; semi-arid area; networking

5.1 Introduction

Agriculture remains an integral sub-sector for economic development prospects in southern Africa. It is worrying to note that even though in the 1990s, small scale farmers contributed on average 50-70% of total national agricultural throughput (Rukuni *et al.,* 2006), these gains have significantly been reversed in the past one and half decades. This can be attributable to multiple hurdles, key among them weak inter and intra networks between and among value chain actors, underperforming local markets and skewed government support across crop enterprises (Mutami, 2015). However, the choice of appropriate enterprises has also been identified as a key determinant that has compromised the success of agricultural value chains in Zimbabwe.

For example, sorghum production once dominated crop mixes in arid and semi-arid areas of Zimbabwe. The crop was integral in strengthening local kinship networks and sustainably acted as a safety net for drought resilience and mitigation (Mukarumbwa & Mushunje, 2010). However, sorghum production and proportions of land allocated towards the crop has been on the decline in the small scale communities of semi-arid Zimbabwe. Going forward, Zimbabwe has the potential to retain its '*bread basket*'[29] status in southern Africa if appropriate enterprise choices and land allocation decisions which re-accommodate '*orphan crops*' such as sorghum are made at all scales.

[29] From around 1980 to 1995, Zimbabwe was the major agricultural hub in southern Africa. In the SADC arrangement, the country is tasked to sustain food security in the region due to its comparative advantage of vast arable land and a vibrant human capital base.

There is evidence that the main disincentive for intensive cereal crop production is low and variable market prices especially soon after harvesting and/or in good harvest years (Sultan *et al.,* 2013). For example, in Zimbabwe, following the persistent effective price declines in sorghum, the area under the crop declined by 20% from 327 000 hectares in the 2009/10 season to 273 000 hectares in the 2010/11 season. Currently sorghum has a favourable government supported market price of 390 US$/ton[30] and in the arid and semi-arid areas the price should rationally encourage farmers to shift towards sorghum which performs well under the adverse climatic conditions. A surprising scenario as depicted in Figure 2.5 shows that the temporal price elasticity of sorghum supply has been declining as the market price increased. This demands that an examination of the market participation and marketing channel choices be explored further. This further inspires the study as it seeks to explore why presently this seemingly irrational reality is the prevailing case with sorghum using experiences from small scale farmers in the mid-Zambezi Valley of Zimbabwe.

There is scope to redress the current lack of proclivity for sorghum by small scale farmers if balanced and accommodative structural and institutional reforms are adopted and sustained. In Zimbabwe, a maize dominated and biased interventionist philosophy benefits from direct and indirect subsidy programs, extension systems and market liberalisation policies which are introduced through various development models (Rukuni *et al.,* 2006). Historically, sorghum was important for most households in arid and semi-arid areas of southern Africa given its ability to withstand adverse weather conditions of low rainfall and high temperatures. Sorghum has however been side-lined from mainstream livelihood strategies and in recent years its production has declined with the crop accounting for about 15% of the total cropped

[30] This is the government supported price since the 2013/14 farming season. The Grain Marketing Board (GMB) buys the grain from farmers at this price and other buyers are also mandated to buy at the same price. However due to weak monitoring structures, the latter scenario rarely prevails and traders buy at below this price.

land in the smallholder sector of Zimbabwe. There is therefore increased demand for new and robust strategies which encourage small scale farmers' participation in sorghum production and increased land allocation towards the crop. The present state shows that farmer organisations, government agents and private players have singly or collaboratively made efforts to facilitate this revolution. However, making informed enterprise choices and land allocation decisions remain a major challenge in the small scale farming sector (Sarris & Morrison, 2010). This study will be critical at this stage to inform these decision making processes for enhanced participation and possibly more land allocation towards the crop.

In arid and semi-arid regions, cotton has emerged as a major cash income source and displaced traditional cereal crops such as sorghum (Masuka, 2012). The dispensation incentivised a competitive environment which encouraged private players to support activities along the cotton value chain. Of note, with sorghum, limited varietal improvements were nurtured due to the crop's open pollinated nature which dis-incentivised seed houses from investing in research and development. Matshe (2009) notes that this biased support matrix weakened structures for most cereal enterprises with the exception of maize which remains a supported '*strategic*'[31] crop, justified by the food security argument. Government support is almost exclusively channelled towards maize while private players offer contracts for inputs, extension and a guaranteed market to the so called '*cash crop'* small scale farmers especially cotton (Mujeyi, 2013).

As reported by Coulibaly *et al.* (2014), the challenge is that in recent years there has been a generalised global decline in cotton prices and Zimbabwe has not been spared. This has negatively twisted the platform for farmers' dependency on the '*white gold'* and in response,

[31] In Zimbabwe, maize is the staple crop across all geo-political spaces and scale and therefore accounts for the greater component of the total arable land.

the number of contractors has also dwindled. There is however space for sorghum to make a comeback in the livelihood options matrix for the small scale farmers since it has potential multiple uses for food, nutrition and income. Additionally, the crop has competitive productivity ability due to its tolerance to unfavourable climates where temperatures are high, rainfall is variable, poorly distributed and usually below average.

Given the persistent low uptake of sorghum by small scale farmers in Zimbabwe, the main question is whether there is scope for shifting the livelihood lens towards sorghum production and increased land allocation towards the crop through breaking the fundamental barriers of networking arrangements, access to subsidy programs and variable market conditions. This study seeks to explore the determinants that jointly affect decisions for sorghum production and enhanced allocation of land towards the crop in arid and semi-arid areas in efforts to design strategies for possible re-embracing of the crop. This study also aims to add to the production and land allocation decisions knowledge base by exploring the interlinked effect of the aforementioned factors.

5.2 Conceptualising constrained sorghum production and land allocation decisions

The study is guided by the neo-classical economic theory and aims to isolate the determinants of household sorghum uptake and enhanced land allocation towards the crop in arid and semi-arid areas of Zimbabwe. The production status of a farmer was defined and measured as a dummy representing whether or not the farmer produced sorghum during the period under review. The intensity of land allocation was measured as the percentage of total cropped land allocated towards sorghum during the season. The study concurs with Ortmann *et al.* (2007) that small scale farming communities of southern Africa are characterised by information gaps, weak and biased support and market imperfections. These factors manifest in risky

environments in which farmers operate thereby presenting pressure on resource allocation decisions (Di Falco & Bulte, 2013). This is especially so when the primary factor, land is itself also limiting. In similar studies, different forms of the rationality based expected utility model have been used to explain the processes of crop choices as influenced by the utility maximisation rationale subject to a number of constraints (Kreitler *et al.,* 2014).

Given that in small scale farming communities of Zimbabwe, household decision making is multi-faceted, centralised and mainly subsistence oriented, this entails simultaneously making decisions regarding whether to produce a particular crop and the scale of production. The study therefore conceptualises sorghum production and the associated land allocation decisions towards the crop within the random utility framework proposed by Kreitler *et al.* (2014) and Ragasa (2012) but with multiple covariates induced by networking, access to subsidies and variability in market parameters. Assuming that the inclusion of sorghum production in land allocation decisions generates utility, then proclivity for the enterprise may be directly derived from the demand function. Farmers in arid and semi-arid regions of Zimbabwe may have positive desired demand for sorghum production and increased land allocation towards the crop but may be constrained in one way or the other.

The rationality assumption that unconstrained households in arid and semi-arid farming zones decide to produce and allocate more land towards sorghum is herein made as shown in the guiding framework presented in Figure 5.1. The conceptual framework informs the study which then formalises the theoretical production model based on the demand function. As guided by Hassan *et al.* (2016), it is assumed that rationally, a household (h) will likely take up sorghum if the expected utility for the positive state (U_{h1}) is greater than for the negative state (U_{h0}).

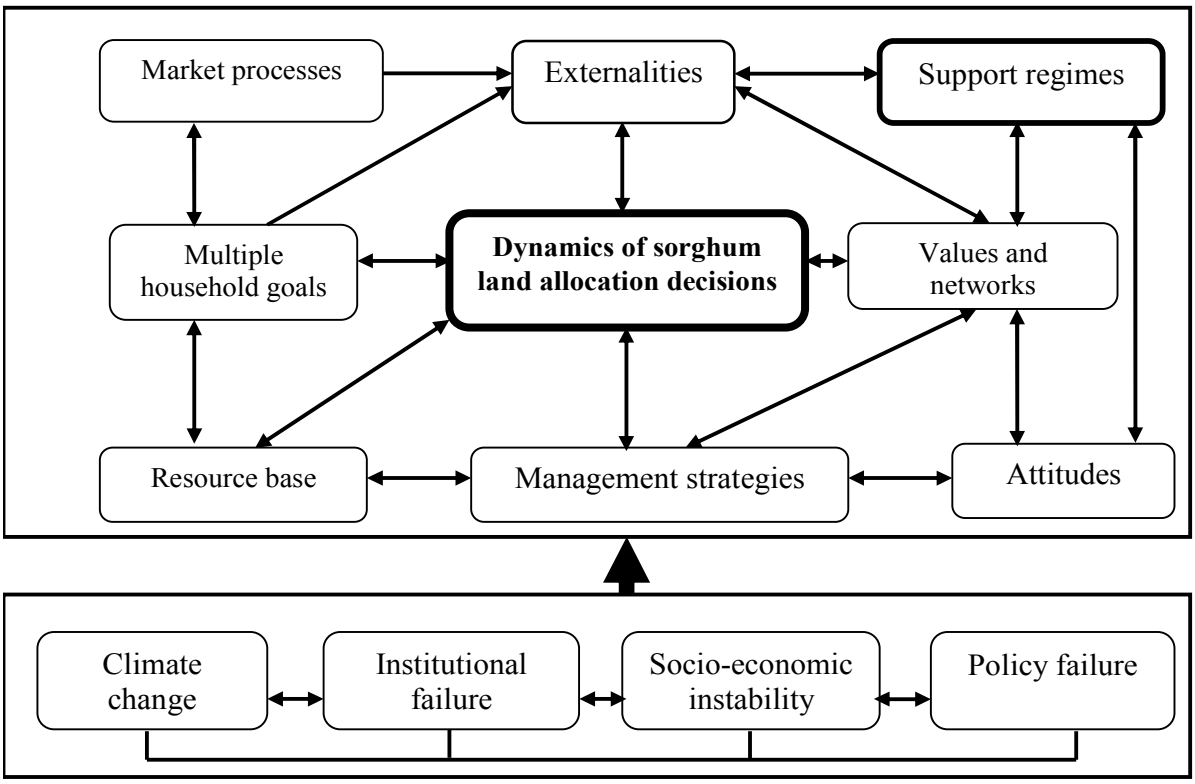


Figure 5.1: Conceptual framework for sorghum production and land allocation

Source: Adapted from Shiferaw *et al.* (2015); Di Falco *et al.* (2014) and Tefera *et al.* (2012).

The difference between the two utility states is then denoted by A^d. Given that, these utilities are not observable, they can therefore be estimated as a dummy function of observable elements denoted by A^{d*} and this is expressed as:

$$A^{d*} = \beta Z_h + \mu_h. \quad (1)$$

Where:

- A^{d*} = binary latent indicator variable of production and enhanced land allocation;
- Z_h = a vector of exogenous variables;
- β = the parameter vector to be estimated; and
- μ = the stochastic error term assumed to be normally distributed.

The farmer's demand, which is hypothesised to influence the positive decision is therefore summarised as:

$$A^{d}{}_{h} = \begin{cases} 1 & if\ E\left(U_{h1} - U_{h0}\right) \geq 0 \Leftrightarrow \beta Z_{h} \geq -\mu_{h} \\ 0 & if\ E\left(U_{h1} - U_{h0}\right) < 0 \Leftrightarrow \beta Z_{h} < -\mu_{h} \end{cases}. \quad (2)$$

In this case, A^{d} is a binary observed indicator variable of interest. Equation (2) stipulates the conditional acceptance or rejection decision based on the utility variations for the two possible positive (1) and negative (0) states.

There is evidence that networking also allows decision making units to evaluate land allocation options and objectively assess the relative expected net gains (Oduol & Mithöfer 2014; Shiferaw *et al.,* 2015; Maina *et al.,* 2015). If the decision maker's information level from networking with friends, relatives and other extension agents is greater than the threshold level needed to make choices, then they can be considered to be at least aware of the practice (Aldana *et al.,* 2011). Additionally, with small scale farmers, access to subsidies and market inconsistency hurdles such as prices and distance to the market may also affect their effective decision making regardless of access to information about the innovation (Brown & Kshirsagar, 2015). As such, the study is cautious to note that a small scale farmer with positive desired demand may not necessarily allocate land towards sorghum due to either or all of the aforementioned determinants. Borrowing from Shiferaw *et al.* (2015), sorghum production and enhanced land allocation can only take place when a number of factors as presented above are simultaneously satisfied. Observing a state of land allocation towards sorghum occurs when specific thresholds in the farmer's decision making process

have been passed. Literature and observations in the study area then guided the choice of variables to be included in the models as in Table 5.3[32].

5.3 Methods

The population was made up of small scale farming households in the mid-Zambezi Valley of Zimbabwe. The area was selected purposively as it is a major sorghum producing zone in the LZ-TFCA. Five Wards namely Chisunga (Angwa), Mahuwe, Gonono, Chikafa and Chitsungo were purposively selected. Three hundred and eighty farmers were proportionately selected at random from the Wards. Data on networks, subsidy access and market conditions were collected using a structured questionnaire. Triangulation was done using Focus Group Discussions and key informant interviews. For detailed sampling and data collection strategies, see Chapter Three.

5.3.1 Modelling sorghum production and associated land allocation decisions

Adoption[33] studies have been dominated by binary regression modelling such as probit, tobit and logit. The underlying assumption of these models is that farmers have full information regarding the innovation and are not resource constrained (Amare *et al.,* 2012). This is not true for small scale farmers in Zimbabwe where input supply systems are poorly developed, extension delivery is not responsive to the demands of advancements in agribusiness, markets are inefficient and networks are weak or absent. Farmers must overcome a number of these hurdles before deciding on whether or not to produce sorghum, let alone allocate more land towards the crop. Using composite probit, tobit or logit in isolation will most likely generate inconsistent parameter estimates if applied in these contexts. Informed by Burke *et al.* (2015),

[32] Refer to Table 4.3 for these variables and their description.
[33] Adoption has been used in the study to mean the decision by a farmer to produce sorghum regardless of the variety selected. The word is used synonymously with production.

to cater for the two hurdles of production and intensity of production, the study estimates a double hurdle model with two equations. A probit model was used for the dichotomous production decision because of its post estimation convenience since the distribution is assumed to be approximately normal. Probit also uses a cumulative distribution function (cdf) which captures more detail. Using logit would assume a logistic distribution. The study however accepts that the outcomes of the predicted probabilities for these two maximum likelihood estimation approaches are similar. A censored tobit model is then applied to the second hurdle of land allocation intensity.

In the study, for any farmer, i , the unobserved (latent) demand (D^*), is modelled as:

$$D_i^* = \beta' X_i + \mu_i \tag{3}$$

Where:

- X = the vector which captures determinants[34] of the demand function;
- β = the parameter vector; and
- μ = a normal variate with mean 0 and variance σ_μ.

Following the argument presented in (2), the observed demand was therefore computed as an index function:

$$D_i = \begin{cases} 1 & if\ D_i^* > 0 \\ 0 & if\ D_i^* \leq 0 \end{cases} \tag{4}$$

This implies that the farmer will only demand the sorghum enterprise if the utility from the positive mode (U_{d1}) outweighs that of the negative condition (U_{d0}).

$$P(D_1) = \Pr(U_{d1} > U_{d0}) \tag{5}$$

[34]The determinants captured by the study are shown in Table 5.3

The study then manipulates the condition presented in equation (5) without losing generality by allowing the variance (σ^2) of the error term to be unrestricted, and have a conditional probability given a set of covariates:

$$\begin{aligned} \Pr(D_i^* > 0 \mid X_i) &= \Pr(D_i = 1 \mid X_i) = \Pr(\mu_i > \beta' X_i) \\ &= \Pr\left(\frac{\mu_i}{\sigma} > \frac{-\beta' X_i}{\sigma}\right) = \Phi\left(\frac{-\beta' X_i}{\sigma}\right) \end{aligned} \tag{6}$$

The latent (unobserved) variable, which is also called the index, is related to the error term in that for there to be observed probability for a farmer to demand sorghum, then the error term should be large enough to produce an index greater than one. Since maximum likelihood estimators are probabilistic, and starting again with the sorghum production decision and making inference to intensity of sorghum production, the study uses the log-likelihood function as:

$$L(\beta \mid d) = \prod_i [\Phi(\beta' X_i)]^{d_i} [1 - \Phi(\beta' X_i)]^{(1-d_i)} \tag{7}$$

The latent variables underlying a farmer's decision to produce and intensify sorghum production are then modelled as in (8) and (9) respectively:

5.3.1.1 *Hurdle one (sorghum production decision):*

$$A_i^* = \theta' z_i + \varphi_i \tag{8}$$

To untangle the effects of the first hurdle of deciding whether or not to produce sorghum (A_i^*) that is the production decision, the study uses a probit model. It has been shown that the parameter estimates for a probit and logit could differ quite a lot between the models, but the marginal effects are very similar. As such, the former is selected for convenience and preference.

5.3.1.2 *Hurdle two (enhanced sorghum land allocation decision):*

$$I_i^* = \alpha' g_i + \omega_i \quad (9)$$

Following Shiferaw *et al.* (2015)'s argument on effectiveness of tobit in censored datasets, the study confidently use a censored tobit model to explain the behaviour of the intensity variable I_i^* as the second hurdle in the decision making process. From equations (8) and (9), z and g are vectors of variables that affect production and intensity of production decisions respectively; θ and α are the corresponding parameter vectors; and φ and ω are normally distributed random variates with mean 0 and variance 1. The latent variable models presented above show the reality encountered in practice that farmers' preferences cannot be observed. The observed demand in equation (4) is characterised by the interaction of equations (8) and (9). In various forms of the hurdle framework, there is consensus that it is not worthwhile to assume dependency between the two equation clusters (Burke *et al.,* 2015; Shiferaw *et al.,* 2015). Literature shows that there is no statistical justification which exists to assume such relationships and this creates a basis for assuming that sorghum production and enhanced land allocation hurdle equations are mutually exclusive[35].

5.4 Results and discussion

A descriptive presentation of production status is done as in Table 5.1. Gonono ward has the largest number (81%) of sorghum producers while Chitsungo ward has the least (14%) number of small scale sorghum producers.

[35] Results for the two models in the study also validate this assumption since determinants of the production decision are not necessarily the same as for the land allocation decision.

Table 5.1: Household sorghum production status across sampled wards

Ward	Sample size	Sorghum growers (%)	Sorghum non-growers (%)
Angwa (2)	80	34	66
Chikafa (12)	70	30	70
Chitsungo (10)	50	14	86
Gonono (4)	79	81	19
Mahuwe (15)	101	26	74
Total sample	**380**		

Source: Field survey data

Notes: Ward number in parenthesis.

The distribution summaries of major sorghum varieties grown are in Table 5.2. The main variety grown across all the five Wards is Silla followed by Macia.

Table 5.2: Major varieties grown by households in the sampled wards

Ward	Variety and associated respondents (%)				
	Chibuku	***Kandevha***	***Kanzvonzvo***	***Macia***	***Silla***
Angwa (2)	11	15	7	48	19
Chikafa (12)	5	13	10	24	48
Chitsungo (10)	0	14	43	14	29
Gonono (4)	5	8	6	33	48
Mahuwe (15)	4	8	3	35	50
Total sample	**6**	**10**	**8**	**34**	**42**

Source: Field survey data.

Notes: Ward number in parenthesis.

The other three are unconventional and undocumented '*emerging varieties*'[36] and are still to be widely accepted by the communities. Kanzvonzvo is a local variety which dominates among farmers in Chitsungo community.

The descriptive profile of variables included in the models is in Table 5.3. On average, 38% of the sampled farmers were into sorghum production with about 26% of the total arable land allocated towards the crop. These values are encouraging and there is scope for expanding and building up on existing strategies so as to get more land under sorghum by an increased number of farmers. To understand and shape this destiny, the study therefore moves a step further to analyse factors which affect the production and intensity of sorghum production.

To test for potential collinearity in the independent variables in Table 5.3, they were subjected to a Variance Inflation Factor (VIF) test as suggested by Murray *et al.* (2012). Results show that all the VIF values for the exogenous variables included in the model are less than 10 and range from 1.11 to 3.85 with a mean of 1.60. From the rule of thumb, there is evidence that this shows the absence of collinearity.

[36] Given the limitation of seed access from the formal markets, farmers have developed their own seed varieties over time from cross pollination of existing varieties.

Table 5.3: Variables list and associated descriptive statistics

Variable	Variable Description	Units	Summary	
			Mean	***Std.***
Dependent Variables				
PRODUCT	Whether a farmer produced sorghum (yes=1)	dummy	0.382	0.486
INTENSIT	Percentage of total cropped land allocated	number	26.08	36.20
Independent Variables				
Network attributes				
EXTFREQ	Contact with extension agents per month	number	7.550	2.140
LCLREL	Number of relatives who reside in the same village	number	2.761	2.958
EXTREL	Number of relatives not residing in same village	number	1.621	2.491
ETHNIC	Household is originally from Ward (yes=1)	dummy	0.663	0.473
FREQLOC	Number of contacts with local relatives in a month	number	45.35	77.51
FREQEXT	Number of contact with other relatives in a month	number	7.402	23.09
NGROUP	Social groups to which household members belong	number	1.295	1.203
Aid attributes				
INFOAID	Number of information sources about aid	number	2.000	0.477
AIDBENF	Household members who are aid beneficiaries	number	2.303	1.254
NUMAIDS	Aid sources household members are aware of	number	1.034	0.769
DURNAID	Years household members have been receiving aid	number	2.152	2.638
AIDVALU	Total market value of aid accessed by household	US$	8.60	19.41
Markets attributes				
MKTDIST	Average walking distance to the main market	minute	76.51	46.55
TRANSCS	Costs of transporting produce to the market	US$	29.81	48.95
MKTFREQ	Frequency of using the main market in a season	number	23.06	12.51
PYMNTSP	Time taken for payment to sail through after a sale	months	1.855	1.064
NUMBUY	Number of buyers farmer directly interacts with	number	0.487	0.683
WEIGHTP	Average weighted market price	US$	24.06	10.22
MKTINFO	Number of information sources about markets	number	3.000	0.512
Demographic attributes				
AGE	Age of the household head	years	44.73	14.64
ORIENTA	Proportion of total sorghum grain output	percent	65.32	9.142
CROPDIV	Crop diversity index	number	4.00	0.124
LIVEDIV	Livestock diversity index	number	3.00	0.356
GENDER	Gender of household head (male =1)	dummy	0.739	0.439
HHLDSZE	Household members residing at the homestead	number	8.389	4.957
EXPERCE	Number of farmer's years in farming	number	15.49	10.04
INCOME	Total household income (farm and non-farm)	US$	356.8	209.3
ARBLAN	Total amount of arable land owned	hectare	4.31	1.16
STORAGE	Number of storage facilities owned by the farmer	number	2.000	0.275

Source: Generated by authors from sorghum survey data using STATA.

Results of the probit regression for the sorghum production hurdle and a truncated tobit regression for the intensity of sorghum production hurdle are in Table 5.4.

Table 5.4: Estimation of double-hurdle model

Variable	1st hurdle (Production) *Dependent variable: Farmer's status in production of sorghum*		2nd hurdle (Production intensity) *Dependent variable: Farmer's intensity of sorghum production*	
	Coefficient	**p-value**	**Coefficient**	**p-value**
Network attributes				
EXTFREQ	2.042*** (0.647)	0.007	1.971** (0.857)	0.021
LCLREL	-0.198 (0.197)	0.316	-2.302*** (0.763)	0.003
FREQLOC	-0.238* (0.105)	0.065	-0.142** (0.021)	0.042
ETHNIC	1.546 (1.402)	0.270	9.597* (5.464)	0.079
EXTREL	0-.371 (0.271)	0.171	-0.478 (1.083)	0.659
FREQEXT	0.016 (0.015)	0.274	0.318** (0.165)	0.050
NGROUP	1.638** (0.767)	0.033	2.448 (2.148)	0.254
Aid attributes				
INFOAID	1.656* (0.892)	0.064	2.776 (3.833)	0.469
AIDBENFCR	0.376 (0.261)	0.150	2.784* (1.479)	0.060
NUMAIDSC	0.664 (0.532)	0.212	5.633** (2.550)	0.027
DURTNAID	2.998*** (0.985)	0.002	1.766 (1.128)	0.117
AIDVALUE	0.061 (0.014)	0.968	0.112* (0.104)	0.061
Market attributes				
MKTDIST	-0.19*** (0.0123)	0.006	-0.074** (0.063)	0.027
TRANSCST	-0.18* (0.016)	0.059	0.069 (0.072)	0.332
MKTFREQ	0.199** (0.047)	0.035	0.466*** (0.153)	0.002
PYMNTSPD	-0.122** (0.295)	0.044	-2.074 (1.787)	0.246
NUMBUY	0.572 (0.543)	0.292	13.85*** (3.811)	0.0003
MKTINFO	1.807 (1.235)	0.143	2.069 (6.436)	0.159
WEIGHTPRC	0.27 (0.029)	0.139	0.213*** (0.186)	0.009
Demographic attributes				
AGE	-0.108*** (0.043)	0.008	0.042 (0.143)	0.771
GENDER	0.513 (0.718)	0.475	-2.233 (4.355)	0.608
HHLDSZE	-0.362** (0.185)	0.047	1.074 (0.838)	0.199
EXPERIENCE	0.103** (0.038)	0.033	0.414* (0.239)	0.084
INCOME	0.138 (0.029)	0.522	0.146** (0.01)	0.022
ARBLAND	0.453 (0.306)	0.139	0.237** (1.799)	0.048
STORAGE	0.698 (0.225)	0.334	1.176*** (0.839)	0.001

Source: Generated by authors from sorghum survey data using STATA.

Notes: -***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively.
-Standard error for each estimate is placed in parenthesis.

5.4.1 Sorghum production decision

The number of groups to which family members subscribe have significant influence on the sorghum production decision as shown in Table 5.4. This concurs with Di Falco & Bulte (2013) and Rukuni *et al.* (2006) who noted networking as a critical determinant in the success of agricultural practices among small scale farmers. The study findings can be attributed to information sharing practices in various group platforms beyond the family structures. Family members will then digest this information and make more informed and unbiased decisions. Langyintuo & Mekuria (2008) also observed positive neighbourhood effects on adoption decisions. Results from the study show that payment period also significantly affects sorghum production decisions among small scale farmers. A study by Asogwa, State, & Okwoche (2012) reports that, delayed payment for a transaction made is a hidden transaction cost of doing business. During FGDs, it was noted that longer time lags between a transaction and a payment discourage production. Since small scale farmers heavily depend on agriculture for livelihood and have limited income sources, the incentive of instant payments can trigger increased sorghum production. The study findings also build on existing evidence by Smale *et al*. (2018) who also reported that due to the low profit margins in sorghum marketing, farmers prefer instant payments for the grain.

Information about subsidy sources and the duration household members have been receiving subsidies exhibit positive and significant relationships with sorghum production. Baquedano, Sanders, & Vitale (2010) are of a similar opinion and note that the availability of information about the sources of inputs and their relative advantages in terms of costs and availability are important considerations made by farmers. Deliberations during FGDs and key informant interviews indicated that, reduced costs incentivise adoption of supported enterprises since

farmers enjoy convenient and timely production, higher yields and favourable marketing margins. Coulibaly *et al.* (2014) reported increased participation and perfomance by sorghum farmers who had access to complete subsidy packages.

The estimated coefficient of household size was negative and significant at the 5% level. With labour intensive agricultural production systems, larger household sizes would be favourable since they imply more labour available and hence higher chances of innovation adoption (Diiro, 2013). The findings from the study differ from this as sorghum does not necessarily follow the same trends since most agronomic processes do not require much labour. Additionally sorghum yield levels are low and cannot be an incentive enough for the large households. This conflicts with Josephson *et al.* (2014) who reported the limitation in livelihood options with large households as one prime driver of extreme and continuous poverty in arid rural areas thus demanding production of drought tolerant crops such as sorghum.

From Table 5.4, farmer's age had the expected negative and significant influence on the chances of sorghum production at the 1% level. This concurs with Manda *et al.* (2016) who highlighted that with increase in age, farmers tend to turn away from some crop enterprises for less risky cropping systems which have lower transaction costs and favourable support. In the present case sorghum has no reliable markets and is vulnerable to pests such as qualea birds which need constant monitoring thus increasing the chances of crop failure. Additionally, FGDs deliberations indicated that processing sorghum grain can also be a challenge in these economically constrained environments thus exerting additional burden on the elderly. Mafuru *et al.* (2007) weigh in and argue that being older creates an experience based conservative feeling about new practices.

5.4.2 Sorghum land allocation decision

Results in Table 5.4 show that with the second hurdle model, once farmers have decided to produce sorghum, different factors influence their decision to allocate more land towards the crop. For example, as the number of aid sources and aid beneficiaries in the household increase, chances of allocating more land towards sorghum also increase due to the higher value of accessed aid packages. This tallies with observations by Mabiso *et al.* (2014) and Ricker-Gilbert *et al.* (2011) who reported that well targeted aid programs can be useful for expansion in agricultural activities among resource constrained farmers. During FGDs and key informant interviews, stakeholders were of the perspective that appropriate subsidies open avenues for commercial and market driven agribusiness. Shiferaw *et al*. (2015) however, differs and suggest that subsidy programs can induce market imperfections and make enterprises unprofitable, thus pushing away farmers.

As expected, the number of buyers with whom the farmer interacts has a positive and significant estimated coefficient. The variable is an indicator of the efficient functioning of markets and as such is expected to significantly affect the decisions by farmers to intensify sorghum production. Higher numbers of buyers usually imply lower chances of risk and exploitation for the farmers. Tefera *et al.* (2012) also report the sensitivity of farmers' selection of sorghum to the relative market inefficiency caused government policy which created barriers to entry for private players.

Weighted average market price had the expected positive and significant influence on the land allocation decision as shown by results in Table 5.4. Based on the opportunity cost principle, the variable has widely been reported by Mmbando *et al*. (2016) and Brown & Kshirsagar (2015) to significantly affect the decisions by farmers as to whether they should

allocate more land towards a given crop or not. Higher producer prices usually imply higher margins which are favourable performance indicators to farmers (Coulibaly *et al.,* 2014). Total household income had the expected positive and significant effect on the intensity of land allocation towards sorghum. Maina *et al.* (2015) alludes to this and reports that on average, well-to-do farmers are more likely to access inputs and markets. From FGDs, it was noted that the reinforcing effect, where allocating more land towards sorghum increases the income gains, and in turn also increasing the likelihood of further increases in land allocated towards the crop prevails.

The same arguments can also be made for the landholding variable which has a positive and significant effect on the land allocation decision. Availability of arable land creates the opportunity to diversify across multiple crops or allocate more land towards a preferred crop (Scoones *et al.,* 2011). As such, the study findings are in sync with this observation since farmers with large pieces of arable land can allocate more land towards sorghum without compromising the productionof other crops such as maize, soyabean and cotton.

Postharvest handling accounts for over 60% of the losses experienced by smallholder sorghum farmers (Mukarumbwa & Mushunje, 2010). The data show that the adequacy of storage facilities has a positive and significant estimated coefficient. This implies that as storage becomes a limiting factor, chances of increased land allocation towards sorghum are also reduced. Azam, Imai, & Gaiha (2012) observed the same results in Cambodia where farmers who had access to adequate storage facilities had the proclivity to produce more crops. FGDs deliberations showed that farmers become more concerned with the higher losses which will be incurred if the output levels from sorghum increase beyond the holding capacity of the storage facilities at their disposals. Pinckney (1993) also noted similar

patterns with maize in southern African countries when an analysis of the market liberalisation scope was done.

Family networks are emerging as strategies sources of reliable and updated information among sorghum farming communities in developing countries (Smale *et al.,* 2018). Frequency of contacts with relatives in the locality has negative and significant estimated coefficient. The more farmers are exposed to localized networks, the less likely they are to produce sorghum and allocate more land towards the crop. Kinship networks have however been reported by Bale *et al.* (2013) to have a positive effect on technology adoption decisions. The same observation was made by Di Falco *et al.* (2013) in their study on adoption of risk mitigating strategies. However, discussions during FGDs show that the reverse scenario may be attributed to the negatively oriented conservative tendencies that diffuse within relatives and friends with respect to the benefits of sorghum production. These negative perceptions are perpetually reinforced in family structures thereby reducing the likelihood of sorghum production.

The findings build upon existing evidence which shows that linkage to markets can catalyse rural agricultural development prospects (Gulati *et al.,* 2007). Table 5.4 shows that the frequency of visiting the market is another significant determinant of sorghum production and intensity of land allocation towards the crop. Farmers who frequent the market platforms have higher chances of capitalizing on market window opportunities as and when they arise. Escobal *et al.* (2015) also note that these farmers are usually the first to identify market opportunities and the chances of being affected by consequences of market failure are reduced. The platforms also act as additional information sources which can influence a farmer's decision.

There is consensus in previous work that, extension capacitates farmers with requisite skills and knowledge on sustainable production practices (Hassan *et al.,* 2016; Rukuni *et al.,* 2006). It avails up to date information on production practices, market prices and benefits of commercializing farming. As expected, the estimated coefficient for frequency of contact with extension agents was positive and significant. Farmers who have more interactions with the extension agents have a higher chance of producing and intensifying sorghum production. This is because extension programs have accepted sorghum as an important cereal for food and income security and hence have updated information (Kerr, 2014). This concurs with Amare *et al.* (2012) who in Tanzania, observed a positive impact of extension in influencing increased uptake and utilisation of agricultural technologies among small scale farmers.

Rationally, farmers who are located closer to their preferred markets are more likely to participate in the markets (Musemwa, 2007; MacInnis, 2004). The data shows that, distance to the market negatively influenced both the adoption and intensity of land allocation decisions. Due to the time and expenses associated with travelling to the market, as the market distance increases, there are higher chances that farmers will opt not to take the risks and choose alternative enterprises. This is in agreement with Birachi *et al.* (2013) who reported that longer distances have a disincentive effect on decisions made by farmers. Evidence from FGDs and observations were that in most cases rewarding markets were located away from production hubs and rarely did their agents make purchases at the farm gate.

Most farmers had on average 15 years of farming experience. As per prior expectations, duration in agricultural production activities has a positive and significant estimated coefficient for both models. This determinant influences the farmers' decision to produce and

intensify sorghum production as rooted in their dependency on farming over long periods of time as a livelihood strategy (Rukuni *et al.,* 2006). Experience in production creates the ability of farmers to obtain, process and use information relevant to commercialising sorghum production (Ndoro *et al.,* 2015). FGDs showed that experience has tendencies of generating confidence among farmers leading to higher proclivity of venturing into sorghum as a source of food and income. The same patterns were reported by Amare *et al.* (2012) in a maize-pigeonpea intensification study in Tanzania.

5.5 Conclusions

The study concludes that, the frequency of contact with local relatives, number of groups to which household members belonged, duration of receiving subsidies, age of the household head and household size had a significant influence on the sorghum production decision. A different set of variables including number of local relatives, ethnicity, frequency of contact with external relatives, number of subsidy sources, number of subsidy beneficiaries, market access frequency and number of buyers significantly influenced the sorghum land allocation decision. However, as hypothesised, information flow from networks and conditions of market platforms are reported to be important variables in the two decisions. As opposed to the much held view that a rational farmer who adopts sorghum production will naturally allocate more land towards the crop, the two decision pathways are influenced by a different set of variables. This shows independence in these two decisions.

5.6 Policy Recommendations

The primary barrier of access to production factors needs to be broken to place farmers in the proximity of markets. There is need to develop and sustain subsidy strategies which do not only provide short-term benefits but capacitate the farmers in the long term through holistic

and complementary production-marketing support regimes. An immediate option is to provide contract arrangements across sorghum commodity value chain nodes. This can generate rewards from low cost production, favourable prices and binding mutually beneficial relationships. Since information is an ingredient to success of the sorghum value chain, the study recommends the need to strengthen local networks starting at household level and cascading to the extended family. This should facilitate generation and dissemination of up to date and acceptable information about the enterprise.

Naturally, this is expected to incorporate sorghum related discussions on the mainstream kinship based extension platforms and beyond. The hope is that the crop, upon being allocated a significant share of land can then be transformed into a commercial enterprise which can generate higher margins for the farmers and other stakeholders along the value chain alike. Aggregately, the broader policy space should transform systems where ideologies for rural agricultural development initiatives in arid and semi-arid regions of Zimbabwe need to migrate towards re-accepting sorghum as a potential option for reducing risks and earn income. It therefore becomes important to catalyse the adoption process with sorghum by re-training extension agents hoping for the multiplier effect to spill over to increased allocation of land towards the crop.

CHAPTER 6

MARKET PARTICIPATION AND MARKETING CHANNEL PREFERENCES BY SMALL SCALE SORGHUM FARMERS IN SEMI-ARID ZIMBABWE

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Abstract

A fundamental concern of agricultural development is the efficient marketing of goods and services. The study examines determinants of market participation and marketing channel choice decisions by small scale sorghum farmers using a case comprising 380 households from five Wards in the mid-Zambezi Valley of Zimbabwe. Mixed data collection approaches including a questionnaire, observations and focus group discussions were used. Secondary data triangulated and validated farmers' responses. A double hurdle based on probit and multinomial logit regression models was applied to the two decision making stages. Ninety six percent of the sampled farmers participated in some market as influenced by payment time, number of buyers in the market, age of principal decision maker and distance to market. Three marketing channels were isolated as local, traders and a combination. The local marketing channel dominates due to its convenience and relatively lower transaction costs. Using the local market option as the referent category, weighted average market price of sorghum, number of buyers in the market, distance to the market, dependency ratio and household income are the most robust determinants of marketing channel selection. Sorghum marketing channel options are limited for small scale farmers in Zimbabwe. Strengthening cooperative based and extension anchored marketing can reduce the risks associated with relating to external traders who usually exploit farmers for price, payment time and quality

requirements. Decentralising the sorghum markets and promoting value addition activities in the sorghum value chain is likely to reduce transaction costs and increase the market size.

Key words: sorghum marketing, marketing information, market performance, probit, multinomial logit

6.1 Introduction

Market failure induced food, nutritional and income insecurity remains embedded in rural areas of southern Africa (Ortmann & King, 2007; Makamure *et al.,* 2001). The potential of small scale agriculture is being compromised by constrained resource bases and limited access to rewarding markets. This is happening at a time when there is unharnessed potential effective market demand for nutritious food and fibre products (Brown & Kshirsagar, 2015). Tapping into these market platforms and meeting their demands may only be attained if game-changing innovations are introduced and adopted at a pace that acknowledges the existing lag in development of agricultural marketing systems in Africa (Sarris & Morrison, 2010). In Zimbabwe, it is acceptable that small scale farmers play an integral role in attaining food and nutritional security. They have however been marginalised from mainstream linkages and decision making processes at all levels of strategic commodity value chains, especially along the marketing pillar (Rukuni *et al.,* 2006).

Consensus on its own is not enough, but instead, there is need for action to redress this by researching further on drivers of market participation, choices and access (Poulton *et al.,* 2006). This far, realities on the ground show that uptake of welfare enhancing marketing innovations by small scale farmers remains worryingly low (Oduol & Mithöfer, 2014). Productivity has been following similar patterns as is with market participation and

penetration preferences along various agricultural value chains. This is particularly true for arid and semi-arid regions of Zimbabwe where appropriateness of these innovations has also been questionable (Jayne, Mather, &, Mghenyi, 2010).

Effectiveness of marketing choices by small scale farmers operating in constrained environments is an area that has been widely debated (Ortmann, 2000). For example, in southern Africa, there is evidence that sorghum production and marketing has been side-lined from mainstream development debates at both local and national levels (Kerr, 2014). The policy space has worsened this by excessively advocating for maize as the *'universal'* staple crop at the expense of other complimentary crops such as sorghum and millets even in areas where the former is relatively uncompetitive. Socio-cultural dimensions have also responded by pushing sorghum out of the production and marketing matrices (Laico *et al.,* 2011). Given that the majority of small scale farmers are located in arid and peripheral parts where sorghum can outperform other cereals such as maize, it is surprising that the farmers have limited appetite for sorghum market participation (Asogwa *et al.,* 2012). This is mainly because these small scale farmers are alienated from accessing market information, training programs, credit lines and land (Mukarumbwa & Mushunje, 2010).

Even though significant milestones have been reached, current agribusiness oriented development mechanisms in Zimbabwe do not adequately facilitate the transmission of and access to sufficient market information, production factors and quality food at household and market-wide levels for small scale farmers. Technically this paints a picture where small scale sorghum farmers remain subsistence oriented and play second fiddle in agricultural marketing development strategies. There is evidence that, for example, sorghum farmers seldom have direct linkages with highly rewarding agents such as processors and neither do

they perform marketing as groups to reduce transaction costs and risks (Rohrbach & Kiriwaggulu, 2007). This compromises their ability to extract value from sorghum value chains. In extreme cases, some farmers lose potential revenue since they do not participate in any marketing platforms for their produce. Jayne, Mather, & Mghenyi (2010) reported that the immediate observable is that these small scale farmers account for over 65% of the world's food, nutrition and income insecure population. This is mainly because they are failing to tap from the sorghum production and marketing potential due to limited integration in value chains.

Experiences show that appropriate strategies and policies influencing market participation and preferences among sorghum producing farmers may also induce additional participation in production and marketing of the crop (Mafuru *et al.,* 2007; Rohrbach *et al.,* 2007). Understanding market participation and preference for marketing channels should therefore catalyse a transition in sorghum production and marketing within competitively advantageous environments. As reported in Mali, this will only occur when modes for innovative farmer inclusion are identified along strategic sorghum value chains (Baquedano *et al.,* 2010).

In Kenya, sorghum market participation and informed choices of marketing channels significantly increased productive efficiency up to about 41% (Chepng *et al.,* 2014). The outcome is that this may trigger meaningful changes in transaction costs incurred and marketing margins gained. This translates to improved market relations, policy re-configurations and diversity in livelihoods at the local level as reported in Tanzania's successful brewing (Rohrbach & Kiriwaggulu, 2007). This study agrees that the household dimensions have been widely explored with agricultural decision making in southern Africa. Surprisingly, to the best of our knowledge, not much research efforts have been channelled

towards explicitly unpacking the determinants of market participation and preferences with sorghum in the arid and semi-arid areas of the region, particularly so in Zimbabwe. The study therefore conducts an analysis of these dimensions for sorghum market nodes using a double hurdle with probit and multinomial logit models.

6.2 Conceptual framework

In this section the study conceptualises and develops a double-hurdle framework with the likelihood of market participation and preferences for specific marketing channels in sorghum based value chain business driven nodes. Specifically, the household and market specific drivers of the two decisions are explored as guided by similar previous studies (Burke *et al.,* 2015; Benfica & Tschirley, 2012) and observations in the study area. These studies have shown that market participation and choice of marketing channel can be determined by household specific characteristics, the level of transaction costs, community wide attributes, exogenous shocks to production and prevailing market prices[37]. Since small scale farmers are the main providers of production factors and are outsourcers of information through their networks, there is reason to examine their proclivity towards market participation and marketing channel choices so as to develop sustainable and rewarding strategies. Experiences in West Africa show that this has the potential to enhance efficiency of sorghum based value chains through scaling up and scaling out efforts (Rohrbach & Kiriwaggulu, 2007).

The study develops a two-step decision structure. Initially, a first stage in the framework is introduced where a farmer has to decide whether or not to participate in a market. The same

[37]The study uses the same set of covariates for the two decisions. The study also however acknowledges that since exclusion restrictions are possible, not both equations necessarily need to be specified with identical explanatory variables.

set of covariates is then used in a second stage of the exact marketing channel chosen by the sorghum farmer. The double hurdle specification of the two decisions was then outlined as:

$$D_1 = D_1(x_1, x_2, ...x_n) \quad (1)$$

$$D_2 = D_2(x_1, x_2, ...x_n) \quad (2)$$

Where:

- D_1 is a binary indicator showing whether a farmer will participate in marketing or not;
- D_2 is an indicator which takes any of the three distinct values of marketing channel choice as local, traders and the combination of local and traders; and
- $x_1, x_2, ...x_n$ are the selected covariates.

6.3 Methodology

The study was conducted in the purposively selected mid-Zambezi Valley of Zimbabwe, located in the LZ-TFCA. The area was selected since it is traditionally a sorghum producing zone since it is a semi-arid environment and receives below average rainfall coupled with high temperatures. A multistage sampling approach with purposive selection of five wards was used to generate a representative sample of 380 randomly selected farmers who then participated in a survey which generated cross sectional data in April 2016. One focus group discussion (FGD) comprising 8 farmers was conducted in each ward. For detailed description of sampling and data collection procedures, see Chapter 3.

6.4 Econometric estimation

Using STATA 13, the local marketing option was selected as the referent category and the results in Table 6.2 were interpreted relative to this marketing channel with two replicates

(traders and combination) of the predictor variables. The levels of the categorical variable (marketing channel choice) are assumed to have no natural ordering.

6.4.1 Market participation decision (stage one)

A non-marketer is defined as a sorghum farmer who marketed their produce during the 2014/15 season and was observed not to participate in marketing during the 2015/16 season[38]. Given the binary nature of the market participation decision, the probit[39] was the immediate candidate for modelling the first stage. The probit model uses a cumulative distribution function (cdf) which captures more detail. Using logit would assume a logistic distribution. Additionally, there is post estimation convenience with the probit model since the distribution is assumed to be approximately normal as opposed to the logistic distribution of the next best logit alternative (Amare *et al.,* 2012). The study however accepts that the outcomes of the predicted probabilities for these two maximum likelihood estimators (MLE) are similar.

Based on the probit model, the study assumes that for any farmer, i , the unobserved (latent) demand for participation in a sorghum market is modelled as:

$$D_i^* = \beta' X_i + \mu_i \quad (3)$$

Where:

- X = a vector capturing determinants[40] of the market participation demand function;
- β = the parameter vector; and
- μ = a normal variate with mean 0 and variance σ_μ.

[38]Data for the study were collected in April 2016 which was during the 2015/16 marketing season.
[39].The study opts for the probit instead of the logit alternative for modelling binary choices in the first stage. Most previous studies have adopted the probit model and the study stands guided by the same. Average partial effects and predicted probabilities do not differ between probit and logit and as such the choice is mainly grounded on preference.
[40]These are captured in Table 6.1.

Following the argument presented above, the observed demand for sorghum market participation was therefore computed as an index function:

$$D_i = \begin{cases} 1 & if\ D_i^* > 0 \\ 0 & if\ D_i^* \leq 0 \end{cases} \tag{4}$$

The probability that a household will effectively participate in sorghum marketing is given based on the utility intuition (Lazaro *et al.,* 2002). The farmer will only participate if there is a positive utility difference between the participation and non-participation states.

$$P(D_1) = \Pr(U_{d1} > U_{d0}) \tag{5}$$

Guided by Bonin & Schneider (2006) and Sazuka (2005), the variance of the error term was unrestricted and a conditional probability of market participation given a set of covariates was adopted as:

$$\Pr(D_i^* > 0 \mid X_i) = \Pr(D_i = 1 \mid X_i) = \Pr(\mu_i > \beta' X_i)$$

$$= \Pr(\frac{\mu_i}{\sigma} > \frac{-\beta' X_i}{\sigma}) = \Phi(\frac{-\beta' X_i}{\sigma}) \tag{6}$$

The latent variable included in the model is also called the index (Hausman & Wise, 1978). It is related to the error term in that for there to be observed probability for a small scale sorghum farmer to participate in a market, then the error term should be large enough to produce an index greater than one.

6.4.2 Marketing channel choice (stage two)

Conditional on being a sorghum marketer, a farmer's marketing channel choice can then be categorized as being local, traders or local and traders. Schneider & Kubis (2009) adopted the grouped conditional logit philosophy which greatly limits the scope of factors affecting a particular marketing decision. Grouping the individuals into specific categories does not

allow the researcher to understand the heterogeneity which characterizes these individuals. However more recent studies on marketing channel choice have simultaneously analysed multiple variables such as age of household head, education of principal decision maker, profitability and transaction costs. The marketing channel choice dimension in the model is captured using a conditioning dummy variable applied to the complete data set. This allows for the isolation of the marketing channel alternative (local, traders or a combination of both) specific effect of each determinant on marketing channel choice. Hoffman & Duncan (2009) noted that both multinomial logit and conditional logit can be used to analyze the choice of an individual among a set of alternatives. However they observed that, the main difference between the two approaches is that the former focuses on the individual as the unit of analysis and uses their characteristics as explanatory variables. The latter pays additional particular attention to the alternatives available to each individual with the explanatory variables being the attributes of the options.

Given the marketing channel decision to be made by the small scale sorghum farmers, the multinomial logit regression model was opted for. Khonje *et al.* (2015) reported that the multinomial framework has advantages over a multivariate framework in that it can evaluate both alternative individual choices and combinations of choices as is the case with the local and traders option in the current study. Additionally, self-selection bias and interaction between choices of alternative practices are accounted for by the model (Crost *et al.,* 2007). This is a case of unordered choice where the study is interested in explaining how the characteristics of the individuals and alternatives affect the decision maker's choice. The study is therefore guided by the principles laid in earlier work by Hoffman *et al.* (2009) who in their multinomial probability based logit models derived a probability function within the

framework of the random utility model. In the present case, the study also argues that rational decision making agents, at the micro level (household), will likely choose a discrete alternative market option which maximises their utility, subject to a number of factors. The probability function will help us determine this likelihood. The (unobserved) utility U of a representative household decision maker i making a choice j is given as:

$$U_{ij} = \beta' X_{ij} + \varepsilon_{ij} \qquad i \in N,\ j \in J \tag{7}$$

The vector of variables X contains attributes of both the market choice, j and the individual, i. The reality in the study area is that not all the sampled respondents face the same set of choices due to the status and surrounding conditions. The rationality condition stipulates that an individual will make an informed choice so as to maximise their utility. The probability of marketing channel choice, c_i as suggested by is Kreitler, Stoms, & Davis (2014) is:

$$P(c_i = j) = P(U_{ij} > U_{ik}) \qquad \forall k \neq j \tag{8}$$

Within the utility framework, equation (8) above was manipulated to express the probability of an individual, i to use a specific sorghum marketing channel, j as:

$$P(c_i = j) = P\left(U_{ij} > \max_{k \neq j}\{U_{ik}\}\right) \tag{9}$$

$$= P\left(\beta' X_{ij} + \varepsilon_{ij} > \max_{k \neq j}\{\beta' X_{ik} + \varepsilon_{ik}\}\right) \tag{10}$$

An assumption that ε_{ik} are independent of each other and each has a type-I extreme-value distribution was made in the study. This implies that:

$$F(\varepsilon_{ij}) = \exp\{-e^{\varepsilon_{ij}}\} \tag{11}$$

From this, equation (2) was then transformed into:

$$P(c_i = j) = p_{ij} = \frac{e^{\beta' X_j}}{\sum_{j=1}^{J} e^{\beta' X_j}} \tag{12}$$

Where β is a vector of parameters.

An indicator variable for a particular marketing channel choice decision d_{ij} was therefore defined as:

$$d_{ij} = \begin{cases} 1 & if\ U_{ij} \geq 0 \Leftrightarrow \beta' X_{ij} \geq -\varepsilon_{ij} \\ 0 & if\ U_{ij} < 0 \Leftrightarrow \beta' X_{ij} < -\varepsilon_{ij} \end{cases}. \tag{13}$$

This implies that the log likelihood function of the marketing channel choice decision is then computed as a joint probability encompassing individuals and alternatives.

$$L(\theta) = \prod_{i=1}^{N} \prod_{j=1}^{J} p_{ij}^{d_{ij}} \tag{14}$$

In the present case there was a less likely to be a chance of experiencing the problem of over-dispersion since the variable choice is ungrouped, broader and caters for potential inter-group variations (Hoffman *et al.,* 2009). However, the Independence of Irrelevant Alternatives (IIA) was assumed in the model so that parameter estimates remained unbiased and consistent. This is because of the extreme value assumption that we made earlier. To validate this, the Hausman-Macfaden specification test was conducted to assess the validity of the assumption (Hausman & MacFadden, 1984). Based on the tests, the conclusion that the odds ratio of two alternatives does not involve any other alternative was confidently made.

$$\frac{P(c_i = j)}{P(c_i = k)} = \frac{\exp(X_{ij}\beta)}{\exp(X_{ik}\beta)} = \exp\{(X_{ij} - X_{ik})\beta\} \tag{15}$$

The study considered running a multinomial probit so as to change the extreme value distribution to normal. However since the model parameters are estimated by the MLE, it was then realised that the dependent variable need not necessarily be normally distributed because the estimates remain consistent (Amare *et al.,* 2012). The model adopted for the study was then:

$$Y_{ij} = X_{ij}\beta + \varepsilon_{ij} \qquad i \in N, j \in J \tag{16}$$

Where:

- Y_{ij} is the vector of marketing channels chosen by the i^{th} farmer;
- X_{ij} is a vector of the covariates;
- β are the parameter estimates; and
- ε_{ij} is the error term assumed to have distribution with mean 0 and variance 1.

The parameter estimates of the multinomial regression simply give the direction of effect of the regressors on the regressand. It does not show the actual magnitude of change or the probabilities associated with each independent variable. Interestingly, from (12) and (18) the study notes that there was actually a parameter vector, β and the aim therefore is to maximise the log likelihood function in (14) with respect to this vector. Notably, by nature of the multinomial logit approach the identification problem was anticipated. This means that since the actual utilities derived from a particular sorghum marketing channel choice could not be observed, all that could be analysed are the relative utilities. To deal with this, the study uses the normalization tactic and make $X_{ij}\beta = 0$ by setting one alternative (the local market in this case) as the base. The marginal effects are then computed as:

$$\frac{\partial P(c=j)}{\partial x^{n}{}_{j}} = P\left(c=j\right) \text{ . } [1 - P\left(c=j\right)].\beta_{n} \tag{17}$$

$$\frac{\partial P(c=k)}{\partial x^{n}{}_{j}} = -P\left(c=\text{j}\right) \text{ . } P\left(c=\text{k}\right).\beta_{n} \tag{18}$$

6.5 Results and Discussion

Table 6.1 shows the variables used in the regression models and the summary statistics.

Table 6.1: Description of independent variables used in the models[41]

Code	Variable Description	Means for market participation			Means for marketing channels			
		Participate	***No-participate***	***Diff.***	***Local***	***Traders***	***Traders and Local***	***Diff.***
AGE	Age of principal decision maker in years	44.86(14.6)	41.33(9.05)	-0.922	45(14.98)	44.3(14.6)	45.5(14.2)	0.854
EDU	Principal decision maker's years in education	8.25(4.05)	7.67(2.53)	-0.552	8.3(4.25)	8.1(3.99)	8.5(3.69)	0.814
GEND	Gender of principal decision maker (male=1)	0.715(0.45)	0.8(0.41)	0.715	0.74(0.4)	0.69(0.46)	0.71(0.46)	0.710
DEPN	Dependency ratio as a percentage	33.32(18.6)	31.67(9.53)	-0.343	35(22.1)	33.9(15.9)	28.8(14.4)	0.088*
L_INC	Log of total household income in US$	5.74(0.51)	5.77(0.43)	0.214	5.75(0.5)	5.71(0.51)	5.75(0.48)	0.752
ASSC	Groups to which household members belong	1.69(1.15)	1.73(1.16)	0.123	1.72(1.2)	1.68(1.07)	1.66(1.25)	0.909
PRICE	Weighted average market price in US$c/kg	33.49(12.9)	30.4(12.51)	-0.908	25(11.4)	37.9(10.6)	45.8(7.74)	0.00***
BUYR	Number of buyers in the market	3.35(2.96)	3.2(2.68)	-0.191	5.56(2.8)	1.58(1.27)	1.08(1.05)	0.00***
TIME	Time taken to be paid after a sale in days	11.61(21.2)	3.73(4.22)	-1.45***	3.02(8.6)	5.48(8.84)	4.63(2.64)	0.00***
TRAN	Total transport costs incurred in US$	12.99(6.16)	10.13(0.52)	-1.792*	10.5(1.6)	10.9(3.24)	13.9(6.36)	0.00***
L_DIS	Log of travel time to the market in minutes	3.78(1.07)	3.02(1.01)	-2.74***	2.94(0.7)	4.21(0.65)	5.13(0.59)	0.00***
SALE	Volumes of sorghum transacted in kg	134(156.1)	0(0.00)	-3.31***	98(132.6)	161(189)	173.4(12)	0.00***
EXTN	Frequency of extension contacts/season	5.28(2.98)	5.2(2.78)	-0.0979	5.25(2.1)	5.32(3.15)	5.26(3.13)	0.976

Source: Generated by authors from sorghum survey data using STATA.
Notes: -***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively. ANOVA test was used to test for significant difference among the 3 marketing channel subgroups and t-test used for market participation. The robust standard errors are in parenthesis

[41]The study used data from the 2014/2015 marketing season. Since the data were not collected in situ i.e. for events during the data collection period (April 2016), responses for variables included in the models were recall based from the 2014/15 season, which is the period of interest.

6.5.1 Summary of the models

Thirteen variables were captured and presented in Table 6.1 to examine the market participation and marketing channel choice decisions. This choice was guided by literature and experiences from the study area. Results from the probit model in Table 6.2 show that 4 out of 13 explanatory variables are statistically significant at the 1%, 5% and 10% levels. The Wald chi-square of 20.38 is statistically significant ($p<0.05$). The McFadden pseudo-R square was 0.1319. The multinomial logit regression model results show that for the traders channel model, 5 variables were statistically significant and in the combined marketing channel model, 7 variables were statistically significant at the 1%, 5% and 10% levels. The chi-square value of 148.75 showed that likelihood ratio statistic is highly significant ($p<0.001$) and that the model has a strong explanatory power since at least one of the regression coefficients in the model is not equal to zero. The McFadden pseudo-R square was 0.8091. Since logistic regression modelling does not have an equivalent to the R-squared that is found in OLS regression, we cautiously conclude that the included explanatory variables explained about 81% variance in the choice of the sorghum marketing channel.

6.5.2 Market participation decision

Due to the narrowness of sorghum marketing channel options in the study area, only three distinct alternatives could be isolated as shown in Figure 6.1. Similar marketing channel thinness is also reported by Musemwa *et al.* (2007) in small scale farming communities of South Africa.

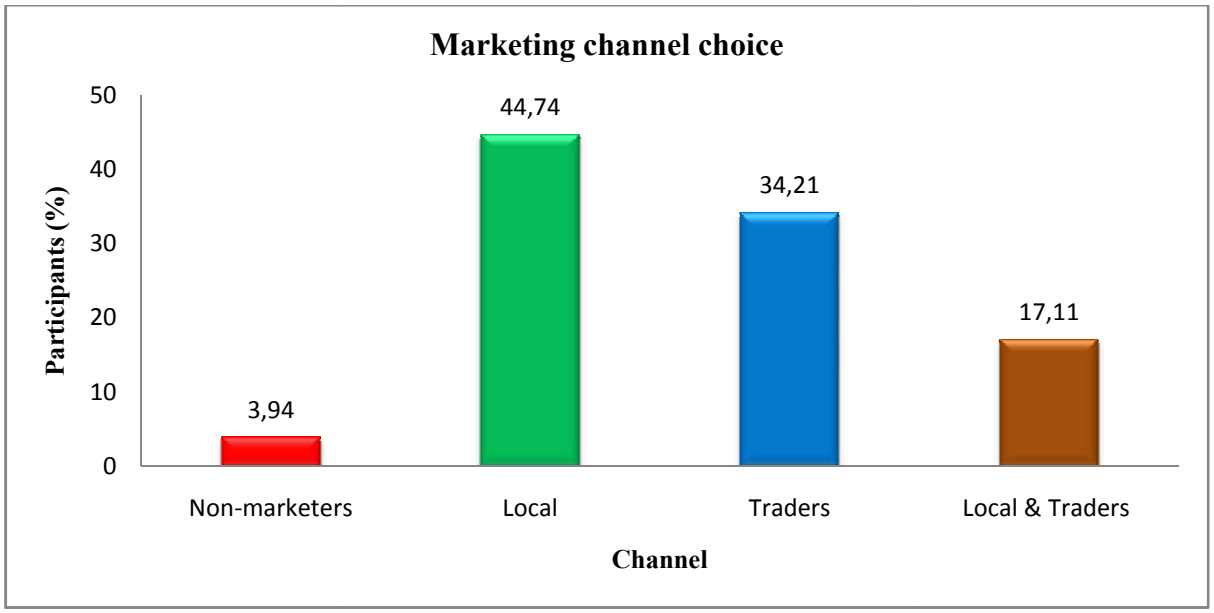

Figure 6.1: Sorghum market participation and marketing channel choice

Source: Survey data

Of the sampled households, 3.94% did not participate in sorghum marketing while the balance participated in some market. There is a significant difference ($p<0.01$) in the number of sorghum farmers for the two market participation categories. A number of household specific factors including the age of the principal decision maker have a bearing on marketing decisions made by small scale farmers (Makhura, Kirsten, & Delgado, 2004). The farmer's age had the expected positive and significant influence on the chances of farmers participating in sorghum marketing at the 1% level. This implies that older farmers who have more experience in transacting with buyers have a higher chance of participating in markets. Previous work shows that, these farmers would have established binding and long-term relationships with buyers and as such the risks associated with transacting are reduced (Birachi *et al.,* 2013). It was noted from FGDs that since sorghum dominates in the study area, there are rationally higher chances that these older farmers would use the crop for both

food and income generation. This is in agreement with MacInnis (2004) who reported a similar trend with farmers in Kenya.

Table 6.2 shows the empirical regression estimates for the two models. The results show that as per *a prior* expectations, the number of buyers with whom the sorghum farmer interacts has a positive and significant ($p<0.1$) estimated coefficient. Market size as determined by the number of buyers can determine the success and convenience of transactions (Azam, Imai, & Gaiha, 2012). The variable is an indicator of the market efficiency and the ability to offer value to participants (Gandhi & Namboodiri, 2002). More buyers increase the chances of a sorghum farmer participating in a market due to reduced transaction costs, lower risks and the likelihood of healthy competition. In semi-arid environments of Mali, it was reported that farmers reject sorghum production and marketing mainly due to limited number of buyers (Tefera, Dahlberg, & Smale, 2012).

There is evidence that, farmers in the smallholder sector prefer instant payment after a transaction due to the burden of financial need in the household (Sebatta *et al.,* 2014). The results show that, payment time also significantly ($p<0.01$) affects the market participation decision. Farmers prefer instant payment for their produce. As the time between a transaction and payment increases, the likelihood of a farmer participating in a market decreases. Usually small scale farmers have limited income sources and mainly depend on marketing of agricultural commodities (Mutenje *et al.,* 2016) for their daily needs such as food, fees and clothing. During FGDs, longer waiting periods were reported as a disincentive for market participation. This is worsened by the inflationary tendencies in Zimbabwe which reduce the buying power of the farmer's earnings if payment is deferred to a later date after a transaction has been concluded.

Table 6.2: Estimates for sorghum market participation and marketing channel choice

Variable	First decision Market participation *(Probit)*		Second decision Marketing channel choice *(Multinomial logit)*			
			Traders		*Local and traders*	
	Coefficient	*z-value*	*Coefficient*	*z-value*	*Coefficient*	*z-value*
AGE	0.0144 (0.0085)	1.70*	-0.0136 (0.0183)	-0.74	-0.0167 (0.0355)	-0.47
EDU	0.0422 (0.0292)	1.45	0.0520 (0.0553)	0.94	0.3370 (0.2498)	1.35
GEND	0.2370 (0.2896)	-0.82	-0.7590 (0.5584)	-1.36	-1.0422 (1.0202)	-1.02
DEPN	0.0029 (0.0040)	0.73	-0.0179 (0.0110)	-1.63	-0.1609 (0.0617)	-2.61***
L_INC	-0.0338 (0.2175)	-0.16	0.8210 (0.6576)	1.25	4.5360 (1.0911)	4.61***
ASSC	0.0619 (0.1071)	0.58	0.0598 (0.1975)	0.30	-0.5050 (0.4419)	-1.14
PRICE	0.0015 (0.0106)	0.01	0.1312 (0.0281)	4.66***	0.33078 (0.2062)	1.60
BUYR	0.0997 (0.0564)	1.77*	-0.9625 (0 .1351)	-7.13***	-1.9212 (0.4025)	4.77***
TIME	-0.3255 (0.1258)	3.58***	-0.0162 (0.0583)	-0.28	0.1030 (0.1192)	0.86
TRAN	0.1081 (0.0697)	1.55	-0.1322 (0.1605)	-0.82	0.3837 (0.2043)	-1.88*
L_DIS	-0.3932 (0.1749)	2.25**	2.2495 (0.4745)	4.74***	5.2140 (1.7580)	2.97***
SALE	---	---	0.0036 (0.0017)	2.05**	0.0048 (0.0025)	1.96**
EXTN	0.0002 (0.0392)	0.01	0.1704 (0.0947)	1.80*	0.2675 (0.1484)	1.80*
CONSTANT	-0.7987 (1.3513)	-0.59	-12.6013 (3.9091)	-3.22***	-58.7999 (21.9925)	-2.67***
Number of observations[42]	380		365			
Log pseudo-likelihood	-54.8492		-71.8312			
Pseudo R-square	0.1319		0.8091			
Wald chi-square	20.38**		148.75***			

Source: Generated by authors from sorghum survey data using STATA.
Notes: ***; ** and * p-values significant at 1%, 5% and 10% levels respectively. Base is local market, robust standard errors in parenthesis.

[42]Fifteen (15) farmers have been truncated as those who do not participate in sorghum marketing hence the lower number of observations with the second stage of marketing channel selection.

Results in Table 6.2 show that, distance to the market was another significant ($p<0.05$) determinant in the market participation decision. As distance to the market increases, the proclivity of a sorghum farmer to participate in a market decreases. The variable has a positive co-relationship with transaction costs incurred by the farmer in getting their produce to the market (Makindara *et al.,* 2013). Longer distances also imply that the search costs for the market also increase thus pulling the transaction costs up. Aggregating these costs would imply that farmers lose out on potential gains from sorghum marketing. The immediate option is to produce the crop for subsistence purposes with no need for the market. Similar findings were reported by Cirera & Arndt (2008) in Mozambique's maize markets where farmers in the proximity of the markets were more visible.

6.5.3 Marketing channel choice

Figure 5.1 shows that a significant proportion accounting for 44.7% of the sorghum farmers use the local markets (those in which farmers related directly to other community members at village level within the same ward) to trade in sorghum. Of the sampled households, 32.3% market sorghum through the traders (those in which farmers related to brokers) while 17.1% uses both the traders and local markets (a combination). The study adds new knowledge as reported in results from the marketing channel choice model which shows that, some variables which affected the market participation decision did not necessarily affect the marketing channel used by the farmers.

The dependency ratio was introduced into the model as a proxy for household composition. Table 5.2 shows that, the variable had a negative and significant ($p<0.01$) effect on the marketing channel choice decision for the combined alternative. Families with higher dependent members have been reported to be more risk averse when selecting markets due to

the need to be more secure and reduce the likelihood of losses in markets (Kluve, Lehmann, & Schmidt, 2008). The higher the number of dependents, the more likely the household is to exclusively participate in local markets which are less risky and have lower transaction costs. Since sorghum is used for food and income, chances are high that these families have little to sell in the markets. They then opt for local transactions while retaining much of their produce for household consumption.

The complexity of some marketing channels such as trading with processing companies and supermarkets imply that more administrative costs are to be incurred by farmers who decide to participate in these markets (Hill & Vigneri, 2011). Household income (in log form) had the expected positive and significant ($p<0.01$) effect on marketing channel choice. On average, well-to-do farmers who have higher household income levels are more likely to utilise the combination marketing option. Most marketing activities in rewarding markets also demand an initial investment in terms of information and bargaining related costs (Schaner, 2016). With the combination option, farmers usually invest considerable time and financial resources in managing the administrative demands of two marketing channels. From FGDs, it was noted that the reinforcing effect, where participating in a rewarding market increases income gains, and in turn also increasing the likelihood of further participation in the multiple markets can also explain the observed pattern. This is in disagreement with Burke, Myers, & Jayne (2015) who reported that in Kenya's dairy markets the household income levels andmarketing channel selection are not related.

The observed weighted average market price had the expected positive and significant ($p<0.01$) influence on the traders marketing channel option as shown in Table 6.2. The price is one key indicator of market efficiency since it points towards the value a farmer may

extract (Benfica & Tschirley, 2012). As such, the variable is expected to significantly affect the decisions by farmers as to whether they should use a particular marketing channel or not. Higher producer price usually imply higher margins which are favourable performance indicators to farmers (Hill & Vigneri, 2011). In the study area, traders offer relatively higher prices and also pay cash on the spot. These market characteristics encourage farmers to transact with the traders at the expense of other available alternatives such as the local markets.

More buyers in any given market can be used as a yardstick for market reliability since it points towards the extent of competition in the market (Shiferaw *et al.,* 2015). The number of buyers with whom a farmer directly relates to in a particular market significantly influenced the likelihood of choosing at least one of the two marketing channel replicates at 1% level. This is in line with the hypothesis where an increase in the number of buyers in the local markets decreased the probability of a farmer using the traders' option. The variable also decreased the chances of choosing a combination of the markets. Farmers consider the reliability of having many trading partners in strategic marketing channels such as the local market when entering into a transaction (Asogwa *et al.,* 2012). Key informants suggested that more buyers in the local markets increase the likelihood of competition for price and quantities there by helping the farm to sell in a market with lower transaction costs while still getting acceptable levels of margins.

Transporting commodities to the markets is one major constituent element of transaction costs (Sebatta *et al.,* 2014). Results in Table 6.2 show that the cost of transporting produce to the market had a positive and significant ($p<0.1$) effect on the choice of the blended marketing strategy. During FGDs, it was reported that with increased transport costs, farmers

would choose to reduce their interaction with traders who usually charge exorbitant fees for transport services. The farmers would however opt to increase volumes of transactions with the locals who had lower costs of transport and usually transacted at the farm gate (Poonyth, Van, & Meyer, 2006). This hedging strategy would reduce marketing risks for the farmers who are domiciled in area of poor road infrastructure. The is in line with findings by Maina *et al.* (2015) who also noted that farmers who did not own personal transport had limited ability to penetrate multiple markets without necessarily ballooning the transport costs.

Market decentralisation is perceived as an institutional strategy aimed at encouraging market participation by small scale farmers (Moussa, 2011). The study shows that, distance to the market positively influenced the choice of the traders' option and the combined marketing channel. Due to the time and expenses associated with travelling to the market, as the local market distance increases, there are higher chances that farmers will opt take the risks and choose the more rewarding alternatives. This is in agreement with Osebeyo & Aye (2014) who also reported the negative effect of market distance in marketing channel choices. Evidence from FGDs and observations in the study area were also that, in most cases, the traders tend make purchases at the farm gate hence farmers opt for transacting with them on the basis of their willingness to absorb the distance factor.

A study by Mennecke *et al.* (2007) shows that, the saleable surplus is an important determinant in marketing channel choices that are made by farmers. The sales volumes by households significantly ($p<0.05$) influenced the likelihood of choosing traders and the combination as marketing options. Households with higher volumes of saleable output prefer to be more income secure and are sceptical of transacting in the local marketing channel mode which is usually not rewarding. These farmers are reported to be agribusiness oriented

and have the appetite to tap and explore new marketing channels, thus making them more enterprising (Ortmann, 2000). Traders also prefer transacting with farmers who have higher surpluses because this reduces their administration costs. Jayne & Chisvo (1991) also report that market reforms based on reduced transation costs driven by larger producing households also encourage investment in markets.

The major sources of information in the small scale farming areas are the extension agents who either come from the public or private domains (Shiferaw *et al.,* 2015). The frequency of extension contact had a positive and significant ($p<0.1$) effect on the marketing channel choice. As extension contacts increase, both the chance of transacting with traders and the combination channel also increases. This shows the catalytic effect of extension systems in greasing the migration from subsistence based agriculture to a more agribusiness mentality among small scale farmers (Labeyrie *et al.,* 2014; Ortmann, 2000). During FGDs, stakeholders agreed that, extension impacts farmers by availing multiple information nodes on prevailing and possible future market conditions. This information package then helps sorghum farmers in choosing the most appropriate and beneficial marketing channel (Mennecke *et al.*, 2007).

6.6 Conclusions

The study identifies payment time, distance to the market, the number of buyers and age of principal decision maker as factors affecting the market participation decision. Three distinct marketing channel options were observed in the study area as being the local channel, traders marketing channel and a combination of the two. The most widely used option by small scale sorghum farmers is the local marketing channel. The low number of marketing channels is an indicator of the extent of market thinness in the small scale farming sector of Zimbabwe.

There are a number of significant household and market specific factors influencing marketing channel choice in agreement with (Azam *et al.,* 2012). As hypothesised, average weighted market price, number of buyers in the market and distance to the market are the most robust determinants of marketing channel selection.

6.7 Policy recommendations

In an effort to increase proclivity for market participation, the time between a transaction and payment needs to be minimized. There is scope to establish sorghum marketing associations which can absorb the payment time lag by providing marketing credit lines to traders. Since age of principal decision maker is also a key factor, there is need to structure training programmes which inform farmers on the benefits of investing and participating in marketing. There is need to also introduce tailor made courses on agricultural marketing in schools' curriculum at all levels so that this philosophy can be appreciated by the young and diffuse within communities. The most robust determinants of the marketing channel choice are related to the transaction costs incurred by sorghum farmers. It is imperative to form marketing groups so as to increase farmers' price bargaining power in highly rewarding markets. This should reduce the inherent price related risks of marketing which currently characterise small scale farming systems. The government can also offer direct price support for incentivizing sorghum marketing as is the current case with maize. Improved road network can also be an effective strategy for lowering transactional costs.

Market decentralisation can be important to reduce distance to markets and associated transport costs. Fostering public-private collaboration in developing rural distribution networks from prime production zones to processing and consumption hubs can catalyse sorghum marketing. This should incentivise choice of more rewarding external marketing

channels due to reduced transaction costs. Once transaction costs are reduced, chances are high that small scale sorghum farmers who are located in the geo-political peripheries of Zimbabwe will be mainstreamed into marketing decisions at all levels and nodes of the value chain. Promotion of value addition activities in the sorghum value chain can be done as this is likely to increase the market size.

Extension networks provide timely and updated information on market conditions especially the costs and net benefits associated with each transaction and marketing channel. Sorghum value chain stakeholders need to re-orient and coordinate extension modes geared towards effective and affordable information generation and dissemination avenues so that they become responsive to the dynamic states of interactions on the market platforms. This can be done by increasing the frequency of "*extension-farmer*" contact through the use of informal local networks such as families and friends. Adopting and scaling out the "*train the trainer model*" through lead farmers can also be effective in enhancing extension efficiency.

CHAPTER 7

IMPACTS OF IMPROVED SORGHUM VARIETIES INTENSIFICATION ON HOUSEHOLD WELFARE IN THE MID ZAMBEZI VALLEY OF ZIMBABWE

(This manuscript has been published in *Agrekon*)

Abstract

Attaining income and food security remains a challenge in rural southern Africa. Sorghum production is regarded as a gateway out of poverty in arid and semi-arid zones. The paper uses propensity score matching and endogenous switching regression to estimate impacts of selected improved sorghum varieties and associated land allocation differentials on welfare. Household dietary diversity score and household food insecurity access score were used as proxies for food security. Productivity and net income gains were also adopted for analysis. Data were generated from 380 households in a representative survey conducted with five purposively selected wards in mid-Zambezi Valley of Zimbabwe. Analysis of the data shows that associations, market prices, income, age, dependency, ownership of draught power and storage facilities have implications on food and income security. Counterfactual analysis shows that farmers who allocate more land towards improved sorghum varieties are relatively better off in food diversity and access, productivity and net returns. Social networking should be strengthened through local, government and private partnerships. Market size needs to be increased so as to improve the prices.

Key words: smallholder sorghum farmers, food security, land allocation intensity, propensity score matching, endogenous switching regression

7.1 Introduction

Sorghum has for long been marginalised from mainstream development strategies in southern Africa (Hamukwala *et al.,* 2010; Dicko *et al.,* 2006). However, sorghum driven food and income security remain important discussion points in the rural development debate in the region (Mabiso *et al.,* 2014; Nyanga, 2012; Jayne, Mather, & Mghenyi, 2010; Matshe, 2009). Most countries in southern Africa, including Zimbabwe are small open economies experiencing food and income insecurity due to limited livelihood options triggered by high costs of production and trading (Scoones *et al.,* 2011; Matshe & Young, 2004; Jayne & Chisvo, 1991). These countries also inherently depend on agricultural activities for GDP stability, foreign currency generation and employment opportunities (Government of Zimbabwe, 2013; Juana & Mabugu, 2005; Jayne & Chisvo, 1991).

With the advent of declining performance in the sector and increased incidences of food insecurity and malnutrition, a number of interventions have been implemented by both the public and private domains to support the subsector (Musemwa & Zhou, 2013). Re-embracing sorghum in the land allocation decision making processes has evidently emerged especially in the arid and semi-arid zones (Munyati *et al.,* 2013; Tefera *et al.,* 2012; Aduguna, 2007; Poonyth *et al.,* 2000). It is however important at this stage of the food and income stability revolution aimed at supporting small grains as the '*future grains*' to examine the welfare impacts of these decisions among farming households with a focus on improved varieties. Smale *et al.* (2015) reported the welfare effect of adopting high yielding and hybrid seed in Sudan Savanna of West Africa. They noted that adoption of the seed resulted in higher yields, harvest share that is sold and dietary diversity among households.

Inspired by the aforementioned possibilities, mechanisms for enhancing sorghum productivity through adoption of innovations and strengthening market linkages have been embraced at different administrative, spatial and temporal scales. The aim is to design and sustain strategies which address both the means and dimensions for attaining household welfare improvement. One approach simultaneously addressing these aspects is by integrating smallholder farmers into sustainable commercial food systems (Navarro *et al.,* 2012; NEPAD, 2003). This has been attempted through strengthening institutions and policies which catalyse low cost identification and intensification of viable sorghum based innovations such as high yielding varieties (Pye-Smith, 2013; Rukuni *et al.,* 2006).

As noted by Maina *et al.* (2012) and Mutenje *et al.* (2016), similar transitions have however mainly been driven by policy shifts, albeit in a preferentially biased manner. For example, notably, food security policies in Zimbabwe have been primarily anchored on maize production, processing, marketing and consumption systems. This is the case even in marginalised areas where the crop is not as strategically competitive as small grains including sorghum (Mukarumbwa & Mushunje, 2010; Zerbe, 2001; Eicher, 1995; Jayne & Nuppenau, 1993; Jayne & Chisvo, 1991). The mentality has compromised effectively beneficial crop and livestock intensification prospects and worsened the poverty status of farming households whose main livelihood is agriculture.

Misselhorn (2005) defines food security as a stable state in which all people perpetually have both physical and economic access to sufficient, safe, affordable and nutritious food to meet their dietary needs and food preferences for a healthy and active life. In most parts of rural Zimbabwe, households have been reported to be food insecure primarily because they cannot guarantee access to their food requirement through socially acceptable means (Mabiso *et al.,*

2014; Nyanga, 2012). The observable consequences of food insecurity are on nutrition status, health and overall economic productivity (Musemwa & Zhou, 2013; Misselhorn *et al.,* 2012). With unpredictable rainfall patterns, unstable prices for cereal crops and reduced government control in markets expected to push maize out of arid and semi-arid zones of Africa (Sultan *et al.,* 2013; Haussmann *et al.,* 2012; Ahmed *et al.,* 2000), there is imminent need to identify and support strategies that provide new avenues for enhanced food and income security in these areas (Mazvimavi & Twomlow, 2009; Howard *et al.,* 2000). This matrix demands informed and responsive land allocation decisions based on appropriate crop and variety choices.

The immediate option is reverting to sorghum production which once dominated the crop mix in these climate change sensitive environments (Proietti, Frazzoli, & Mantovani, 2015; Kerr, 2014; Makindara *et al.,* 2013; Rohrbach & Kiriwaggulu, 2001). The crop has resilient capabilities to climate adversities coupled with multiple potential uses including domestic consumption, stock feed, provision of energy and beer brewing (Sultan *et al.,* 2013; Taylor, 2003; Goodman & DuPuis, 2002). Despite its economic and health related potentials, value chain stakeholders including farmers spurn the enterprise due to inadequate institutional support and high transaction costs (Bean & Ioerger, 2014). This induces poor enterprise performance primarily due to limited investment effort by farmers in high yielding varieties and in activities by other value chain actors alike (Hamukwala *et al.,* 2010). On one hand, farmers cultivate the crop on small pieces of unproductive land using low yielding varieties which are also susceptible to incidences of pests and diseases. On the other end, processors and consumers are invisible to the farmers along rewarding value chains leading to exploitation by middlemen (Asogwa *et al.,* 2012; Baquedano *et al.,* 2010). The result is that

in most parts of semi-arid southern Africa, the welfare enhancing space for sorghum is therefore presently missing and/or untapped.

In response to this, several sorghum seed development, financing, production and marketing support programs have been implemented by a number of partners in the mid-1990s (Labeyrie *et al.,* 2014; Howard *et al.,* 2000; Eicher, 1995). These efforts left residual positive externalities in the farming communities. The study hypothesises that in such environments, farmers are at least aware of the potential benefits of increasing land under improved sorghum varieties. There is widely held consensus that there are opportunities to pick up from these efforts and increase land allocated towards improved sorghum varieties production for food and income security benefits (Baquedano *et al.,* 2010; Mukarumbwa & Mushunje, 2010; Ahmed *et al.,* 2000). The expectation is that it will emerge as a livelihood stability enhancing strategy for improving household welfare and general economic development.

However, limited studies (see for example Smale *et al.,* 2018) have examined the welfare impacts of sorghum production decisions with improved varieties on household welfare. To bridge this gap, the study adopts a combination of propensity score matching (average treatment effect of the treated) and endogenous switching regression modelling to ascertain causality of increased land allocation of improved sorghum varieties on welfare as shown by prime indicators of productivity, food and income security gains.

7.2 Conceptual framework

The study is guided by previous studies which defined intensive practices in terms of additional demand for a production factor as pulled by observed or anticipated benefits

(Josephson *et al.,* 2014; Ndiritu *et al.,* 2014; Amare *et al.,* 2012; Barnes & Poole, 2012; Faltermeier & Abdulai, 2009). In the present case, intensive sorghum production is defined as a state when a farmer has passed the production decision stage and decides to allocate more land towards improved sorghum varieties[43]. The censoring technique is used to define intensifiers as those sorghum producers who allocate at least 50% of the available arable land towards high yielding varieties. In this study, there is an attempt to enhance understanding of research for development efforts by examining causality of an innovative land partitioning decision on rural farmers' welfare.

This section presents a framework that contributes towards the debate of how intensified improved sorghum varieties production affects household food and income security status as indicators of household welfare[44]. The study accepts that intensification is not fixed but a dynamic set of processes characterised by adaptability in order to generate incentivising returns. However, focus was on the decisions observed during the 2015/16 ccropping season. To achieve this, a modified Sustainable Livelihoods Framework (SLF)[45] as presented in Figure 7.1 is used to unravell the welfare concept.

[43]These authors have successfully used a similar definition of intensification in previous innovation adoption and intensification studies, including high yielding seed varieties and intercropping practices. Farmers included in the analysis have passed the sorghum production decision stage and are then partitioned into intensifiers and non-intensifiers regardless

[44]This section builds on Chapter 5 of this thesis report on the determinants of sorghum production and associated land allocation decisions towards the crop. The selected improved varieties are Silla, Macia and Chibuku as shown in Table 5.2 and accounts for 82% of total farmers.

[45]See (Ashley & Hussein, 2000; Matshe, 2009) for detailed explanation of the framework.

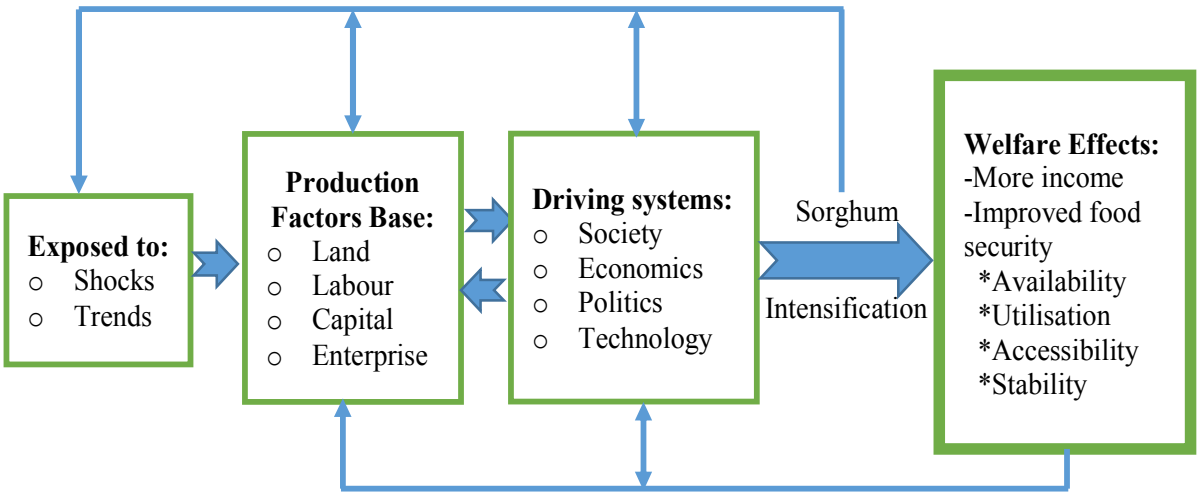

Figure 7.1: Conceptualising welfare effects of sorghum intensification

Source: Adapted from Matshe (2009) and Ashley & Hussein (2000).

The essence is to trace critical outcomes emanating from the intensification decision, namely productivity, food and income security gains. This guiding framework presents avenues for exploring the existing relations and gaps that can be filled to enhance the benefits from systematic intensification of improved sorghum varieties. The two selected varieties were Macia (coded M) and Silla (coded S). This yielded three possible combinations of M only (M_1S_0), S only (M_0S_1) and a combination of M and S (M_1S_1). The study hypothesises that improved sorghum varieties intensification directly and indirectly affects household welfare. Sorghum can withstand unfavourable natural conditions of low rainfall, pest infestation and high temperatures (Kerr, 2014; Sultan *et al.,* 2013) which characterise the mid-Zambezi Valley of Zimbabwe. As such, directly the intensification of improved sorghum varieties have a bearing on the household food security status through increased and relatively stable yields from the crop. To understand this better, the study therefore traces the productivity gains and unpacks the governing pillars of food security using the Household Dietary Diversity Score (HDDS) and Household Food Insecurity Access Score (HFIAS). Improved

sorghum varieties intensification also has an implication on market prices and hence indirectly affects the income levels of households. In both scenarios, since there is the use of survey based observational data on household behaviour, causality is cautiously inferred.

Informed by previous work by Asfaw *et al.* (2012) and Barrett *et al.* (2012), the study appreciates that in reality it is almost impossible to objectively measure absolute causal effects at the individual level. As such, this is circumvented and depends on the average causal effects to understand the relationships under study. In this case therefore, a dummy variable (D_i) showing the two states of sorghum production (=1) and sorghum non-production (=0) was assigned to the relationship between those farmers who intensify improved varieties (Y_{0i}) against those who do not (Y_{1i}) to generate:

$$Y_i = Y_{0i} + D_i\left(Y_{1i} - Y_{0i}\right) \tag{1}$$

The study intentionally uses the same covariates[46] to estimate the effect of improved sorghum varieties intensification for the regression and matching techniques and then compare the outcomes. The estimates α_r present a model for discrete X_i given as:

$$Y_i = d_{iX} X\beta_X + \alpha_r D_i + \mu_i \tag{2}$$

Where:

- Y_i is the dependent/outcome variable (selected welfare indicators);
- β_x is the regression induced effect when $X_i = X$; and
- α_r is the regression parameter.

[46]This set of covariates however differed for the income-productivity cluster and HDDS-HFIAS cluster. The covariates which affect these outcomes have also been reported to be different and as such modeling on the same set would lead to inclusion of spurious variables. This was also inspired by Noltze *et al.* (2013) who used different sets of variables for yield and income differentials.

7.3 Empirical estimation of welfare impacts

The wellbeing effects of improved sorghum varieties intensification can be expressed by indicators such as income, output, and incidences of limited food diversity. A study by Khonje *et al.* (2015) also used incidences of malnutrition amongst children under the age of five years as an indicator of food security. Guided by previous work, the study lets Y_i be the outcome variables (yield per hectare, income per hectare, HDDS and HFIAS) and estimate the effect of improved sorghum varieties intensification on these (Sebatta *et al.,* 2014; Takeshima, Adeoti, & Salau, 2011; Kluve *et al.,* 2008). The study lets Y_1 be the welfare value when household i is subject to treatment i.e. allocates at least 50% of available arable land towards improved sorghum varieties ($P = 1$) and Y_0 be the same variable under the less than 50% allocation state ($P = 0$). The observed welfare then becomes:

$$Y = PY_1 + (1 - P)Y_0 \tag{3}$$

When ($P = 1$) the study can observe Y_1 and ($P = 0$) an observation of Y_0 is made. The Average Treatment Effect on the Treated (ATET) is used in the study and is defined as:

$$ATET = E(Y_1 - Y_0 \mid P = 1) = E(Y_1 \mid P = 1) - E(Y_0 \mid P = 1) \tag{4}$$

Since the study is a micro analysis where random sampling was used during data collection, it benefits from the assumption that the treatment of one unit does not have an effect on the others. Equation (4) shows the net gain in welfare from improved sorghum varieties intensification. In reality, the outcome variable for the allocation state, $E(Y_1 \mid P = 1)$ is the observed and the study cannot do the same for farmers who allocate, assuming they had not allocated more land towards improved sorghum varieties, $E(Y_0 \mid P = 1)$. Counterfactual analysis then caters for this reality by matching the control and the treatment (Abdulai &

Huffman, 2014; Di Falco & Veronesi, 2013; Asfaw *et al.,* 2012). This implies mimicking the randomisation technique used in experiments. The Nearest Neighbourhood Method (NNM)[47] was used in the study. Matching estimators are primarily governed by the assumption which states that the decision by a farmer to allocate more land towards improved sorghum varieties is conditional on a set of observed covariates X.

$$\left(Y_1, Y_0\right) \perp P \mid X \tag{5}$$

This assumption implies that the counterfactual welfare indicators in the treated group are the same as the observed welfare change for the non-treated group.

$$E\left(Y_0 \mid X,\ P=1\right) = E\left(Y_0 \mid X, P=0\right) = E(Y_0 \mid X) \tag{6}$$

The assumption therefore rules out selection bias in the improved sorghum varieties land allocation decision and eliminates the positive state on the basis of unobservable gains from being an intensive improved sorghum variety farmer. This assumption also requires that the set of observed covariates, X, should capture all factors that jointly determine the welfare indicators without treatment and the selection into the treatment. Informed by Amare *et al*. (2012), under this assumption therefore, the ATET is computed as:

$$ATET = E(Y_1 - Y_0 \mid X,\ C=1)$$

$$= E\left(Y_1 \mid X, C=1\right) - E(Y_0 \mid X, C=1) \tag{7}$$

Where:

- Y_1 is the treated outcome;
- Y_0 is the untreated outcome; and
- C is the treatment status which equals 1 for treatment and 0 otherwise.

[47]A detailed explanation of the method is found in (Ali & Abdulai, 2010; Amare *et al.,* 2012; Becerril & Abdulai, 2010; Newson *et al.,* 2006). The Kernel Method has also been widely used in literature but was not adopted in the current study.

Challenges with matching are encountered when the number of covariates gets large[48]. However due to the relatively small number of covariates in the study, this problem will less likely set in. The ATET relationship in (7) was then transformed to:

$$ATET = E\left(Y_1 \left| P\left(X\right), P=1\right) - E(Y_0 \left| P\left(X\right), P=1\right) = \alpha \quad (8)$$

This shows that ATET is a difference between the welfare indicator for the treated group (observable) and the welfare indicator for the treated group assuming it had not been treated (unobservable). The latter component is the counterfactual scenario which needs to be treated.

Since propensity score matching only accounts for the observed (and observable) covariates, factors that can affect assignment to the treatment and outcome but cannot be observed are not accounted for in the matching procedure. The study appreciates that there might be endogeneity of improved sorghum varieties intensification in the welfare models. The first effort to reduce the chances was to include a richly selected set of covariates which encompass significant attributes about the population and the surroundings as guided by literature (Mutenje *et al.,* 2016; Khonje *et al.,* 2015; Manda *et al.,* 2015; Zeng *et al.,* 2015; Di Falco & Bulte, 2013; Diiro, 2013; Musemwa & Zhou, 2013; Amare *et al.,* 2012) and observations in the study area. Additionally, the soil fertility instrumental variable[49] which was captured as a multinomial treatment indicator variable was also included in the analyses. The study also uses the maximum likelihood method to fit the endogenous two-stage switching regression to cater for the unobserved effects. Considering the household welfare indicators described above, Y_{0i} is assigned for non-intensifiers and Y_{1i} for non-intensifiers.

[48]With large numbers of covariates, the solution will be to match along a single index variable which summarises the covariates instead of matching along a particular covariate per se. This propensity score is then a response conditional probability that a household will allocate more land towards sorghum given a set of covariates.

[49] An instrumental variable, soil fertility was selected and applied across all the welfare models. See the results section for justification of the selected instrumental variable.

Guided by Shiferaw *et al*. (2013), the following conditions were laid down while letting:

- X_{0i} and X_{1i} be $1 \times n_o$ and $1 \times n_1$ vectors of the explanatory variables for each of the two groups respectively; and
- β_o and β_1 be $n_o \times 1$ and $n_1 \times 1$ conformable individual specific parameter vectors and γ and $m \times 1$ vector.

Since the status of outcome variables may be specific to individual farmers, the condition that $\beta_o = \beta_1.$ was relaxed. Additionally, the following conditions were satisfied:

- P be the latent variable determining as to which group applies;
- z_{ip} a $1 \times m$ vector of explanatory variables assumed to explain the improved sorghum variety land allocation probability; and
- $u_{ip}.$, ε_{0ip} and ε_{1ip} be the error terms.

From the above conditions, the switching regressions were then defined by the following set of equations:

$$P_{ip} = 1\left(z_{ip}\gamma + u_{ip} > 0\right), \tag{9}$$

$$\textit{Regime 1:} \quad Y_{0ip} = X_{0i}\beta_0 + \varepsilon_{0ip} \quad if \;\; P_{ip} = 0 \tag{10}$$

$$\textit{Regime 2:} \quad Y_{1ip} = X_{1i}\beta_1 + \varepsilon_{1ip} \quad if \;\; P_{ip} = 1 \tag{11}$$

Equations (10) and (11) describe the relationship between the variables of interest in each of the two clusters (regimes). Equation (9) is a selection equation which determines as to which regime applies. The error terms are idiosyncratic and assumed to be trivariate normally distributed with mean zero. Since logically individuals can only be observed in either state, $P_{ip} = 1 \; or \; P_{ip} = 0,$ but never in both states, then the covariance of Equations (10) and (11) is zero.

Equations (10) and (11) are the endogenous switching regime model. When $\rho_1 = \rho_0 = 0$, these equations then switch to the exogenous regime model where ρ_1 is the covariance of ε_{1ip} and u_{ip} and ρ_0 is the covariance of ε_{0ip} and u_{ip}. As guided by Amare *et al*. (2012) and Asfaw *et al.* (2012), standard errors in stage two have widely been corrected by bootstrapping both the outcome and intensification equations. The same technique[50] was adopted in this study and estimated the mean outcome variables as:

$$E\left(Y_{1ip} \mid x_{ip}, C_{ip} = 1\right) - E\left(Y_{0ip} \mid x_{ip}, C_{ip} = 1\right)$$

$$= x_{ip}\left(\beta_1 - \beta_0\right) + \rho_1\lambda_1 - \rho_0\lambda_0. \qquad (12)$$

The second term on the left hand side of equation (12) is the expected value of Y if the household had allocated more land towards improved sorghum varieties (the unobserved component) which the study intended to isolate.

7.4 Methods

The study was conducted with 380[51] households randomly selected from five Wards in the mid-Zambezi Valley of Zimbabwe. The area was selected purposively as it falls in the prime sorghum producing zones of Zimbabwe where the crop has the potential to generated food and income security gains. Temperatures in the area average 30^{o}C with annual rainfall received ranging from 350 to 550 mm. Despite poor soils, erratic rainfall and crop destruction by wildlife, households in the mid-Zambezi Valley still depend on agricultural practices for subsistence and cash income. For detailed description of sampling and data collection methods, see Chapter 3.

[50]See Table 4 in this section.
[51]82% of the sampled farmers grew improved sorghum varieties as shown in Table 4.2. As such a sub sample of 312 farmers was used in the analysis

7.5 Measuring food security

Food security is unversally acceptable as an integral component of welfare and can be analysed at varied global, regional, national, community and household levels (Cafiero *et al.,* 2015; Musemwa *et al.,* 2015; Reyes, 2009; Maxwell *et al.,* 2008). Food secure households do not neccesarily depend on emergency food aid or other socially unacceptable ways of acquiring food. The study isolates a number variables from welfare indicators (Y_i) related to the food and income security domains. These include household food access and diversity, productivity and household income.

Significant work has been done to understand food security dimensions (Maxwell *et al.,* 2008; Oldewage-theron, Dicks, & Napier, 2006). As reported by Dewi *et al.* (2014), the most commonly used indicators of food security revolve around consumption. We borrow from this mentality and as further guided by Maxwell *et al.* (1999), the study uses the diversity of consumed food and adequacy of food access. Adopting the Coping Strategies Indicators[52] has not been widely used in food security studies but the Coping Strategy Index (CSI) was however succesfully used in some studies (Mabuza *et al.,* 2016; Maxwell *et al.,* 1999). The technique reduces the chances of categorising food insecure households as being food secure. The Food Security Ratio (FSR) has also been used in a study by Silvestri *et al.* (2016) to show how own production and purchases can meet household energy needs. However it is usually inaccurate since determining the exact values of the two inputs is a challenge with most social science based studies. Musemwa *et al.* (2015) also adopted the Household Food Insecurity Access Prevelance (HFIAP) in the Eastern Cape Province of South Africa.

[52]The current study could not use the Coping Strategy Index (CSI) since farmers could not easily recall the strategies adopted during the review period.

The household dietary diversity score (HDDS) and the household food insecurity access score (HFIAS) have widely been used as proxies for food security (Fielden *et al.,* 2014; Mango *et al.,* 2014; Lo *et al.,* 2012; Kennedy *et al.,* 2010). The study adopted the Food and Nutrition Technical Assistance Project guidelines to develop these food security surrogates. There is widely held consensus that these two indicators of food insecurity can adequately accommodate the dimensions of food insecurity, namely uncertainty and anxiety about food, insufficient quantity and inadequate quality (Maxwell, Vaitla, & Coates, 2014).

7.5.1 Household dietary diversity score (HDDS)

The advocacy for using the HDDS as a measure of food security is not new in food security studies. The HDDS is defined as a measure based on a recall of all food or drink items consumed by the household members during the last 24 hours. It is a useful proxy for food security and has widely been used in literature across the world in various contexts (Anema *et al.,* 2014; Fielden *et al.,* 2014; Kennedy *et al.,* 2010). Its main strength is that it has a very strong co-relationship with key food security indicators such as the adequacy of a household's intake of proteins, calories and other nutrients. Literature acknowledges that analysing dietary diversity using individual foodstuffs has a weaker nutrient adequacy prediction capacity than when using food groups (Lo *et al.,* 2012). The argument is that for example an isolated energy adequacy observation might not be enough to sustain an active life since some nutrients might be missing in the diets. It therefore becomes integral to factor in key nutritional quality indicators in household food security studies.

Dietary diversity is a varied and composite consumption based indicator showing nutrient availability and reflects on the household's income capacity (as shown by per-capita income) to consume multiple food stuffs. Empirical evidence shows that a high HDDS can be

confidently used to reflect on balanced diets and lower incidences of malnutrition (Fielden *et al.,* 2014; Lo *et al.,* 2012). High intakes of starch based diets will yield low HDDS values which are an indication of limited micro nutrients (Mango *et al.,* 2014). Ground breaking work by FAO (2008) generated the HDDS from 14 food groups consumed within the household excluding those consumed outside the household. This same scale was successfully used by Mango *et al.* (2014) in Zimbabwe. However, Lo *et al.* (2012) used a scale of 0-6 in a study conducted in Taiwan. In this study, the six point scale was adopted given the limited diversity observed from the universe of food items which yielded 93 items.

The score was then computed as the total sum of the food groups consumed in the household. An equal weighting of one was given to each food group. The major weakness of the score is that it does not allow for estimates to be made with respect to how much food is lacking in a diet because it cannot directly quantify the amount of food consumed. Additionally, the measure does not explain causality for observed consumption patterns (Kennedy *et al.,* 2010). There are also methodological shortfalls associated with the measure in terms of universally acceptable food groups and food types to include (see for example Mango *et al.,* 2014 and Lo *et al.,* 2012). Additionally, even though HDDS as a measure of food security can effectively be used to trace changes in dietary energy uptakes, it cannot adequately be used to explain nutrient adequacy.

The study used 252[53] households and questions were presented to them so that they recalled food and drink stuffs consumed in the past 24 hours. The foods were then classified into 6 distinct categories with a score of *1* for yes and *0* for no. The classifications were grains and rice, fat and oils, dairy, meats, vegetables and fruits and presented in a HDDS as:

[53]A net sample of 252 households was used.

$$HDDS = \sum_{i=1}^{6} X_i \quad (13)$$

Where:

- $HDDS$ is the score; and
- X_i is the food group consumed by household member.

7.5.2 Household food insecurity access score (HFIAS)

According to Mango *et al.* (2014), Maxwell *et al.* (2014) and Musemwa *et al.* (2015), the HFIAS is a continuous access measure of the degree of household food insecurity over the past 30 days. The measure is an indicator of household food insecurity in terms of insufficient food supplies and assumed quality thereof. It also factors in anxiety about household food insecurity which is an important indicator. Musemwa *et al.* (2015) noted that HFIAS is a more subjective measure since it captures the household members' perception about the consumed diets and this may completely miss the nutritional composition of these diets. The score pays attention to consumption-related strategies and is concerned with the household members' behavioural and psychological responses to food insecurity as they perceive it. Using the survey data, a score was generated based on a much held assumption that based on long-term consumption experiences, respondents were able to relate to their food insecurity status with some level of confidence. Eight distinct categories of occurrences were isolated in the study as:

"1= Anxiety about food (in)adequacy; 2= Eating foods of a limited variety; 3= Eating less-preferred foods; 4= Inability to eat even the less-preferred foods; 5= Eating smaller meals than needed; 6= Eating fewer meals in a day; 7= Going to bed hungry; 8= Failing to obtain food of any kind during the whole day or night".

The progression from 1 to 8 shows increasing insecurity. A binary response was used as yes *(1) and* no *(0)* depending on whether any of the 8 occurrences were encountered in the household over the past 30 days. A severity question which was based on frequency of occurrence was assigned as a follow up to the occurrence observation over the same period. A scale was developed as, *"1 = rarely, 2 = sometimes, and 3=often"*. This implies that the range[54] for the HFIAS was 0-24. Guided by Leroy *et al.*(2015) and Parnell & Gray (2014), the HFIAS is therefore computed as:

$$HFIAS = \sum_{i=1}^{8} X_i F_i \tag{14}$$

Where:

- $HFIAS$ is the score
- X_i is the food insecurity occurrence observation; and
- F_i is the frequency of occurrence.

7.6 Effects of sorghum improved varieties intensification

Attempts to estimate the impact of an innovation on household welfare can be done using indicators such as income, consumption and yield changes (Zeng *et al.,* 2015; Amare *et al.,* 2012; Asfaw *et al.,* 2012; Barrett *et al.,* 2012). The study uses the same approach with differential land allocation decisions towards improved sorghum varieties in semi-arid rural areas of Zimbabwe. Doing this for non-experimental events is usually challenging since we have to deal with the unobserved outcome dimension for the inclusion state in the event that farmers who have allocated more land towards improved sorghum varieties had not done so (Argüello & Valderrama-Gonzalez, 2015; Di Falco & Veronesi, 2013). This challenge is

[54]A household whose HFIAS score is high has high levels of food insecurity. Different ranges have been reported in literature (Cafiero *et al.,* 2015; Coleman-jensen, 2010; Mango *et al.,* 2014) but the present argument still holds. The study adopted the narrower spectrum of the responses since wider ranges would imply more possible responses which can compromise the ability of respondents to place their response in a particular specific category.

easily addressed in experiments by randomly assigning a control (Roth, 2010) whose outcomes represents the pseudo non-intensification state. However, it is imperative to note that deciding to allocate more land towards improved sorghum varieties as a state is not randomly distributed in a sample but peculiar to an individual household's potential to utilise the available information and resources. This implies potential systematic differences between farmers who intensify and those who do not intensify production of improved sorghum varieties. It is therefore necessary to use econometric techniques which account for this potential selection bias whenever innovation impact evaluation studies are carried out (Asfaw *et al.,* 2012; Faltermeier & Abdulai, 2009; Ashley & Hussein, 2000).

Some studies used Average Treatment Effects (ATE) k-factors to understand the impact of agricultural technology (Diagne & Groom, 2012). However, these approaches may not be the best if farmers are rational and profit maximising agents. ATE has been reported to be zero even in cases where the k-factors are large enough to justify high impact technologies. This distorts the meaning of the k-factors as for example the measures of productivity increases induced by a change in practices. Additionally, attempting to evaluate innovation impact on this basis limits the scope of the evaluation since it is an effective toolkit for the binary definition of adoption which does not clearly cater for the intensity component of adoption. This is inappropriate in this study since the objective is to trace intensity of land allocation towards improved sorghum varieties and its effects on food and income security.

Other studies have adopted the matching[55] approach which is also technically based on the ATE philosophy. This study used a combination of matching techniques with Average Treatment Effect on the Treated (for the observable outcome) and endogenous switching

[55]For more detailed use of propensity score matching, see (Caliendo, Caliendo, & Kopeinig, 2005; Garrido *et al.,* 2014; Newson *et al.,* 2006; Sianesi, 2001)

regression (for the unobservable outcome). This approach has also been successfully used in agricultural innovation impact evaluations (Ngeno, 2017; Abdulai & Huffman, 2014; Słoczyński, & Wooldridge, 2014; Noltze, Schwarze, & Qaim, 2013). Switching validates the matching results and this eliminates the challenge of having non-zero treatment effects (for example as is the case with large k-factors) which do not necessarily reflect the direct impact of an innovation but other factors including non-separability. Switching therefore eliminates hidden selection bias that might set in due to some latent variables (Kluve *et al.,* 2008). The choice of this analytical toolkit was also influenced by the nature of the sample which is large enough to overcome the dimensionality problem and has substantial overlap between the control and treatment categories. In the present context, confounding is also assumed to be minimal since we controlled for alternative, non-causal explanations for anticipated observations in the relationship between the dependent and independent variables.

7.7 Results and Discussion

The data indicated significant variations within the isolated categories for both Household dietary diversity score (HDDS) and Household food insecurity access score (HFIAS) (Table 7.1). These patterns are common as also reported by Musemwa and Zhou (2013) in a food access study in South Africa. Results show that, a significant proportion of households who did not intensify production of improved sorghum varieties had lower HDDS values, accounting for about 97% in the 1-2 and 3-4 ranges.

Table 7.1: Summary of HFIAS and HDDS categories

Indicator category	Proportion (%)		Difference-test
	Non-intensifiers	Intensifiers	
Household dietary diversity score (HDDS)			
1 to 2	97.30	2.70	11.258***
3 to 4	96.41	3.59	9.356***
5 to 6	22.97	77.03	-6.887***
Household food insecurity access score (HFIAS)			
0 to 5	33.0	67.0	-2.564**
6 to 10	70.6	29.4	5.328***
11 to 15	88.6	11.4	11.381***
16 to 20	88.6	11.4	11.381***
21 to 25	100	0.0	16.785***

Source: Generated by authors from sorghum survey data using STATA.
Notes: -***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively (for intensifiers versus non-intensifiers).

The reverse can be said for the HFIAS values where the non-intensifying households had high food insecurity as indicated by higher values compared to their intensifying counterparts. A summary of the variables in Table 7.2 shows that some variables are significantly different between improved sorghum varieties intensifiers and non-intensifiers. These variables will be subject to further analyses in the following sections.

Table 7.2: Description of variables included in the models and descriptive statistics

Variable	Description	Units	Sample mean	Intensive mean	Non-intensive mean
Outcome variables					
PRODUC	Yield from improved seed	kg/ha	902.73	944.344	691.17
NETRET	Net returns from improved seed	US$	307.45	329.328	196.25
HDDS	Household dietary diversity score	score	4.192	5.492	3.578
HFIAS	Household food insecurity access score	score	9.408	4.574	11.69
Treatment variable					
INTENS	Intensified production (yes=1)	dummy	0.82	0.68	0.48
Explanatory variables					
ARBLD	Total arable land for the household	hectare	4.3153	4.1869	4.375
LG_VAR	Logarithm of variable costs	number	3.457	2.387	3.170
AGE	Age of household head	years	44.721	45.713	44.252
DEPEN	Proportion of dependant members	percent	33.258	34.738	32.558
EDUC	Duration in schooling of household head	years	8.226	7.852	8.4031
DRAU	Number of effective draught animals	number	5.989	6.131	5.922
GEND	Gender of household head is male (yes=1)	dummy	0.718	0.615	0.767
FRMEX	Years experience in agricultural practices	years	15.487	15.311	15.569
SRGEX	Years experience in sorghum production	years	7.679	8.909	7.097
CROPDV	The total number of crops grown	number	3.161	3.615	2.946
INCOME	Real total income for the household	US$	353.02	356.76	351.252
INCMDV	Farm and off-farm income generating activities	number	2.647	2.893	2.531
AID	Value of sorghum aid received	US$	8.597	14.795	5.667
ASSOCI	Social groupings to which household members belonged	number	1.697	1.574	1.756
STORG	Farmer has adequate storage facilities (yes=1)	dummy	0.4955	0.5	0.492
PRICE	Average weighted price in markets	US$	35.703	40.139	33.605
BUYERS	Number of buyers with whom a farmer directly relates to	number	3.342	3.754	3.147
DISTAN	Time taken to get to main market	minutes	73.647	73.525	73.705
PYMNT	Time taken for payment to be made after a sale	days	11.297	11.639	11.136
Instrumental variables					
SOILFERT	Fertile soil (yes=1)	dummy	17.579	48.680	2.872

Source: Generated by authors from sorghum survey data using STATA.
Notes:***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively.

7.7.1 Estimating drivers of improved sorghum varieties intensification

The empirical analyses were done using STATA 13 statistical package. Table 7.3 shows results of the maximum likelihood regression with the selection equation and the equations for the two regimes as explained in earlier sections. The selection equation is shown in the first columns and results are explained as the normal probit model. We included the soil fertility gradient for the farmer fields (soil fertility) as a valid instrumental variable in the selection equation to assure identification (Ngeno, 2017; Baum, 2006; Lokshin *et al.,* 1977). The instrument is uncorrelated with all the four outcome variables (selected welfare indicators) and is also highly significant ($p<0.01$) in all selection models and hence we are confident that it is valid (Abdulai & Huffman, 2014). A strong co-relationship with the sorghum high yielding varieties intensification decision shows that farmers who have higher proportions of fertile land are more likely to intensify production of high yielding sorghum varieties since there is lesser competition for fertile land with other crops such as maize and soya bean.

Based on the selection criterion shown in the first column of Table 7.3, the most important factors affecting improved sorghum varieties intensification at the household level are associations and availability of draught power. Associations are hubs of information as alluded to by Mutenje *et al.* (2016); Bale *et al.* (2013) and Di Falco & Bulte (2013). This information exposes farmers to new sources of seed, appropriate production systems and viable markets thereby catalysing the intensification prospects. Reduction in risk of crop failure is also another benefit which emanates from networking in these associations. Availability of effective draught power assures timely land preparation which also plays an integral role in enhancing agricultural activities. In conservation agriculture studies by

Nyanga (2012) and Mazvimavi & Twomlow (2009), similar observations were made in small scale farming settings of Zambia and Zimbabwe respectively. In rural farming communities of southern Africa, draught power has also widely been used as a source of transport for inputs from markets and produce to the markets. This reduces the transport costs and hence increases the marketing margins accruing to the farmers (Matshe, 2009). As such, rationally farmers who have access to reliable draught power are more likely to intensify production of improved sorghum varieties in anticipation of increased productivity levels.

In farming systems, production costs are also directly related to the net benefits (Ortmann & King, 2007). The selection model shows that as the variable costs increase, the likelihood of improved sorghum varieties intensification is observed to decline. Farmers who experience higher variable costs tend not to prefer the intensification avenue and opt for other enterprises with lower costs. This is particularly so since variable costs will increase as the scale of production increases (Birachi *et al.,* 2013; Mujeyi, 2013). Additional increases in land allocated towards the improved sorghum varieties will also further pull with it the variable costs structure. If this sets in, then farmers will be sceptical that the condition will reduce their margins and as such adhere to the lower land allocation state.

Table 7.3: Maximum likelihood estimates of productivity and net returns

	Intensification equation	Yield/ha		Intensification equation	Net returns/ha	
		Intensifiers	*Non-intensifiers*		*Intensifiers*	*Non-intensifiers*
Variable	***Coefficient***	***Coefficient***	***Coefficient***	***Coefficient***	***Coefficient***	***Coefficient***
PRODUC	---	---	---	0.01*** (0.04)	0.35*** (0.02)	0.49*** (0.023)
LG_VAR	-1.40** (0.585)	433.5*** (132)	1105.1*** (419.6)	-2.08*** (0.68)	8.41 (27.319)	-177.9*** (56.5)
AGE	0.02 (0.012)	-0.67 (3.061)	19.93** (8.183)	-0.03 (0.013)	0.07 (0.617)	-2.49*** (0.998)
DEPEN	-0.01 (0.007)	-0.98 (2.001)	-7.13 (6.165)	-0.03 (0.008)	0.52 (0.405)	0.96 (0.779)
EDUC	-0.06 (0.046)	-4.49 (10.355)	-13.00 (33.920)	-0.05 (0.047)	2.12 (2.109)	-2.74 (3.683)
DRAU	0.13** (0.059)	4.27 (13.831)	-98.79 (75.057)	-0.12* (0.064)	-1.24 (2.656)	15.40* (9.325)
GEND	-0.41 (0.346)	104.1 (80.871)	-633.51 (259.664)	-0.64 (0.399)	7.49 (16.165)	113.1*** (36.7)
SRGEX	0.03 (0.023)	-9.93** (4.799)	120.46 (30.476)	0.03 (0.026)	0.17 (0.980)	-12.51*** (4.35)
AID	0.01 (0.008)	-2.28 (1.7101)	-1.38** (6.552)	0.03 (0.008)	-0.18 (0.351)	0.65 (0.754)
ASSOCI	0.24* (0.140)	65.92** (33.5)	450.69*** (128.2)	-0.42*** (0.16)	-12.46 (6.924)	-56.3***(20.33)
DISTAN	0.03 (0.004)	0.51 (0.549)	-3.52 (3.268)	0.01* (0.006)	0.246** (0.11)	1.12*** (0.367)
PYMNT	0.02 (0.019)	-1.12 (2.508)	23.56** (12.466)	-0.01 (0.020)	0.19 (0.509)	-3.31** (1.395)
SOILFERT	0.03*** (0.008)			0.04*** (0.01)		
CONSTANT	6.69** (2.750)	-742.01 (561.8)	-4018.7** (1733)	8.50*** (3.15)	-58.02 (112.76)	573.3** (237.5)
Log pseudo-likelihood	-1125.079			-869.321		
Wald test of independent equations	3.74**			4.63**		

Source: Generated by authors from sorghum survey data using STATA.

Notes: -***; ** and * show p-values significant at 1%, 5% and 10% levels respectively. z-values on robust standard errors in parenthesis.

Results for the two regime equations are shown in the second and third columns of Table 7.3. Managing the variable cost structure is a missing link among small scale farmers in southern Africa (Laico *et al.,* 2011). The study shows that, variable costs emerge as an extremely important consideration in both regimes for the yield per hectare cultivated. The same can be said for the productivity variable in relation to net returns per hectare cultivated. However, the yield effect is relatively higher (0.49) for non-intensifiers as it is for intensifiers (0.35). In the future, this might act as a disincentive for the present non-intensifiers to migrate into the intensification cluster as they will lose a net benefit in the process (Goodman & DuPuis, 2002). However, the variable cost structure shows that as the variable increases, then the net returns for the non-intensifiers decrease at a steeper rate relative to the yield gains. As such, assuming favourable output market prices, the net effect based decision from yield and variable cost will be for farmers to intensify production of high yielding sorghum varieties. This was also reported by Chepng *et al.* (2014) in a sorghum technical efficiency study in Kenya where there was a gain of 41% for those who intensified sorghum production.

The distance to the market is an important factor when farmers decide whether to use a market or not (Maina *et al.,* 2015; Osebeyo & Aye, 2014). The results show that, for the two regimes under net returns per hectare, the distance is an important parameter. As the distance to the market increases, the net returns also increases. Observations from the study area showed that, distant markets are the ones which offer higher prices. As such the observed model outcome is in tandem with observations. Literature also points towards trends in which local markets are not as lucrative as external markets (Giuliani *et al.,* 2005; Loureiro & Hine, 2002). In a study by Torero (2011), it was however reported that, the net effect of distant markets cannot be offset by the higher prices in the market and as such, farmers closer to the

market have higher margins. The payment time is an important consideration for non-intensifiers in both the productivity and net returns clusters. However the direction of effect is different, it is positive in the former and negative in the latter. The variable is however insignificant in the intensifiers' decisions. This can be attributed to the outcome that payment time is not significantly variable among respondents in this cluster. Makhura, Kirsten, & Delgado (2004) postulate that, one of the most immediate concern of farmers is when the payment will be made after settling a transaction. Ndoro *et al.* (2015) also allude to this notion and suggest that farmers prefer instant payments in selected markets so as to reduce additional transaction costs imposed by the need to follow up on the payment. However, Pye-Smith (2013), is of the opinion that, in some instances, delayed payment can be a source of savings for the farmers who can use the money when paid at a later date for other mid to long term needs. Table 7.4 shows the results for the food security indicators.

Table 7.4: Maximum likelihood estimates of HDDS and HFIAS

	Intensification equation	HDSS		Intensification equation	HFIAS	
Variable	***Coefficient***	***Intensifiers Coefficient***	***Non-intensifiers Coefficient***	***Coefficient***	***Intensifier Coefficient***	***Non-intensifier Coefficient***
AGE	0.02* (0.010)	0.003 (0.004)	0.003 (0.004)	0.015 (0.01)	-0.06* (0.035)	0.01 (0.024)
DEPEN	0.04 (0.007)	0.05 (0.0028)	0.003 (0.003)	0.028 (0.007)	-0.02 (0.023)	-0.03* (0.018)
EDUC	-0.03 (0.038)	-0.005 (0.014)	0.01 (0.016)	-0.026 (0.039)	-0.05 (0.118)	0.067 (0.089)
DRAU	-0.05 (0.042)	0.005 (0.018)	0.009 (0.018)	-0.04 (0.043)	0.09 (0.145)	-0.07 (0.097)
GEND	-0.34 (0.264)	-0.18* (0.108)	0.013 (0.131)	-0.29 (0.269)	-0.31 (0.877)	-0.39 (0.724)
FRMEX	-0.02 (0.021)	0.004 (0.009)	-0.006 (0.007)	-0.021 (0.0219)	0.12* (0.074)	-0.021 (0.039)
SRGEX	0.02 (0.024)	0.011 (0.010)	-0.096 (0.009)	0.028 (0.025)	-0.04 (0.083)	0.11** (0.051)
CROPDV	0.01 (0.092)	0.19*** (0.035)	0.24*** (0.037)	-0.017 (0.087)	-1.88*** (0.3)	-1.57*** (0.2)
INCOME	0.36*** (0.118)	0.004 (0.045)	0.09* (0.056)	0.37*** (0.122)	-0.88** (0.37)	0.14 (0.308)
INCMDIV	0.01* (0.074)	0.003 (0.002)	0.01** (0.003)	0.01* (0.008)	-0.03* (0.002)	0.004 (0.002)
AID	0.02*** (0.007)	0.003 (0.002)	0.07** (0.003)	0.04** (0.071)	-0.01 (0.020)	0.027 (0.019)
ASSOCI	-0.16 (0.114)	0.04 (0.049)	0.03 (0.049)	-0.164 (0.115)	-0.16 (0.401)	-0.042 (0.268)
STORG	-0.85*** (0.31)	-0.025 (0.115)	0.183 (0.112)	-0.83*** (0.315)	-0.52 (0.938)	0.461 (0.619)
PRICE	0.03** (0.013)	0.006 (0.006)	-0.002 (0.005)	0.04*** (0.014)	-0.05 (0.051)	0.044 (0.0273)
BUYERS	0.06 (0.055)	0.028 (0.020)	-0.04* (0.023)	0.074 (0.057)	-0.29* (0.159)	-0.07 (0.124)
DISTAN	0.02 (0 .002)	0.001 (0.008)	-0.01 (0.083)	0.002 (0.002)	-0.05 (0.007)	-0.004 (0.005)
PYMNT	-0.04 (0.008)	-0.003 (0.004)	-0.06* (0.003)	-0.003 (0.008)	-0.03 (0.0294)	0.006 (0.017)
SOILFERT	0.07*** (0.008)			0.08*** (0.008)		
CONSTANT	-4.83*** (1.27)	4.29*** (0 .568)	2.65*** (0 .469)	-5.33*** (1.376)	22.2*** (4.45)	15.6*** (2.58)
Log pseudo-likelihood	-482.862			-1179.192		
Wald test of independent equations	9.06***			6.20***		

Source: Generated by authors from sorghum survey data using STATA.
Notes: -***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively. z-values on robust standard errors are in parenthesis.

The critical factors influencing the improved sorghum varieties intensification decision are the age of principal decision makers, household income and its diversity, availability of storage facilities and the observed weighted average market prices. As the age of the principal decision makers increases, the likelihood of improved sorghum varieties intensification also increases. Older farmers have also experienced both options of retained seed and high yielding varieties and they have the knowledge of how the latter performs relative to the former. Younger farmers on the other hand have been reported to view investing in high yielding sorghum varieties as an unnecessary cost (Mafuru, Norman, & Langemeier, 2007). This can be attributed to the inclination of the young decision makers towards enhancing activities which they view as profitable (Ragasa, 2012). Post the initial production stage, the older farmers then opt for intensification so as to harness the benefits from the innovation.

Grain storage by small scale producers has been a persistent major challenge discouraging the uptake of innovations (Laico *et al.,* 2011; Rukuni *et al.,* 2006). There is consensus that, the availability of storage facilities also guarantees reduced post-harvest loses and as such incentivise intensification (Pinckney, 1993). Membership to associations has been discussed above. Market prices have a positive and significant bearing on the benefits accruing to the farmer. Higher market prices have been reported as catalysts for market participation which can be one major reason why farmers decide to intensify (Hill & Vigneri, 2011; Moussa, 2011; Cirera & Arndt, 2008; Jayne & Rubey, 1993). However, from a study done by Kerr (2014), in Malawi, there is evidence that, the price can be overtaken by dimensions related to the indigenous knowledge beliefs and attitudes as important factors which can affect the intensification decision.

Most farmers in small scale farming zones of southern Africa have migrated for monoculture systems to more diversified practices (Hosu & Mushunje, 2013). From the two regime equations presented in the second and third columns of Table 7.4, it can be concluded that, crop diversity has a significant impact on both HDDS and HFIAS. The ability of households to produce multiple crops can act as a cushion for food diversity and availability (Labeyrie *et al.,* 2014; Mutenje *et al.,* 2010). This multiple basket can guarantee food security even in extreme cases where one crop fails especially since the risks such as low rainfall and extreme temperatures are common in arid and semi-arid zones of Zimbabwe. However, Hill & Vigneri (2011) differ and argue that the crop diversity decisions can be stalled by market supply responses governed more by gender dynamics. This, they say, can then influence the diversification decision more than the need for food security.

Notable differences are observed with a number of coefficients between the two regimes of intensification and non-intensification. This is an indication that the switching methodology is a more appropriate approach than lumping the output in one regression model (Abdulai & Huffman, 2014). The gender dimension can have a bearing on the diversity of the food consumed in a household (Mutenje *et al.,* 2016). The sex of household head has a significant bearing on the HDDS for intensifiers but insignificant for non-intensifiers. Household headed by females tend to have higher dietary diversity. This can be attributed to the ability of females to source various foods including indigenous vegetables and fruits for the family (Lo *et al.,* 2012). With HDDS, other differences are with income and its diversity, value of aid, number of buyers in market and payment time. Farmers with a number of income sources are reported to have chances of having a diverse basket of food (Mabuza *et al.,* 2016). Higher incomes and income diversity increase the HDDS for non-intensifiers while the impact on the

intensifying counterparts is insignificant. The study findings attribute this to limited variability in both variables for the intensifying farmers. Mabuza *et al.* (2016) also reported a similar pattern in Swaziland where they reported that farmers who depend on off-farm income sources were more likely to be food secure than their counterparts who depend on on-farm income.

Farmers in the small scale production areas have limited capacity to relate to a large number of buyers especially when the demands and expectations of the buyers are not the same (Nyanga, 2012). As the number of buyers with whom the farmer interacts in markets increases, for non-intensifiers, the HDDS decreases. This can be explained by the fact that these farmers will spread their bargaining power. With reduced bargaining capacity, the benefits from sorghum production are diluted leading to a low basket of the consumed goods. However, Mango *et al.* (2014) differs and postulate that, having access to more buyers in the market open up opportunities for farmers to have a more stable network from which they can ultimately relate and earn from sales.

Access to aid by small scale farmers in developing countries is still critical in enhancing productivity (Ricker-Gilbert *et al.,* 2011). The aid value also has a positive and significant effect on the HDDS for non-intensifiers. Aid in the study area takes different forms including seeds and fertilisers. On one hand this capacitates farmers into production hence increasing their food diversity. On the other hand, we observed that in some cases farmers sell the items received as aid to get income hence the increase in HDDS. Aid diversion is a common practice because there is no comprehensive monitoring and evaluation systems linked to the aid provided to the farmers (Baquedano *et al.,* 2010).

For HFIAS, differences are reported with age of principal decision maker, dependency ratio, household income and income diversity, number of buyers in the market and experience. Interestingly, income diversity is negative and significant with intensifiers. This is logical because as the income diversity increases, the HFIAS decreases. As reported by Mango *et al.* (2014), lower values are favourable as they indicate higher food security.

7.7.2 Economic impacts of sorghum improved varieties intensification

Table 7.5 shows the real mean costs and returns for intensifiers versus non-intensifiers. This is a simple picture of the absolute differences in the selected indicators. There is evidence from the data that, intensifiers had significantly higher productivity ($p<0.05$), market prices, gross margins and net returns per hectare ($p<0.01$) but they however had significantly lower variable costs per hectare of sorghum produced ($p<0.05$) (Table 7.5).

Table 7.5: Absolute economic benefits of sorghum improved varieties intensification

Economic indicator	Intensifiers	Non-intensifiers	Average treatment effect
	(1)	(2)	(3) = (1) – (2)
1. Productivity (kg/ha)	944.344 (42.562)	691.167 (116.419)	253.178**(108.859)
2. Price (US$)	40.139 (0.829)	33.605 (0.795)	6.53469*** (1.289)
2. Gross value (US$/ha)	377.992 (17.949)	254.208 (50.627)	123.78*** (46.224)
3. Variable costs (US$/ha)	48.623 (1.675)	58 (4.025)	9.377** (4.175)
4. Net returns (US$/ha)	329.328 (17.218)	196.250 (50.547)	133.08*** (44.764)

Notes: -Generated by authors from sorghum survey data using STATA.
-Absolute value of the z-statistic is placed in parenthesis.
-***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively.

Similar results were also reported by Mango *et al.* (2014) in Mudzi District of Zimbabwe. However, Lo *et al.* (2012) noted higher expenditures and food security among the elderly in

Taiwan. The variations in the outcomes can be attributed to the inherent differences in the contexts within which the studies were conducted, with Taiwan being a relatively higher income country compared to Zimbabwe. The comparison in Table 7.5 might be misleading at face value since it does not accommodate the counterfactual condition. This approach assumes that improved sorghum varieties intensification is determined exogenously but in practice it can be a potential endogenous variable. Abdulai & Huffman (2014) also reported this possibility in an adoption of conservation strategies study. Unobservable characteristics of the sampled households could be the cause for the observed differences. For example the observed differences in the indicators in Table 7.5 might be a case where a more skilled farmer could have generated higher net returns per hectare without necessarily intensifying production of improved sorghum varieties. Results of the counterfactual analyses are shown in Table 7.6.

Table 7.6: Counterfactual impact analysis using nearest neighbour method

Welfare indicator	Actual (household intensify)	Counterfactual (if household did not intensify)	Average treatment effect
	(1)	(2)	(3) = (1) – (2)
1. Productivity (kg/ha)	944.34 (42.6)	700.75 (11.56)	243.6**124.0)
2. Net returns (US$/ha)	329.33 (17.22)	229.44 (5.14)	99.89* (55.49)
3. HFIAS	4.57 (0.50)	11.53 (0.07)	6.96*** (0.69)
4. HDDS	5.49 (0.06)	3.63 (0.01)	1.86*** (0.13)

Notes: -Generated by authors from sorghum survey data using STATA.
-Absolute value of the z-statistic is placed in parenthesis.
-***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively.

There is statistical evidence that households who intensify sorghum production have significantly higher productivity ($p<0.05$) and net returns per hectare ($p<0.1$). The same observation was made for the food security indicators of HDDS and HFIAS ($p<0.01$). In a study conducted by Diiro (2013), similar obseravtions were made for adopters of conservation practices as opposed to their non-adopter counterparts. In a rice intensification study conducted by Faltermeier *et al.* (2009) in Ghana, similar patterns were also reported where intensive rice farmers were better off. Josephson *et al.* (2014) however reported that it is population density in farming communities which directly determine the intensification and associated productivity gains. A maize study on incomes and yields conducted by Manda *et al.* (2015) pointed towards the need to adopt more sustainable practices to grease the benefits from intensification. The study uses endogenous switching regression to account for potential unobserved heterogeneities in the data. Results are presented in Table 7.7.

Table 7.7: Multinomial endogenous treatment effect of intensification on welfare

Seed variety choice	Exogenous				Endogenous			
	(1) *Productivity (kg/ha)*	(2) *Net returns (US$/ha)*	(3) *HFIAS*	(4) *HDDS*	(5) *Productivity (kg/ha)*	(6) *Net returns (US$/ha)*	(7) *HFIAS*	(8) *HDDS*
M_1S_0	0.193***	0.142***	-0.168**	0.215***	0.283***	0.324***	-0.292**	0.349***
	(0.021)	(0.017)	(0.077)	(0.136)	(0.111)	(0.031)	(0.082)	(0.065)
M_0S_1	0.242**	0.229***	-0.119**	0.328**	0.247*	0.318***	-0.335**	0.353***
	(0.131)	(0.108)	(0.028)	(0.213)	(0.032)	(0.058)	(0.041)	(0.052)
M_1S_1	0.216**	0.159**	-0.144**	0.267***	0.261***	0.306***	-0.304**	0.345***
	(0.013)	(0.017)	(0.042)	(0.166)	(0.139)	(0.020)	(0.106)	(0.023)
Selection terms								
λ_{M1S0}					0.152***	0.171*	-0.137*	0.194**
					(0.113)	(0.062)	(0.055)	(0.039)
λ_{M0S1}					0.215***	0.184*	-0.159*	0.223***
					(0.131)	(0.096)	(0.073)	(0.050)
λ_{M1S1}					0.189***	0.193**	-0.118**	0.174*
					(0.106)	(0.096)	(0.010)	(0.009)

Source: Generated by authors from sorghum survey data using STATA.
Notes: -Standard errors in parenthesis.
-***; ** and * indicate p-values significant at 1%, 5% and 10% levels respectively.

Multinomial endogenous treatment effect results on impacts of intensification of improved sorghum varieties using various indicators of welfare are shown in Table 7.7. The study focus is placed on the endogenous results since they account for the factors which are not observed (Abdulai & Huffman, 2014). Results from columns (5) to (8) in Table 7.7 show that intensification of improved sorghum varieties can increase productivity, net returns and dietary diversity by 25-28%, about 32% and about 35% respectively while reducing food insecurity by 29-34%. The study findings build on work by Sarris & Morrison (2010) who observed that market conditions have a bearing on food security. As such, in the present case, farmers who source high yielding varities from various markets have stable welfare status. Silvestri *et al.* (2015) is also of the opinion that households which take up innovative strategies are more food secure. The study adds new knowledge and goes on to report that, however, the highest benefits overall are observed with intensification of Macia only (M_1) with Silla also having notable benefits especially with food security and diversity. Mafuru, Norman, & Langemeier (2007) report that, it therefore remains important to support the sorghum systems which advocates for production and scaling out of improved varieties to small scale farmers.

7.8 Conclusions and implications for policy

Based on results from an endogenous switching regression model, there is evidence that a number of factors affect the welfare of households through the selected indicators. The important variables include associations, market prices and household specific variables of household income, age of principal decision maker, dependency ratio, ownership of draught power and storage facilities. From the counterfactual analysis, it can also be reported that farmers who decide to allocate more land towards improved sorghum varieties are relatively

better off in terms of food diversity and access, productivity and net returns from the enterprise. Given these observations, there is need for policy which fosters development of locally driven cooperatives which accommodate diverse households. These platforms should catalyse the generation and dissemination of information regarding production and marketing of sorghum and other related income sources.

This starting point should be followed by infrastructural development initiatives such as seed banks and storage facilities which unlock the avenues for smallholder farmers in arid marginalised zones to interact efficiently and effectively with link-agents and consumers. Additionally, human capital development options need to be opened up so that the farmers are able to effectively access and interpret information on the right seed varieties in the contexts as well as the sources of affordable seed. Farmer groups can be developed within the cooperative model so that adult education oriented training programmes which capacitate farmers are designed and scaled up and out. Youth empowerment initiatives need to be realigned with the potentials of migrating towards market driven sorghum systems. Overall, reducing transaction costs of doing business can help increase the productivity, net returns and food security status for the households. Since the study area is arid, experiencing low rainfall, high temperatures and limited livelihood options, sorghum intensification can offer a gateway out of food and income insecurity. The government needs to facilitate partnerships of farmers with the private sector players along the sorghum value chain so as to grease the relationships among these strategic stakeholders. For example, farmers need to access highly rewarding markets if the benefits from intensification are to be enjoyed.

CHAPTER 8

GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

This Chapter discusses the overall findings on sorghum production, land allocation towards the crop, market participation, marketing channel choice and welfare impacts associated with production of improved sorghum varieties. This is important in unlocking the potential of sorghum value chain through a lens which interrogates its adequacy to sustain viable investments as interpreted from the currently untapped realities in the semi-arid environment of Zimbabwe.

8.1 General Discussion

Sorghum is important in the livelihood strategies of farmers especially in the arid and semi-arid areas of Zimbabwe (Mukarumbwa & Mushunje, 2010). The sorghum value chain is however compromised by limited participation of farmers and other stakeholders alike on the platform. To help in the design of sustainable strategies towards enhancing efficiency of the sorghum value chain, it is important to understand the key pillars including production, marketing and processing. Improvement of farmer participation in sorghum production and the associated land allocation towards the crop in the arid areas is a critical ingredient into unlocking the value chain's potential (Tefera, Dahlberg, & Smale, 2012). Participation of small scale farmers in markets is fundamental for increasing incomes and networking with other stakeholders including traders and brokers. In order to formulate feasible approaches for improving market participation and appropriate market selection, it is essential to know the major drivers of these two decisions.

It therefore means that it becomes inevitable to also examine the welfare impacts of sorghum production at various scales in terms of land allocation towards high yielding varieties

(Guimberteau, Traore, & Baron, 2013; Taylor, 2003). The broad objective of the study was to examine the determinants of sorghum production, factors which are important in determining market participation and market choice and the welfare impact of producing high yielding sorghum varieties in terms of productivity, food security and income gains. This was achieved through a cross sectional survey conducted with 380 small scale farmers in 2016 in the mid-Zambezi Valley of Zimbabwe.

To consolidate the sorghum value chain, it is inevitable to conduct a comprehensive value chain mapping procedure. Chapter 4 presents the findings from a participatory analysis of the value chain aimed at tracing the movement of products and services across stakeholders and the associated margins at each node. The analysis confirms that, based on the evidence from the value chain map, there are challenges with inputs such as accessing high yielding sorghum varieties and marketing options for farmers (Kerr, 2014) which confirms the reports in Chapters 5 and 6. For example in Chapter 5 farmers identified access to subsidies as one important determinant to the sorghum production decision. This could be a reflection of the weak seed and fertiliser systems as reported during FGDs and key informant interviews in Chapter 4 and the low use of high yielding sorghum varieties as reported in Chapter 7.

The study confirms the need for strengthening the seed value chain made by Hamukwala *et al.* (2010) but contradicts the findings of Rukuni *et al.* (2006) who insist that sorghum production must remain a low cost crop to the extent of not using fertilisers. Building of existing evidence by Asogwa, State, & Okwoche (2012), there are only 3 functional marketing channel options at the disposals of the farmers as reported in Chapter 6. This is also confirmed in Chapter 4 where farmers for example do not have direct linkages with processing companies thereby reducing the number of marketing channels which they are

currently tapping into. The study therefore contributes and presents a comprehensive picture of the currently untapped marketing linkages which farmers can take advantage of. For these farmers, there are a number of marketing channel options which they can still possibly tap into if forward and backward linkages are established (Chapter 4) through a robust network and functional capacity building programme (Lundy, 2012; Lundy *et al.,* 2007).

There is evidence in literature that, the decision to produce sorghum and how much land to allocate towards the crop varies across regions, cultures and socio-economic status of households (Smale *et al.,* 2018). In Chapter 5, the determinants of sorghum production and land allocation towards the crop were assessed. In line with the hypothesis, there is evidence that networks (the frequency of contact with relatives and number of groups to which household members belonged) and subsidies (duration of receiving subsidies) had a significant influence on the sorghum production decision by the farmer. Hamukwala *et al.* (2010) reported similar findings but within the sorghum seed value chain. These results contributes a clearer understanding of how various dimensions including subsidy sources and information from local networks can help increase the number of sorghum producers. Interestingly, a different set of variables influenced the land allocation decision.

This does not fit with the theory that once a farmer decides to produce a crop, then similar determinants will affect the decision to allocate more land towards the crop (Mason, 2010). Market related variables (market frequency and the number of buyers in the market) and infrastructure (availability of storage facilities) were important for the land allocation decision. Farmers however reported that information flow from networks and conditions of market platforms remain important variables in the two decisions and as such the need to focus on strengthening communication hubs. These results should therefore be taken into

account when designing networking platforms for the commercialisation agenda as alluded to by Rohrbach & Kiriwaggulu (2007). To trace the next pillar of the value chain, it was important to fully understand the marketing decisions made by sorghum farmers.

To achieve this, the determinants of market participation and market selection decision making were determined in Chapter 6. At first sight, the marketing of sorghum can be viewed as not being a problem since almost all farmers but about 4% market their sorghum through one of the three available channels. This challenges the observations by Poonyth *et al.* (2006) who reproted that few farmers were involved in marketing of sorghum grain in South Africa. This study therefore presents new insights into understanding the relationship between various factors and the market participation and marketing channel choices with sorghum. In line with the hypothesised associations, a number of factors including the time between a transaction and payment, number of buyers in the market and the distance to the market affect the market participation decision. These results build on existing evidence by Makindara *et al.* (2013) which show that these issues imply that on one hand the farmer is exposed to high transaction costs and on the other hand, they experience delays in payments. This mismatch plays to the disadvantage of the farmer.

As such it becomes imperative for the farmer not only to market their produce but to do so in the appropriate market where they will extract value. These observations also concur with Kerr (2014) and what is presented in Chapter 5 where farmers reported that the number of buyers is an important factor when deciding to produce sorghum since farmers will be concerned with where they will sell their produce. To reduce the transaction costs alluded to above, farmers mainly participate in the local market. These results concur with findings by Escobal *et al.* (2015) who reported that strengthening local market networks is a source of

wealth for farmers. Market variables including the weighted average market price of sorghum, number of buyers in the market and distance to the market determined which specific marketing channel a farmer would use. While previous research has focused on the number of buyers in the market *per se*, these results demonstrate that the number of buyers who directly interact with the farmer is a more refined indicator of market considerations. This dimension greatly adds to the body of knowledge in terms of marketing dynamics.

A major concern of Chapter 6 was to understand the drivers of market participation and marketing channel preference. Use of the local market as the dominant market would mean that farmers get low incomes from their efforts. It therefore becomes imperative to examine the welfare impacts of sorghum production with particular attention to high yielding varieties.

In Chapter 7, productivity, food security and income gains were used as proxies for welfare. As per *aprior* expectations, there is evidence from the data which suggests that, generally, farmers who produce high yielding sorghum varieties and decide to allocate more land towards the crop are relatively better off across all the indicators of welfare. Stakeholders must take this into account when they make decisions on how to support small scale sorghum producers. Mafuru, Norman, & Langemeier (2007) also noted similar patterns but in different contexts in Tanzania where support structures for sorghum producers already exist. This evidence will be important especially for farmers in Chapter 5 who are currently producing sorghum but at a small scale since it informs them on the benefits of increasing land towards the crop for welfare gains. Since farmers who allocate more land towards improved sorghum varieties are also better off in terms of productivity, there is scope for evidence in Chapter 6 to be used to the farmers' benefit since when they produce more sorghum per unit land, they

may be able to sell more in rewarding markets to gain income and further improve their welfare status.

These findings directly feed into earlier work by Hamukwala *et al.* (2010) and Laico *et al.* (2011) in that it further exposes the welfare impact analyses to the counterfactual dimension. As suggested by Aduguna (2007), if small scale farmers decide to produce sorghum and allocate more land towards the crop (Chapter 5), they can produce more and sell in rewarding marketing channels (Chapter 6) as suggested by Rohrbach and Kiriwaggulu (2007), improve their welfare in terms of food security and income (Chapter 7) by adopting and intensifying production of high yielding varieties (Mafuru, Norman, & Langemeier, 2007).

8.2 Conclusions

The findings from mapping done in this study show that sorghum practices are stalled by limited number of stakeholders willing to produce and utilise the crop in their businesses and unfavourable market prices at all the value chain nodes. The study concludes that most markets are centralised in the urban areas and this does not create opportunities for farmers to bargain for better prices and link directly with the markets. The sorghum market size as proxied by marketing channels and number of players is still limited with few farmers, buyers and processors participating in a low value and unbeneficial platform. Contrary to the hypothesis, the study concludes that stakeholders do not have binding backward and forward linkages among themselves. The study concludes that the various aid dimensions including source, value and number of beneficiaries are emerging as important factors in influencing sorghum production and intensity of production among small scale sorghum farmers. This shows a shift from the traditional viewpoint that the price is the key factor in influencing production of agricultural commodities.

There is evidence that networking among relatives and in production groups is an important ingredient to the production and intensity of production decisions. During key informant interviews and FGDs, non-sorghum producing farmers also cited constraints related to information access, inputs and markets. The data suggests that, farmers make production and intensity of production decisions as guided by aid, networks and market related conditions. However, the dimensions of these factors do not have the same effects on the production and intensity of production as is widely reported in literature. The distance to the market, payment time and the number of buyers with whom a farmer interacts are critical determinants in both the marketing and marketing channel selection decision. During FGDs, it was reported that, in the Zimbabwean context, the payment time becomes important given the inflationary conditions which deplete the purchasing power of money over time. The study concludes that, household specific, institutional and market factors are important in determining the marketing and marketing channel choices by sorghum farmers in the study area.

An emerging and not well explored variable is the number of buyers with whom the farmer interacts which is reported in the study as an important factor in the two decisions. In line with the hypothesis, there is evidence from the data that the farmers who adopted and allocated more land towards improved sorghum varieties had higher income, productivity and food security status. It can also then be concluded that given the aforementioned factors and benefits, there is scope to enhance efficiency of the sorghum value chain so that farmers will allocate more land towards the crop, take up improved and high yielding varieties, increase their productivity, participate in rewarding markets to boost food security and gain income. This implies reducing food and income insecurity in these marginalised communities

of Zimbabwe while at the same time opening up avenues for commercialisation of sorghum and development of the sorghum value chain.

8.3 Recommendations

It can be recommended that, in order to break the fundamental barrier of access to production factors and information, there is need to develop support strategies which do not only provide short-term benefits such as explicit subsidies, but instead capacitate the farmers in the long run with technical and functional competencies in production and marketing. Responsive and flexible contractual arrangements for production and marketing cooperatives need to be designed to encourage farmers' participation in sorghum production and allocation of more land towards the crop while at the same time reducing the risks associated with this mode of support. Contracts offered to farmers should accept the endogenous and exogenous drivers which vary across locations. The contracts therefore need to be designed accordingly rather than the current scenario where universal contracts are offered to farmers.

This should offer multiple interfaces and options thereby increasing participation by other stakeholders along various nodes. The empirical evidence suggests that information is critical in agricultural production decisions. As such, the study recommends that there is need to strengthen local networks within the communities cascading to other extension agents such as lead farmers. This enables the smooth and balanced flow of appropriate information among stakeholders there by encouraging sorghum production, marketing, processing and consumption. It therefore becomes imperative to restructure policies towards spearheading the sorghum agenda by re-training extension agents for the multiplier effect to spill over to increased allocation of land towards the crop among farmers.

The study findings point towards the importance of payment methods in the market participation decision by farmers. Reducing the waiting time before a payment sails through will increase the proclivity for market participation by farmers. Policies which target the establishment of organisations such as financial institutions which offer support for sorghum marketing need to be put in place. These can absorb the payment time lag by providing marketing credit lines to traders. On the other hand, forming collective marketing groups at the local level increases farmers' price bargaining power in highly rewarding markets. This will also naturally reduce the market price related risks which are currently common in Zimbabwean small scale farming systems. These efforts should increase market participation, open up new marketing avenues and create competition in sorghum markets benefiting all the stakeholders in the process.

There is evidence that, distance to the markets is another concern for farmers who incur high transaction costs. Policies which encourage and support market decentralization through public-private collaboration in developing rural distribution networks from prime production zones to processing and consumption hubs can help to restructure sorghum marketing. This should incentivise participation of farmers in more rewarding external marketing channels due to reduced transaction costs. These partnerships can also be critical in promoting value addition activities such as infrastructure development and investment in processing equipment thereby increasing the market size.

Empirical evidence from the welfare analyses show the importance of reducing transaction costs of doing business as a driver of increasing the productivity, food security status and net returns for the surveyed households. Policies and interventions which support the production of high yielding sorghum varieties on high proportions of arable land can offer a gateway out

of food and income insecurity among households while at the same time increasing the surplus for the markets. The government needs to consider facilitating partnerships of farmers with the private sector players along the sorghum value chain so as to grease the relationships among these strategic stakeholders. Additionally property rights need to be reinforced so as to encourage investment by stakeholders especially when there are reported benefits as is in the present study.

Access to information is noted as being critical in the efficiency of the sorghum value chain. Policies which create a breeding ground for multiple extension networking modes which provide timely and updated information on conditions in factor and product markets, especially the costs and net benefits associated with each transaction and marketing channel need to be supported. Sorghum value chain stakeholders need to re-orient and coordinate extension modes geared towards effective and affordable information generation and dissemination avenues so that they become responsive to the dynamic states of interactions on the market platforms. Input access is another challenge faced by farmers and the starting point can be the development of infrastructural initiatives such as seed banks and storage facilities which unlock the avenues for accessing inputs at the right time of the season.

Additionally, human capital development options need to be opened up so that the farmers are able to effectively access and interpret market information. Farmer groups can be developed within the cooperative model so that adult education oriented training programmes which capacitate farmers are designed and scaled up and out. Youth empowerment initiatives also need to be realigned with the potentials of migrating towards market driven sorghum production and marketing systems. Processors also need to be supported by for example, a tax holiday policy so as to encourage them to invest in the sorghum value chain activities

coupled with import/export incentives. This will enhance chances of developing an otherwise commercially viable sorghum value chain in the mid-Zambezi Valley of Zimbabwe.

8.4 Suggestions for future research

Due the lack of available panel data because the crop has been greatly side-lined from mainstream research, the study used the available cross sectional data to ascertain the welfare effects of enhanced allocation of land towards sorghum by small scale farmers . A more holistic analysis would have required the use of panel data which acknowledges and controls for the heterogeneity of households. This is a task that cross sectional data cannot achieve without introducing some level of biases. Studying the welfare phenomenon with panel data will also bring out the temporal dimension into the study i.e. answering the question of whether the currently observed positives in the present study along the sorghum value chain nodes persist over periods of time.

The generalisability of the results is limited by non-replication to other similar semi-arid conditions in Zimbabwe. The study focused on one dominant sorghum producing zone of Zimbabwe where there is current work on developing strategic value chains. In as much as these results provide great insights into the sorghum value chain practices and issues, expanding this to other production zones will benefit decision makers to get a more comprehensive state of the sorghum value chain in Zimbabwe.

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APPENDICES

Appendix I: Household level survey questionnaire for small scale sorghum farmers

Introductory Statement

Good day. I am carrying out a study on **"Economic analysis of the sorghum value chain in the mid-Zambezi Valley of Zimbabwe".** I am conducting this survey to study and share your experiences on sorghum production and marketing in this village. Any information gathered from this interview will be securely stored and not be used for any other purposes except for this research. Your identity and the responses you provide will also be treated with confidentiality. Taking part in this study is voluntary the decision not to participate has no consequences. The questions herein are intended for the household head or his/her representative. Other household members may be requested to assist during the process of the discussion upon their free consent. Your cooperation will be greatly appreciated. Thank you.

SECTION ONE: VILLAGE AND RESPONDENT IDENTIFICATION INFORMATION

1.1. Basic identification characteristics					
1.	Name of Enumerator		2.	Date of Interview (dd/mm/yyyy)	
3.	Name of Ward		4.	Name of Village	
GIS readings of homestead					
5.	Waypoint ID		6.	Latitude (South)	
7.	Longitude		8.	Altitude (meter above sea level)	
9.	Household ID		10.	Is respondent the household head? **(Code A)**	
11.	Status of respondent in the household? **(Code B)**				
12.	Gender of respondent? **(Code C)**		13.	Marital status of respondent? **(Code D)**	

14.	Is respondent the principal decision maker in household? **(Code A)**		15.	Who is the principal decision maker in household? **(Code B)**	
16.	Respondent's experience in crop farming? **(years)**		17.	Respondent's experience in growing sorghum? **(years)**	
18.	Respondent's attitude towards farming? **(Code E)**		19.	Respondent's attitude towards sorghum? **(Code E)**	
20.	Respondent's position in village? **(Code F)**		21.	Availability of household head in homestead in the last 12 months? **(Code G)**	

Code A	**Code B**	**Code C**	**Code D**	**Code E**	**Code F**	**Code G**
1=Yes ; 0=No	1=Spouse; 2=Child; 3=Inlaw; 4=Employee; 5=Other relative (please specify); 6=Other non-relative (please specify)	1=Male; 2=Female	1=Married living with spouse/s; 2=Married but spouse away; 3=Divorced/separated; 4=Widow/widower; 5=Never married; 6=Other (please specify)	1=Positive; 2=Neutral; 3=Negative	1=None; 2=Village head; 3=Committee member (any); 4=Multiple positions	1=Never; 2=Rarely; 3=Frequently; 4=Always

1.2. Household composition and characteristics

1.	Name **(start with household head)**?	Gender **(Code A)**	Age **(state years)**	Education **(years)**	Marital status **(Code B)**	Main occupation **(Code C)**	Involved in off farm activities? **(Code D)**	Own farm labour contribution ? **(Code E)**
M1								
M2								
M3								
2.	Did you experience mortality of household head/spouse during the last year? **(Code F)**							
3.	Did you experience mortality of member during the last year? **(Code F)**							

Code A	**Code B**	**Code E**	**Code F**
1=Male; 2=Female	1=Married living with spouse/s; 2=Married but spouse away; 3=Divorced/separated; 4=Widow/widower; 5=Never married; 6=Other (please specify)	1=Farming (crop + livestock); 2=Salaried employment; 3=Self-employed off-farm; 4=Casual labourer on-farm; 5=Casual labourer off-farm; 6=School/college child; 7=Non-school child; 8=Herding; 9=Household chores; 10=Other (please specify)	1=Yes ; 0=No

SECTION TWO: SOCIAL CAPITAL, NETWORKING, ACCESS TO INSTITUTIONS AND SERVICES

2.1. Household proximity to institutions and markets		Average walking time **(minutes)**	Estimated distance **(km)**	Frequency of using […] in the last 12 months	Are the markets/sources/roads reliable? **(Code A)**
1.	How far is the village market from your homestead?				
2.	Transport means frequently used to get to the village market?				
3.	How far is the nearest main market from your homestead?				
4.	Transport means frequently used to get to the main market? **(Codes B)**				
5.	Number of months the road to main market is passable for				
6.	Quality of road to the main market. **(Codes C)**				
7.	Nearest seed source from your homestead?				
8.	Nearest fertilizer source from your homestead?				
9.	Nearest herbicides/pesticides source from your homestead?				
10.	Nearest farmer cooperative from your homestead?				
11.	Nearest Agritex office from your homestead?				
12.	Nearest lead farmer from your homestead?				
13.	Nearest National Parks office from your homestead?				

Code A	**Code B**	**Code C**
1=Very reliable; 2=Reliable; 3=Average; 4=Unreliable; 5=Very unreliable	1=Walking; 2=Bicycle; 3=Tractor; 4=Vehicle; 5=Cart; 6=Other (please specify)	1=Very poor; 2=Poor; 3=Average; 4=Good; 5=Very good

2.2. Social capital (state membership of husband, wife or child in formal and/or informal institutions in the last **3** years. separate multiple responses with commas where appropriate. present responses in similar order across columns for a particular answer)

	Family code **(Code D)**	Type of group **(Code E)**	Most important group functions **(Code F)**			Year joined **(YYYY)**	Role in group **(Code G)**	Still a member now? **(Code H)**	Year left **(YYYY)**	If **NO** in **Col 8**, **Rank 3** reason/s for leaving the group **(Code I)**		
			1st	2nd	3rd					1st	2nd	3rd
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
1.												
2.												
3.												
4.												
5.												

Code D	**Code E**	**Code F**	**Code G**	**Code H**	**Codes I**
1=Husband; 2=Wife1; 3=Wife2; 4=Wife3; 5=Son; 6=Daughter	1=Input supply/farmer coops/union; 2=Crop/seed producer and marketing group/coops; 3=Local administration; 4=Farmers' Association; 5=Women's Association; 6. Youth Association; 7. Religious association; 8. Saving and credit group; 9. Funeral association; 10. Government team; 11. Water User's Association; 12=Other (please specify)	1=Produce marketing; 2=Input access/marketing; 3=Seed production; 4=Farmer research group; 5=Savings& credit; 6=Funeral group; 7=Tree planting & nurseries; 8=Soil & water conservation; 9=Church group; 10=Input credit; 11=Other (please specify)	1=Official; 2=Ex-official; 3=Ordinary member	1=Yes; 0=No	1=Not useful/profitable; 2=Poor management; 3=Unable to pay annual subscription fee; 4=Group ceased to exist; 5=Other (please specify)

2.3 Social networking

1.	Originally from this Province? **(use Code H in 2.2 above)**	
2.	Number of years the respondent has been living in this village?	
3.	Frequency of visits to other villages in the Ward in the past 12 months?	
4.	Frequency of visits to other villages in other Wards in the District in the past 12 months?	

5.	Frequency of visits to other villages in other Districts in the Province in the past 12 months?			
6.	Frequency of visits to other villages in other Provinces in the past 12 months?			
		Number of **[---]**	Frequency of contact with **[---]** in the last 12 months	Reliability of **[--]** **(Code A)**
7.	Relatives that you can rely on for critical support in times of need within this village? **(use Code A in 2.1 above)**			
8.	Non relatives that you can rely on for critical support in times of need within this village? **(use Code A in 2.1 above)**			
9.	Relatives that you can rely on for critical support in times of need outside this village? **(use Code A in 2.1 above)**			
10.	Non relatives that you can rely on for critical support in times of need outside this village? **(use Code A in 2.1 above)**			
11.	Are any of your friends/ relatives in leadership positions in formal or informal institutions within this village? **(Code H in 2.2)**			
12.	Are any of your friends or relatives in leadership positions in formal or informal institutions outside this village? **(Code H in 2.2)**			

2.4 Agricultural extension services

		How many times did you interact/discuss with **[---]** in the past 12 months?	How many field days/training organized by **[---]** did you attend in the past 12 months?	What were the topics of discussion with [**---**]? **(Code J) (multiple responses possible and separate with commas).**	How relevant was the information/training? **(Code K)**
1.	Government extension service provider				
2..	Government research service provider				
3.	Farmer cooperatives or groups representatives				
4.	Neighbouring farmers				

5.	Lead farmers				
6.	Agro-dealers/processors				
7.	Crop output traders				
8.	Animal feed suppliers				
9.	NGOs				
10.	Private, national and international research institutions				
11.	Financial services providers				
12.	Government officials (e.g Ministers, MPs)				

Code J	**Code K**
1=Maize related; 2=Sorghum related; 3=Cowpeas related; 4=Cotton related; 5= Other crops; 6=Livestock related; 7= Input use; 8=Specific technologies; 9=General management practices; 10=Product marketing; 11=Product quality; 12=Financial management; 13=Others (please specify)	1=Very high; 2=High; 3=Okay; 4=Not relevant; 5=Don't remember

2.5 Rural credit and subsidy networks

1.	Do you experience times when there is critical shortage of funds available for agricultural activities? **(Code H in 2.2 above) If NO go to Question 4**			
2.	How frequent have you experienced these timesin the last 5 years?			
3.	In which months do you usually face critical funds shortage? **(Code L) (multiple responses possible**			
4.	Did you receive any cash and/or input credit from any source in the last 12 months for crop production or household consumption? **(Code H in 2.2 above)**			
5.	From what source (s) did you receive the cash and/or input credit? **(Code M) Rank 3**			
6.	How reliable are the sources in **Question 5? (Code A in 2.1 above) follow order in Question 5**			
7.	How frequent have you used the sources in **Question 5** in the last 5 years? **(Code N) (follow order in Question 5**			
8.	Do you think you can rely on government support (subsidies, food aid, etc.) if your crop fails? **(Code H in 2.2 above)**			

Code L	**Code M**	**Code N**
1=January; …; 12=December	1=Government subsidy; 2=Donor supported vouchers; 3=Gift from relatives and friends; 4= Credit from savings and credit organizations; 5=Credit from bank; 6=Credit from money lender; 7=Credit from micro-finance institution; 8=Credit from NGO; 9=Other (please specify)	1=Very frequent; 2=Frequent; 3=Average; 4=Rarely; 5=Was a once off use

SECTION THREE: LAND OWNERSHIP AND ALLOCATION

3.1. Land holdings during 2014/15 cropping season (A **field** is a piece of land physically separated from others)

	Land attributes	Total **(fields/hectares)**	Cultivated **(hectares)**	Uncultivated **(hectares)**
1.	How many farm fields do you own?			
2.	What is the total size of the farm fields?			
3.	What size of your own land did you cultivate in the season?			
4.	What is the size of the land rented in? **(If not rented, write zero)**			

3.2. Characteristics of farm plots owned by household, land allocation and grain yield per crop in 2014/15 season (Refer sorghum only here) (A plot is a subunit of a field)

	Plot # and name **(start from one nearest to homestead)**	Plot size **(hectares)**	Fertility of plot **(Code E)**	How far is the plot from home **(walking minutes)?**	Soil slope **(Code H)**	Soil type/colour **(Code I)**	Soil & water conservation practice **(Code J)**	Percent (%) allocated to crop	Bags harvested **(50kg bags)**
	A	**B**	**C**	**F**	**G**	**H**	**I**	**J**	**K**
P1									
P2									
P3									
P4									
P5									

Code E	**Code F**	**Code G**	**Code H**	**Code I**	**Code J**
1=Very fertile; 2=Fertile; 3=Average; 4=Infertile; 5=Very infertile; 6=I don't know	0=Not irrigated; 1=Flood; 2=Drip; 3=Sprinkler; 4=Other (please specify)	1=Myself ; 2=Husband; 3=Wife; 4=Husband and wife; 5=Children; 6=Family; 7=Other (please specify)	1=Gently slope (flat); 2=Medium slope; 3=Steep slope	1.=Black; 2=Brown; 3=Red; 4=Grey; 5=Other (please specify)	0=None 1=Terraces; 2=Mulching; 3=Grass strips; 4=Trees on boundaries; 5=Basins; 6=No tillage

SECTION FOUR: SEED KNOWLEDGE, INFORMATION AND ACCESS

4.1. Seed variety knowledge, source and usage during 2014/15 cropping season (Sorghum only)		
		Response
1.	Year seed variety first known or heard of? **(YYYY)**	
2.	Year seed variety first planted? **(YYYY)**	
3.	What was the source of the first seed variety grown? **(Code A)** *(multiple responses possible and separate with commas)*	
4.	For how long have you been planting this seed variety **(years)?**	
5.	What seed varieties have you grown during the last **3** seasons?*(multiple responses possible and separate with commas)*	
6.	How many kilograms of seed did you purchase during the 2014/15 season?	
7.	What was the source of the seed? **(Code A)** ***(****multiple responses possible and separate with commas)*	
8..	How many kilograms of seed did you plant during the season from other free sources? **(Codes B).** *(multiple responses possible and separate with commas) [e.g. 5:2] meaning 5kg from "Other farmers")*	
9.	For how long have you been using these options for seed source in the past 3 years? **(years)?** *(follow same order as in Qstn 7)*	
10	State major constraints determining your choice of local seed varieties, **(Codes D)**	

Code A	**Code B**	**Code C**	**Code D**
1=Local agrodealers; 2=Other farmers; 3=Contractor; 4=Other agrodealers; 5=Government subsidy; 6=Own savings; 7=NGOs	1=Very reliable; 2=Reliable; 3=Average; 4=Unreliable; 5=Very unreliable	1=No seed in markets; 2=Lack of cash/credit to buy seed; 3=Susceptible to diseases/pests; 4=Poor taste; 5=Low yields; 6=Low grain prices; 7=No market; 8=Theft during green stage; 9=Inadequate land; 10=Requires high skills; 11=Content with current; 12=Other (please specify)	1=Yes; 0=No

4.2. Sorghum variety characteristics grown during 2014/15 and in the past							
Characteristics (Code E)	**Sorghum varieties** (main local variety first) **(see Crop Codes in Annex)**						
	1……	**2…….**	**3……**	**4……**	**5……**	**6……**	**7……**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Agronomic							
1. Grain yield							
2. Stover (crop residue) yield							
3. Drought tolerance							
4. Water-logging tolerance							
5. Disease and pest tolerance							
6. Early maturity							
7. Uniformity in maturity							
8. Grain size							
9. Labour input requirement							
10. Other inputs requirement							
Market and economics							
11. Marketability (demand)							
12. Availability of market information							
13. Grain colour							
14. Output (grain) price							
Processing; Cooking & utilization							
15. Storability							
16. Ease of local processing							
17. Cooking time							
18. Taste							
19. Palatability of stover to livestock							
20. Overall variety score							
Code E 1=Very poor; 2=Poor; 3=Average; 4=Good; 5=Very Good							

SECTION FIVE: MARKETING OF SORGHUM GRAIN

5.1. Output sales, markets and reliability of markets during 2014/15 cropping season (Identify **MAIN MARKETS** for **Sorghum only here!!)**

	Total Sales Volume **(kg)**			Weighted Average Price **(US$) (Don't ask)**			Average distance from home **(walking minutes)**			Duration using market **(years)**			Peak market price & month **(separate with comma)**			Average market price & month **(separate with comma) (Code D)**			Lowest market price & month **(separate with comma)**			Relation to buyer **(Code E)**			Quality **(Code F)**			Who sold **(Code G)**			Mode of transport **(Codes H)**			Reliability of market **(Code I)**			Source of market information **(Code J)**			Time taken to receive payment after sell crop **(days)**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Market **(Code C)**																																										

Code C	**Code D**	**Code E**	**Code F**	**Code G**	**Code H**	**Code I**	**Code J**
1=Consumer/ other farmer; 2=Farmer grouping; 3=Rural assembler; 4=Broker/middlemen; 5=Rural grain trader/wholesaler; 6=Urban grain trader/wholesaler; 7=Exporter; 8=Millers; 9=Contractor; 10=Other (please specify)	1=Jan; …; 12=Dec	1=No relation & not long time buyer; 2=No relation & long term buyer; 3=Relative; 4=Friend; 5=Money lender; 6=Contractor; 7=Other (please specify)	1=Below average; 2=Fair and Average; 3=Above average	1=Male; 2=Female; 3=Both	1=Bicycle; 2=Hired vehicle; 3=Public transport; 4=Donkey; 5=Oxen/horse cart; 6=Back/head load; 7=Other (please specify)	1=Very reliable; 2=Reliable; 3=Average; 4=Unreliable; 5=Very unreliable	1=Other farmers; 2=Local agrodealers; 3=Contractor; 4=Urban agrodealers; 5=Government extension; 6=Private extension; 6=Own search

5.2. Market and price risk for sorghum		
		Response
1.	Has the price of **[---]** fluctuated significantly over the past 3 years? **(Code B)**	
2.	Is the price of **[---]** expected to fluctuate significantly over the next 3 years? **(Code B)**	
3.	Who determines prices of **[---]** in the main market? **(Code C)**	
4.	Who negotiates for prices of **[---]** for your household in the main market? **(Code D)**	
5.	Are you aware of alternative markets for your **[---]** produce? **(Code B)**	
6.	State major constraints in penetrating these **[---]** markets. **(Code E) (Rank Main 3)**	
7.	How many local traders do you have binding relationships with for **[---]**?	
8.	Please state nature of relationships. **(Code F) (Rank Main 3)**	
9.	How many urban traders do you have binding relationships with for **[---]**?	
10.	Please state nature of relationships. **(Code F) (Rank Main 3)**	
11.	Do you think these relationships are balanced and fair for **[---]**? **(Code G)**	
12.	If NO to Qstn 11, what needs to be done to improve fairness? **(Reverse Code E)**	
13.	If no changes are made, do you think you will remain in the current relationships with local traders for **[---]** in the next 5 years? **(Code B)** (*follow same order as in Qstn 8)*	
14.	If no changes are made, do you think you will remain in the current relationships with urban traders for **[---]** in the next 5 years? **(Code B)** (*follow same order in Qstn 10)*	

Code B	**Code C**	**Code D**	**Code E**	**Code F**	**Code G**
1=Yes; 0=No	1=Buyer; 2=Seller; 3=Farmer cooperative/union; 4=Buyer union; 5=Government; 6=Negotiations between buyer and seller; 7=Lead farmers negotiate on behalf of farmers	1=Male; 2=Female; 3=Both	1=High transport costs; 2=Dominated by large corporate companies; 3=Low prices; 4=Unreliable/untrustworthy buyers; 5=No information on prices and time to sell; 6=Content with current	1=Full package contracts; 2=Production credit only; 3=Marketing of produce; 4=Market information; 5=Credit buying/selling	1=I strongly agree; 2=I agree; 3=Neutral; 4=I disagree; 5=I strongly disagree

SECTION SIX: TRANSFER AND OTHER SOURCES OF INCOME LAST YEAR

6.1 Other sources of income (State member who contributes and source. If payment is in kind, estimate the cash equivalent)

Who earned/received? **(Use family code in Part 1.2)**	Sources of income **(Code A)** *(separate multiple responses with commas)*	No. of units worked/ received *(separate multiple responses with commas)*	Amount per unit (cash and in-kind)		Total income (cash and in-kind)		Total income **(US$) Don't Ask!!**
			Cash **(US$)** *(separate multiple responses with commas)*	Payment in kind **(cash equivalent)** *(separate multiple responses with commas)*	Cash **(US$) Don't Ask!!**	Payment in kind **(cash equivalent) Don't Ask!!**	
1	**2**	**3**	**4**	**5**	**6 = 3x4**	**7 = 3x5**	**8 = 6+7**
1.							
2..							
3.							
4.							
5.							

Code A

1=Rented/sharecropped out land; 2=Rented out oxen for ploughing; 3=Salaried employment; 4=Farm labour wages; 5=Non-farm labour wages; 6=Non-farm agribusiness NET income (e.g. grain milling/trading); 7=Other business NET income (shops, trade, tailor, sales of beverages etc); 8=Pension income; 9=Drought/flood relief; 10=Safety net or food for work; 11=Remittances (sent from non-resident family and relatives living elsewhere); 12=Marriage Gifts; 13=Sales of firewood/charcoal; 14=Brick making; 15=Poles from own and communal forests; 16=Sale of crop residues; 17=Quarrying stones; 18=Rental property (other than land and oxen); 19=Interest from deposits; 20=Social cash transfer; 21=Other (please specify)

SECTION SEVEN: FOOD SECURITY STATUS OF HOUSEHOLD

7.1. Household security status (Please consider what has happened in the past 12 months. Multiple responses possible. Probe these and document on separate sheet).		**Code**		
		I	**J**	**K**
1.	Did you worry that your household would not have enough food?			
2.	Were you or any household member not able to eat the kinds of foods you preferred because of a lack of			
3.	Did you or any household member eat just a few kinds of food day after day due to a lack of resources?			
4.	Did you or any household member eat unpreferred food because of a lack of resources to obtain other types of			
5.	Did you or any household member eat a smaller meal than you felt you needed because there was not enough			
6.	Did you or any other household member eat fewer meals in a day because there was not enough food?			
7.	Was there ever no food at all in your household because there were no resources to get more?			
8.	Did you or any household member go to sleep at night hungry because there was not enough food?			
9.	Did you or any household member go a whole day without eating anything because there was not enough food?			
10.	What is your own assessment of the adequacy of your family's food consumption?			
11.	What is your own assessment of the adequacy of your family's nutrition needs?			
12.	What is your own assessment of the adequacy of the health care your family gets?			
13	What is your own assessment of the adequacy of your children's schooling?			
14.	Taking into consideration ALL food sources ***(own food production + food purchase + help from different sources + food hunted from forests, rivers and dams, etc.***), how would you assess your family's food			
15.	State all food items consumed in the past 30 days (use a separate sheet)			

Code I	**Code J**	**Code K**
0 = Never; 1 = Rarely (in one or two months during the last year); 2 = Sometimes (in 3 to 10 months during the last year); 3 = Often (in more than 10 months during the last year)	1=It was less than adequate for your family's needs; 2=It was just adequate for your family's needs; 3=It was more than adequate for your family's needs; 4=Not applicable	1=Food shortage through the year; 2=Occasional food shortage; 3=No food shortage but no surplus; 4= Food surplus.

Definition: ''**Adequate''** means no more nor less than what the respondent considers to be the minimum consumption needs of the family

SECTION EIGHT: GENERAL CONSTRAINTS

8.1. Constraints to production and marketing of sorghum			
Constraint		How severe is the constraint of in sorghum production and marketing **(Code A)**	
		Production	**Marketing**
1.	Late delivery of inputs (seed, fertilizers, chemicals)		
2.	Unavailability of inputs in local agro dealership		
3.	Inefficient government extension services		
4.	High input prices		
5.	Labour shortages during critical of the season		
6.	Pests and diseases e.g quelea birds and armoured crickets		
7.	Market unreliability (intermittent buyers)		
8.	High transport costs		
9.	Low market prices (e.g. use of local markets or exploitive buyers etc)		
10.	Weak credit networks		
11.	Government policy bias		
12.	Consumer tastes and preferences		
13.	Other (please specify)		
Code A 1=Extremely severe; 2=Very severe; 3=Moderately severe; 4=Slightly severe; 5=Not severe			

Other comments:

……

……

THANK YOU FOR PARTICIPATING IN THE INTERVIEW

Appendix II: Questionnaire for other sorghum value chain actors

Good day. I am carrying out a study on **"Economic analysis of the sorghum value chain in the mid-Zambezi Valley of Zimbabwe"**. This study aims at presenting empirical description and analysis of the value chain in terms of marketing margins and identification of marketing constraints and opportunities. This helps in providing a better understanding of the fundamental dynamics of the chain and also improves the volume and value of sorghum marketed in Zimbabwe through scaling up programs. Information gathered will not be used for any other purposes except for this study. The information will also be treated with confidentiality. Your cooperation will be greatly appreciated. Thank you.

Identification Details

Name of Enumerator: _____
Date of Interview: _____
Name of Company/Buyer (include ID): _____
Location: _____
Nature of business unit: _____

SECTION A: Production and financial performance

1. Duration in business. (State years): _____
   For 2 and 3 fill table below.
2. How many employees do you have? (Separate into permanent and part time)
3. What wage rates do you use? (State for permanent and part time)

Number	Full time	Part time
Wage rate		

4. Do you experience any labour challenges throughout the business cycles?
(Explain)_____
5. How do you finance your business? (Specify in the table below)
Rate the reliability of the source of finance on the scale: 1. Not reliable. 2. Slightly reliable.
3. Moderately reliable. 4. Very reliable. 5. Extremely reliable

Source of finance	Duration	Average finance per year (US$)	Challenges	Reliability
1.				
2.				
3.				

6. What costs do you incur in sorghum business and what are the sources? (Specify in the table below). Rate the reliability of source on the scale: 1. Not reliable. 2. Slightly reliable. 3. Moderately reliable. 4. Very reliable. 5. Extremely reliable

Cost	Units	Unit cost (US$)	Total cost (US$)	Source	Reliability
1.					
2.					
3.					
4.					
5.					
6.					
7.					

7. Do you have any arrangements with the sources of inputs listed in the table above? (put corresponding number in box) □ 0. No 1.Yes

8. If Yes, in your opinion do you think these are balanced?

(Explain)_____

9. If No, what is limiting you from using these arrangements?

(Explain)_____

10. Have you ever purchased raw materials together with other businesses?

(Explain)_____

11. In your opinion, did you realize any benefits to your business as a result of this arrangement?

(Explain)_____

12. From whom do you buy produce (e.g. sorghum grain, stockfeed)? (Fill in the table below). Rate the reliability of market on the scale: 1. Not reliable. 2. Slightly reliable. 3. Moderately reliable. 4. Very reliable. 5. Extremely reliable

Source	Duration (years)	Average annual volume (ton)	Average Price (US$/kg)	Reliability
1.				
2.				
3.				

13. Do you experience any challenges in buying the produce?

(Explain)_____

14. How is the price of the produce determined?

_____

15. Do you have any arrangements with the sources of produce? (Outline these)_____

16. If Yes, in your opinion do you think these are balanced?
(Explain)_____
17. If No, what is limiting you from using these arrangements?
(Explain)_____
18. In your opinion are there are opportunities to buy more produce in the current markets?
(Explain)_____
19. Are you aware of alternative markets to buy produce? (put corresponding number in box)
 0. No 1. Yes
20. In your opinion are there opportunities to buy produce from these new markets?
(Explain)_____
21. What is limiting you from using these markets?
(Explain)_____
22. To whom do you sell your produce? (State whether domestic or export).
Rate the reliability of market on the scale: 1. Not reliable. 2. Slightly reliable. 3. Moderately reliable. 4. Very reliable. 5. Extremely reliable

Destination	**Duration (years)**	**Average annual volume (ton)**	**Average Price (US$/kg)**	**Constraints**	**Reliability**
1.					
2					

23. How is the price of the produce determined?
_____
24. Do you have any arrangements with the buyers of your produce? (Outline these)_____
25. If Yes, in your opinion do you think these are balanced?
(Explain)_____
26. If No, what is limiting you from having these arrangements?
(Explain)_____
27. In your opinion what can be done to improve the relationships with the buyers of your produce?
(Explain)_____
28. In your opinion are there are opportunities to sell more produce in the current markets?
(Explain)_____
29. Are you aware of alternative markets for your produce? (put corresponding number in box)
 0. No 1. Yes
30. In your opinion are there opportunities to sell produce in these new markets?
(Explain)_____
31. What is limiting you from using these markets?

(Explain)_____

32. How do you rate the Critical Success Factors (CSFs) in your markets on the scale provided?

1. Not Important. 2. Slightly Important. 3. Moderately Important. 4. Fairly Important. 5. Important. 6. Very Important, 7. Critically Important

Industry specific CSFs	**Market segment**			**Follow on questions**
	1	**2**	**3**	
Price				What determines the market price? To what extent does it fluctuate in response to supply in a given month?
Quality				What are the key determinants of product and services quality?
Sales volume				At what volume point do you break even? What are the average industry sales volumes?
Delivery Reliability				What distribution channels are most appropriate in line with your business model? How can these be improved for efficiency?
Packaging				How important is the packaging material to the consumer? How does the material affect the production costs?
Flexibility				How flexible is the market to the demands of consumers?
Innovation				What institutions are needed to improve R&D capacity of your firm and industry?
Other (specify)				

33. What equipment and/or machinery do you use? (State these)._____

34. Are there any other assets you think can be useful in your business? (State these):

_____

35. What is limiting you from using these?

(Explain)_____

SECTION B: Management practices

36. What recent activities have you embarked on to improve your sorghum business? (state these):

_____

37. In your opinion, has this improved your sorghum business? (Explain)._____

38. What type of personnel skills are needed to improve your sorghum business?

_____

39. Have you or your employees received any training on farm business management? (put corresponding number in box) □ 0. No 1. Yes

If No, go to question 44

40. Who provided this training?

_____

41. How frequent do you or your employees receive this training? (State average per year)._____

42. In your opinion, did you or your employees benefit from this training? (put corresponding number in box) □ 0. No 1. Yes

43. In your opinion what aspects need to be captured in the training? (Explain)._____

44. What constraints do you experience in your business?

Scale for the problems on the basis of the given scale:

1. Not a serious problem 2. Slightly severe. 3. Moderately severe. 4. Very severe.
5. Extremely severe.

Constraint	**Rating**	**Suggested solution(s)**
Late delivery of raw materials		
Unavailability of raw materials		
Inefficient support services		
High input prices		
Labour shortages		
Market unreliability		
High transport costs		
Low market prices		

SECTION C: Policy environment

45. Are you aware of any policies that can impact on your sorghum business? (Elaborate)_____

46. What policies need to be put in place to support your sorghum business? (Explain)_____

47. Who do you think has to be involved in supporting your sorghum business and how? (Explain)_____

Other comments:

……
…….....
.....……

THANK YOU FOR PARTICIPATING IN THE INTERVIEW

Appendix III: Key Informant Interview Guide

Respondent code: .....

Date of discussion/interview: .....

Moderator number: .....

Key Informant Interview participant demographic information

1. Organisation's main business: .....
2. Position/Job title: .....
3. Experience in financing maize related activities: (please state years). .....
4. Age (please state years): .....
5. Gender (please tick appropriate box): □ 0. Male. □ 1. Female.
6. Highest level of education you have completed? (please state): .....

Key Informant Interview Checklist

1. What is your understanding of a value chain?

   Prompt: please give examples of value chain activities.

2. Is the mode of activities you are involved in formalised?

   Prompt: please elaborate on the unique characteristics of the mode.

3. What drawbacks related to sorghum value chain activities do you frequently experience?
4. Please explain your involvement in the following sorghum value chain activities:

   i) research.

   ii) production.

   iii) processing.

   iv) marketing.

   v) Other (please specify).

5. Please identify the main consumers of your products and services?

Prompt: please also identify the main challenges with these consumers.

6. What are the advantages of using your most strategic activity(ies)?

   Prompt: please highlight the disadvantages as well.

7. What challenges do stakeholders face in the following aspects of the sorghum value chain:

   i) production.

   ii) marketing.

   iii) overall demand for services.

8. Please elaborate on the existing policies that are related to the following aspects of the sorghum value chain:

   i) monopolies.

   ii) repayment.

   iii) administration of finances.

   iv) access to suppliers and consumers.

   v) government intervention.

9. Do you offer any support services to stakeholders after providing them with services?

   Prompt: please elaborate on specific stakeholders and services offered.

10. What strategies can be implemented by stakeholders to improve the current sorghum value chain networking mechanisms?

    Prompt: please elaborate on what is currently limiting this shift.

11. Do you have any other comments regarding this topic? Is there anything else you would like to add?

I will be analysing the information collected and preparing a summary report of the findings. I'll be happy to send you a copy if you are interested. Thank you very much for your time.

Appendix IV: Supplementary results

Table 8.1: Estimating double-hurdle model with farm type and orientation variables

Variable	1st hurdle (Production)		2nd hurdle (Production intensity)	
	Coefficient	***p*-value**	**Coefficient**	***p*-value**
	Network attributes			
EXTFREQ	1.783***(0.198)	0.001	2.173* (0.092)	0.079
LCLREL	-0.338 (0.996)	0.794	-1.651** 1.187)	0.028
FREQLOC	-1.003(0.047)	0.031	0.291** (0.321)	0.015
ETHNIC	1.997 (2.006)	0.928	3.227 (1.254)	0.831
EXTREL	0.089 (0.117)	0.672	-1.237 (0.093)	0.451
FREQEXT	0.016 (0.015)	0.274	0.917** (0.026)	0.037
NGROUP	2.198***(0.007)	0.001	0.089 (2.385)	0.274
	Aid attributes			
INFOAID	1.896(1.007)	0.097	1.339 (2.913)	0.339
AIDBENFCR	0.091 (0.991)	0.383	1.562(2.910)	0.778
NUMAIDSC	-2.165 (3.917)	0.553	4.668 (1.290)	0.311
DURTNAID	0.096 (1.772)	0.136	0.998* (0.037)	0.072
AIDVALUE	1.248* (1.005)	0.018	0.088 (0.329)	0.228
	Market attributes			
MKTDIST	-1.236* (0.127)	0.082	-1.118 (1.017)	0.279
TRANSCST	-0.338* (0.119)	0.066	1.834 (0.179)	0.088
MKTFREQ	1.294 (1.118)	0.103	1.289* (1.180)	0.086
PYMNTSPD	-1.096 (1.117)	0.091	-3.489**(1.198)	0.043
NUMBUY	1.291* (0.339)	0.077	4.572* (1.181)	0.059
MKTINFO	0.911 (0.937)	0.441	0.005 (3.435)	0.221
WEIGHTPRC	1.093* (1.018)	0.085	1.916 (1.119)	0.117
	Demographic attributes			
AGE	-0.281** (0.118)	0.018	1.872 (0.816)	0.668
ORIENTATION	-1.338 (1.293)	0.271	0.881** (1.173)	0.021
CROPDIV	-2.347 (0.986)	0.112	-1.120 (0.915)	0.371
LIVEDIV	1.194 (0.099)	0.417	-3.281 (0.899)	0.110
GENDER	0.395 (1.178)	0.559	-1.096 (1.181)	0.319
HHLDSZE	1.178 (0.993)	0.102	0.995 (0.041)	0.017
EXPERIENCE	1.238 (1.115)	0.114	2.198** (1.290)	0.033
INCOME	-1.893* (1.238)	0.011	4.190 (0.009)	0.226
ARBLAND	1.109 (1.001)	0.419	0.998 (2.191)	0.119
STORAGE	0.990 (1.112)	0.284	0.093 (1.105)	0.216

Source: Generated by authors from sorghum survey data using STATA. Standard error for each estimate is placed in parenthesis

N**otes:** ***; ** and * indicate *p*-values significant at 1%, 5% and 10% levels respectively

Table 8.2: Detailed marketing margins for a sample of sorghum output traders

	Local traders	Assemblers
Total quantity sold (kg)	16000.00	13000.00
Average weighted selling price (US$/kg)	0.35	$0.50
Gross income(US$)	**5600.00**	**6500.00**
Total quantity purchased (kg)	16615.00	13270.00
Purchase price (US$/kg)	0.25	0.35
Purchase cost(US$)	**4153.75**	**4644.50**
Cost of empty sacks (US$)	75.00	52.00
Packaging(US$)	75.00	39.00
Loading (purchase market)(US$)	30.00	26.00
Distribution costs(US$)	35.00	50.00
Offloading (sale market)(US$)	30.00	26.00
Storage costs(US$)	45.00	130.00
Communication costs(US$)	15.00	70.00
Personal travel costs(US$)	20.00	
Total marketing cost(US$)	**325.00**	**393.00**
Total variable costs(US$)	**4478.75**	**5037.50**
Gross margin(US$)	**1121.25**	**1462.50**
Gross margin as % of costs(US$)	**25.03**	**29.03**
Cost per unit(US$)	**0.28**	**0.39**
Marketing margin(US$)	**0.07**	**0.11**

Source: Survey data