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The University of Reading

**'An evaluation of the compound feeds manufactured in Tanzania'**

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## Contents page

Acknowledgements.....	ii
Contents page .....	iii
List of figure.....	i
List of tables .....	i
Abstract .....	ii
List of Abbreviations.....	iii
1. INTRODUCTION.....	1
1.1 Background.....	1
1.2 Problem statement.....	2
1.3 Aims and objectives.....	2
1.4 Outline to the study.....	3
2. LITERATURE REVIEW .....	4
2.1 Political economy of Agriculture .....	4
2.1.1 Agricultural growth and poverty reduction.....	6
2.2 Description of livestock production systems.....	8
2.3 Feeds and Feeding .....	10
2.3.1 Importance of feeding .....	10
2.3.2 Nutrient requirements in animal feeding.....	13
2.4 Current status and challenges of the feed manufacturing industry .....	16
2.4.1 Challenges faced by the industry.....	16
2.4.2 Role of the animal feed industry .....	18
2.4.3 Feed manufacturers association.....	19
2.5 Value chain concept .....	20
3. METHODOLOGY .....	22
3.1 Introduction.....	22
3.2 Project background.....	22
3.3 Study sites.....	23

3.4	Feed producer questionnaire .....	24
3.4.1	Selection of participants .....	24
3.5	Feed sampling protocol .....	25
3.5.1	Feed selection.....	25
3.5.2	Procedure for sample collection.....	26
3.5.3	Sample handling and identification.....	27
3.5.4	Sample preparation: storage, grinding.....	27
3.5.5	DM determination .....	28
3.6	Near-Infrared Reflectance Spectroscopy.....	30
3.7	Data analyses.....	31
4.	RESULTS AND DISCUSSION .....	32
4.1	Mapping the value chain .....	32
4.2	Employment .....	35
4.3	Product distribution.....	37
4.4	Production .....	38
4.4.1	<i>The Production Process</i> .....	38
4.4.2	Total production .....	40
4.4.3	Production Capacity.....	40
4.4.4	Production by species.....	41
4.4.5	Raw material usage in the sector .....	43
4.6	Constraints in animal feed production.....	48
4.7	Product standards.....	51
4.7.1	Feed analysis.....	51
4.7.2	Price and quality .....	53
4.7.3	Nutrient composition of compounds and ingredients .....	54
5.	CONCLUSION.....	58
5.1	Limitations of the study.....	58
5.2	Policy implications.....	59

REFERENCES .....	62
APPENDICES .....	74

## List of figures

Figure 1 Growth rates of GDP, Industry, Services and Agriculture, 2004 -2013.....	7
Figure 2 Quartering technique .....	27
Figure 3 Map of the animal feeds in Tanzania. ....	33
Figure 4 <i>Employment and level of qualification in the compound feeds sector</i> .....	36
Figure 5 Product distribution .....	37
Figure 6 The production process.....	39
<i>Figure 7 Installed vs actual production</i> .....	41
<i>Figure 8 Compound feed production by livestock species</i> .....	42
<i>Figure 9 Breakdown of ingredient usage in feed compounding</i> .....	46
<i>Figure 10 production constraints identified by respondents</i> .....	48
<i>Figure 11 Ranking of constraints faced by feed producers</i> .....	50
Figure 12 Proximate analysis of compound feed and raw materials.....	51
<i>Figure 13 CP and price of compound feeds</i> .....	53

## List of tables

Table 1 Functions and sources of nutrients .....	14
Table 2 Raw material usage and origin .....	44
Table 3 Mean ( $\pm$ SD) nutrient composition of compound feed samples .....	54
Table 4 Mean ( $\pm$ SD) nutrient composition of common ingredients used in the animal feeds sector in Tanzania .....	55

## **Abstract**

Tanzania has recently embarked into a period of liberalisation which is undoubtedly having an impact on the agricultural sector. The effects of liberalisation are feeding through to the animal feeds sector, which is experiencing a period of vibrant growth and change, which is reflected by the rapidly increasing number of feed manufacturers. This implies that this sector will play an important role in meeting the increased demand for animal products. Animal production in Tanzania is hindered by numerous constraints such as poor nutrition and management amongst others (Nkya *et al.*, 2007). However it is widely recognised that feed represents the highest cost in livestock production, accounting for as much as 75% variable costs (Mupeta *et al.*, 2003), implying that the nutritional quality of feed has a profound impact on productivity and income (Roy *et al.*, 2004). Therefore, this study was undertaken to characterise compound feeds sector and assess the quality of compound feeds sold to farmers in Tanzania – through a mixed methods approach, 25 feed producers were surveyed in 4 different cities, to provide an overview of the sector, whilst chemical analysis using NIRS was used to assess the quality of 169 compounds feeds and 131 raw materials. Compound feed production is dominated by poultry products (96.41%), whilst feed mills operate below 50% capacity. Raw materials are sourced locally, and maize products make up more than half of total tonnage. Product standards seem to be satisfactory, as the components assessed fall within range of cross-country parameters used as guidance.



## List of Abbreviations

AI - Artificial insemination

BSE - Bovine spongiform encephalopathy

Ca – Calcium

CAADP - Comprehensive Africa Agriculture Development Program

CF – Crude fibre

DEFRA - Department for Environment Food and Rural Affairs

FAO - Food and Agriculture Organization

GI – Gastrointestinal

IFAD - International Fund for Agriculture Development

ILRI - International Livestock Research Institute

IR – Interest Rates

LC - Least-cost

LDC - Less developed country

LP – Linear Programming

LSU - Livestock Units

MLB - Mineral lick block

MLFD - Ministry of Livestock and Fisheries Development

MOF – Ministry of Finance

N - Nitrogen

Na - Sodium

NEPAD - African Union’s New Partnership for Africa’s Development

NIRS - Near-infrared reflectance spectroscopy

NPN - Non-protein nitrogen

P – Phosphorous

SD - standard deviation

SFR - scavengeable feed resources

SSA - Sub-Saharan Africa

TAFMA - Tanzania Feed Manufacturers Association

TBS – Tanzania Bureau of Standards

TVLA -Tanzania Veterinary Laboratory Agency

VAT

-

Value

Added

Tax

## INTRODUCTION

### 1.1 Background

As Tanzania experiences population growth, economic growth and increased urbanisation, so food consumption patterns are changing and shifting to higher value products such as animal products (UNIDO, 2012). Demand is growing both domestically and internationally; domestically, demand is spurred by a growing population which is urbanising and an emerging middle class made up of wealthier consumers who are more able to participate in niche markets for quality meat. Internationally, meat demand is rising and producers are able to fetch better prices by exporting their produce, largely to neighbouring countries such as Kenya, Ethiopia, and The Democratic Republic of Congo as well as to countries in the middle-East such as Kuwait, United Arab Emirates and Oman (MLFD, 2011; SNV, 2008). In general terms, the events which are unfolding (and which will continue to do so) are common to livestock industries in many developing countries, particularly in Sub-Saharan Africa (SSA), such that the term “*Livestock Revolution*” has been coined to describe such changes (Delgado *et al.*, 1999). These demand driven factors present realistic opportunities for livestock sector growth which can contribute to the provision of income, employment and better quality nutrition in Tanzania and in other parts of the developing world (World Bank, 2005), thus improving the livelihoods of a large portion of the population as well as meeting the Millennium Development Goals (MDG’s) (ILRI, 2011). Furthermore, animal production presents numerous benefits such as; regular income, improved nutrition, by-products such as skin for leather, and organic manure for improved soil fertility amongst others. Tanzania stands in a promising position to capture these favourable circumstances, as it is the third largest livestock-producing countries in Africa (MLFD 2011). However, the potential of the livestock industry is far from being realised and the sector

has not yet been capable of responding to the opportunities presented, such that slaughtering facilities operate below 50% capacity (UNIDO, 2012). Despite vast agricultural resources, Tanzania remains amongst the world poorest countries with a GDP per capita of US\$695 (World Bank, 2013). The agriculture accounts for roughly 27% of the GDP (ibid), 60% of the export earnings, and about 70% of the population is involved in Agriculture (NBS, 2011). Therefore as a low-income, agriculturally dependent economy, improving agricultural productivity will prove vital for the macro-economic growth of the country and in achieving widespread poverty alleviation.

### **1.2 Problem statement**

Livestock productivity across East Africa is constrained by limited access and availability of high quality concentrate feeds (Tolera *et al.*, 2000), such that, despite mild efforts of developing feed production and utilisation technologies, reported usage rates in Kenya, Uganda and Rwanda were of 33%, 4% and 12% respectively (Lukuyu *et al.*, 2009). In a recent study in Tanzania, farmers reported that the amount of concentrate feeds purchased and fed to animals is low. Furthermore, the study showed that farmers are faced with challenges with regards to; poor and inconsistent quality of commercial feeds, limited capital, insufficient knowledge of costs and nutritive value of commercial feeds, and rising feed prices (Laswai & Nandonde, 2013). Furthermore, feeds account for up to 75% variable costs implying that the nutritional quality of feed has a profound impact on productivity and income (Roy *et al.*, 2004).

### **1.3 Aims and objectives**

Based on the issues aforementioned, the main aim of this study is to evaluate the quality of compounded feeds sold on the market, and check these quality parameters.

Specific objectives include;

- Understand and map the animal feeds value chain in Tanzania, identifying the main actors and the interactions between them.
- Evaluate possible relationships between price and quality.
- Assess variations in the nutrient content of feeds.
- Document the different ingredients used in compound feed production and their origin.
- Identify constraints faced by the animal feed sector, and if possible, suggest solutions.

#### **1.4 Outline to the study**

The dissertation is organised into five chapters. The first chapter introduced a background to this study, the problem statement, and the main aims and specific objectives. The second chapter provides an overview of the key literature, looking at livestock production in Tanzania, with an emphasis on feeding. Chapter three details the methods of data collection and analysis, as well as a detailed sampling protocol. Chapter four presents the results and discusses the key findings in relation to existing literature, whilst the final chapter draws on the final conclusions and provides policy implications.

## 2. LITERATURE REVIEW

### 2.1 Political economy of Agriculture

For several decades preceding national independence in 1961<sup>1</sup>, German and British colonial rule had set up a typical colonial configuration of exporting raw materials in order to control supply in Western industries (Helleiner, 1976). Following independence, the newly formed Republic of Tanzania was faced with the challenging task of transforming the country from its role as an exporter of raw materials and importer of finished goods, to the creation of an industrial base capable of self-sustaining the country (Bryceson, 1982). One of the key moments in the country's recent history was the 'Arusha Declaration' launched by president Nyerere in 1967, which set out economic and social organisation based on tight state control, where private sector involvement almost inexistent (Temu and Due, 2000). Farmers effectively worked under government contract as all produce was marketed through co-operatives or state owned crop authorities. These rural collectivisation (or villagisation) schemes were known as *ujamaa* (IFAD, 2014). The environment was not business friendly and entrepreneurs were viewed with a negative eye. As put by Temu and Due (2000), the anti-business environment was such that 'hiding transactions, non-compliance with government directives, evading tax, and bribery to get licences and permits became pre-requisite skills to do business in the country.' Early post-independence failed to achieve the rapid economic growth which was projected in the Arusha Declaration, and following a famine in 1974 and a collapse of the coffee boom in 1978 the country entered an economic crises which only worsened with the Uganda War and the OPEC oil price shock in close succession (Bigsten & Danielsson, 1999).

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<sup>1</sup> The Republic of Tanzania is made up of former Tanganyika and Zanzibar. Mainland Tanzania was first under German protectorate from 1885-1920, only to become a British-administered territory under a League of Nations mandate, whilst Zanzibar was under the Sultanate of Oman. Tanganyika gained independence in 1961 (Putzel and Lindemann, forthcoming).

During the crisis period (1979-1985), per capita income fell by 1.5% per year,<sup>2</sup> and much of this can be attributed to the poor performance of the agricultural sector (Bigsten & Danielsson, 1999); rewards for peasant production were reduced which led to production inefficiencies and low producer prices. Low peasant commodity production proved critical in exposing the weakness of the system; firstly, because export commodities are a source of foreign exchange reserve, and secondly the non-food population relies on peasant production surplus for administrative and industrial growth (Bryceson, 1982). In fact, during the late 70's and early 80's, Tanzania became dependent on the import of major grains maize and rice (Skarstein, 2005).

The events during the crisis led to the resignation of President Nyerere and called for immediate structural transformation. Under pressure from donors, Tanzania began liberalising its economy in 1986 and has since introduced a broad range of economic reforms such as the Economic Recovery Programmes I and II which were supported by the International Monetary Fund (IMF) and the World Bank (WB) (IFAD, 2014; Temu and Due, 2000). Economic liberalisation was seen as a fundamental tool to liberate private economic initiative and fix the price distortions such that prices would represent relative scarcities and ensure optimal resource allocation (Skarstein, 2005). With almost immediate effect, competition between the private sector and the cooperative system was legalised in order to adjust the price distortions that had been created by state-owned marketing boards who bought agricultural products (Kape *et al.*, 1994). By 1992 the grain market was almost completely controlled by the private sector (Skarstein, 2005). Furthermore, procurement and distribution of agricultural inputs were liberalised and agricultural subsidies on inputs and outputs were removed, in order to incentivise specialisation and innovation, governed by forces of supply and demand (Ngowi, 2007), and in 1995 the

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<sup>2</sup> Figure is uncertain because of a lack of reliable data and many economic activities took place in the parallel economy.

National Land Policy (NLP) of Tanzania was developed, which entitled property ownership (Lugoe, 2011).

### **2.1.1 Agricultural growth and poverty reduction**

Less than three decades have gone by from when the economy had collapsed, and since then the Republic has undergone sweeping socio-economic changes. Although there have been many challenges, the overall outlook is positive; firstly, whilst surrounding countries have experienced unrest and political instability, Tanzania has remained out of conflicts and can be seen as a peaceful haven in a region where violence is not uncommon (Bigsten & Danielsson, 1999). While this is not represented in economic indicators, it should not be underestimated and may prove vital in offering a friendly environment for future growth and investment. Secondly, Tanzania is an emerging economy with a high growth potential (TAFSIP, 2011), which has been represented by the continuous growth in GDP, averaging a 7% increase per year over the last 10 years (World Bank, 2014). However, this strong economic growth has not been translated into widespread poverty reduction, as the proportion of people living below the food poverty line in 2007 was 16.6%, down from 22% in 1990 (HDR, 2014). Furthermore, from the Reform period to 2011, per capita incomes grew by a modest average of 0.6% per year (Lugoe, 2011). This can be explained by the fact that agricultural growth has stagnated, and economic growth in the last decade has been driven by the service and industry sectors (Mashindano *et al.*, 2011), as shown in the figure below.

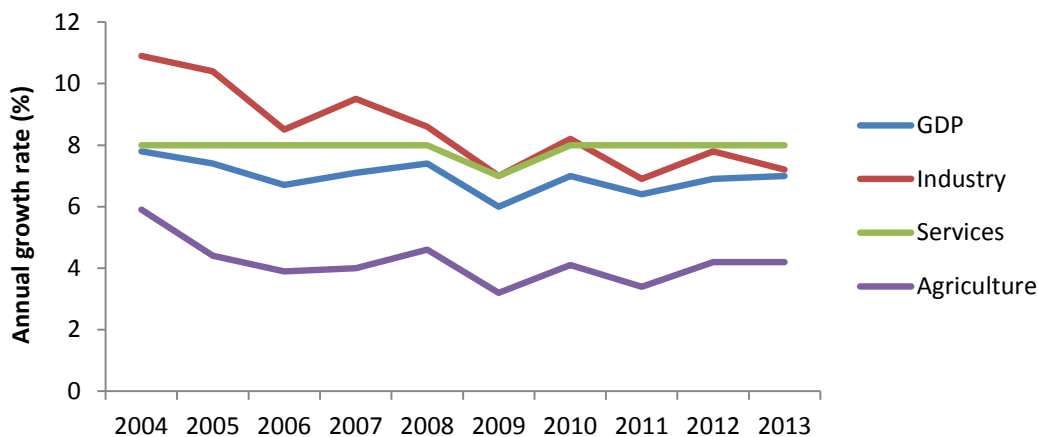


Figure 1 Growth rates of GDP, Industry, Services and Agriculture, 2004 -2013.

Source: Computed using World Bank Data (<http://data.worldbank.org>)

Given that agriculture supports 70% of the population, particularly in rural areas, (Mashindano *et al.*, 2011) it becomes clear that agricultural sector growth on a national scale a vital ingredient in achieving widespread poverty reduction and food security. Agriculture sector growth has averaged 4.2% annual growth over the last decade, whilst services and industry has grown at 7.9% and 8.5% per annum over the same time period (Figure 1). This is only marginally above by the average annual population growth of 2.9% (World Bank, 2014). There does seem to be a concerted effort to drive agricultural growth on behalf on the government and stakeholders, who have come to recognise that strong agricultural growth is a necessity to make significant reductions in rural poverty and food insecurity (Sarris *et al.*, 2006). In fact, de Janvry and Sadoulet (2010), estimated that overall growth originating from agriculture is at least three times as effective in reducing poverty compared to overall growth originating in the rest of the economy. The URT (with the help of donors and public sector) is committed to allocate a minimum of 10% of its budget in order to achieve the CAADP<sup>3</sup> target of 6 per cent annual growth in agriculture (TAFSIP, 2011). The main aim of the 10 year Tanzania Agriculture and Food Security

<sup>3</sup> The CAADP is an initiative of the African Union's New Partnership for Africa's Development (NEPAD)



Investment Plan (TAFSIP), is to address core national problems of poverty and food insecurity, by promoting agricultural growth in Tanzania under the CAADP framework (TAFSIP, 2011). In order to achieve this, a number of key policies and strategic instruments have been introduced, such as *Kilimo Kwanza* (Agriculture First), in order to address the multi-sectorial challenges and capture the opportunities to transform agriculture in Tanzania (Ngaiza, 2012). As discussed in section 2.1, agricultural sector growth has the largest impact on poverty reduction (Sarris *et al.*, 2006), implying that livestock will prove critical in the future socio-economic health of the country.

## **2.2 Description of livestock production systems**

Tanzania has an immense resource which is yet to be tapped; recent estimates from the 2012 Economic Survey estimated that the livestock population consists of about 22.8 million cattle, 15.6 million goats, 7.0 million sheep, 2.01 million pigs and 60.0 million chickens (URT, 2013).

*Poultry* - Traditional poultry management remains dominant in Tanzania (especially in rural areas), in which local chicken breeds roam freely in search of their own food, and are kept indoors at night within the household (Minga *et al.*, 2000). Indigenous chicken, commonly referred to as local chicken, are the most numerous poultry species and are reared under a low input/low output management system, where their diets mainly consist of scavengeable feed resources (SFR) and household feed waste. As stated by Minga *et al.* (2000), the low productivity (in terms of meat and eggs) of local chicken are low due to poor nutrition, poor or no housing, no targeted breeding, and no veterinary interventions. Nonetheless, this system is an important component of smallholder farming communities in Tanzania, as it is often the only affordable poultry system for rural households (Goromela, 2009). Commercial poultry production is becoming more common in Tanzania, which presents an opportunity for feed producers to

absorb this demand. This system is very distinct from the traditional sector in that capital investment and management is far more intensive, and high nutrient density feeds ensure rapid turnovers and maximum productivity (Parr, 1988). Feed costs typically constitute roughly 75% of variable costs of poultry production (Mupeta et al., 2003), implying that the diet of chicken has a profound impact on productivity and income (Roy et al., 2004).

*Cattle* - As for cattle, the majority are reared for beef by pastoralists and agro-pastoralists in arid and semi-arid areas of the country (Mlote *et al.*; 2013). Milk and meat production from the indigenous cattle is generally low, which is why Tanzania is a net importer of cattle products (Mwambene *et al.*, 2014). In mainland Tanzania, as in most less developed countries (LDC's), smallholder dairy production is common in urban and peri-urban settings, and is especially important in supplying the increased demand of dairy products from urban residents, since rural dairy production is very low (Mlay et al., 2005). In this production system, farmers usually keep a small number of cattle, which are typically crossbred European dairy cattle and Shorthorn Zebu (Chang'a *et al.*, 2010). Due to rapid urbanisation, small-holder dairying has grown immensely, yet it is constrained by several factors including low genetic potential and high cost of feeding (Gillah *et al.*, 2013). Most milk is sold as raw milk through informal channels.

*Others* – Sheep and goat are mainly raised for meat production in smallholder, extensive production systems which rely on grazing natural pastures for the supply of feeds (Shija *et al.*, 2013), whereas pigs kept under indoor systems and are fed by-products and kitchen waste (Swai and Lyimo, 2014).

## **2.3 Feeds and Feeding**

### **2.3.1 Importance of feeding**

Animal performance, regardless of whether it is expressed as yield (meat or milk), growth rate or disease resistance, is dependent on the quality of nutrition. However, nutrition is often the most limiting factor of productivity in ruminants and non-ruminants (Corson *et al.*, 1999). With the increase in size and wealth of the population, and the subsequent increase in demand for products of animal origin (as previously discussed), increasing the quantity and quality and quantity of feeds ought to be considered an important duty for the economy of Tanzania (Babić and Perić, 2011). Feed costs typically represent the highest cost item in smallholder production systems, implying that both quantity and quality of feed have a significant effect in determining profitability (Muller *et al.*, 2007; Roy *et al.*, 2004). Furthermore, when concentrates are fed, it is provided in small quantities, and therefore low returns are achieved from their inputs (Biwott *et al.*, 1998). The effect of feeding concentrate supplementation on animal performance is relatively well known and has been documented by several authors; for example, Ebro *et al.* (1998) showed that supplementing grazing goats with concentrate increased live weight gain by 23.6% compared to un-supplemented goats, whilst other research has shown that milk yield increases at higher levels of concentrate feeding (Biwott *et al.*, 1998; Muller *et al.*, 2007). Supplementary feeding with nutrient rich feeds is especially important in small-holder systems in East Africa because animal diets mainly consist of fibrous crop residues and low quality hay and pastures, which are low in protein and energy. Thus, increasing the protein supply through supplementation helps to build the microbial population to better digest and extract the nutrients in poor quality feedstuffs (Tolera *et al.*, 2000). Furthermore, supplementation is important to compensate for low availability and nutritional value of forage during dry periods (Bosing *et al.*, 2014).

With an increasing human population, land holdings are decreasing whilst animal numbers are increasing (Githinji *et al.*, 2009). At present, 70% of the 88.6 million ha of land in Tanzania are rangelands (Mwilawa *et al.*, 2008) with a carrying capacity of 20 million livestock units (LSU), and this land is capable of providing over 90% of feed resources to livestock (Njombe *et al.*, 2011). However, due to several constraints such as high stocking rates and a growing human population, these communal pastures typically have a low nutritional value, especially during the dry season (Mwilawa *et al.*, 2008). As of 2010, the contribution of the livestock sub-sector to the GDP was of 3.8% (NBS, 2011), yet it is the biggest land user of the economy, using 60 million hectares. Therefore, 68% of the land contributes to 3.8% of the GDP (Lugoe, 2011). In reversing this trend, more efficient feeding can alleviate land pressure due to reduced stocking rates, without compromising total animal mass output per unit area of land (Bosing *et al.*, 2014). However, the efficiency of supplementation will depend on the quality of the supplement (*ibid*), highlighting the importance of feed manufacturers in alleviating such pressures.

As previously discussed, the new growing demand propelled by the 'livestock revolution' provides opportunities for development in many regards. At a national level high protein foods can ensure wide-spread food security, whilst livestock producers can benefit from increased income, provision of employment, draught power, by-products such as skin for leather, and organic manure for improved soil fertility (Delgado, 2003). However, in order to achieve this, it is necessary for the nation to commercialise smallholder agriculture, as highlighted by the Tanzania Agriculture Policy 1997 and the Livestock Policy 2006 (Kurwijila *et al.*, 2011). Currently, practices such as beef fattening are not common in Tanzania (Mlote *et al.*, 2013). Although there is no data for Tanzania, reported usage rates of feed production and utilisation technologies in neighbouring Kenya, Uganda and Rwanda were of 33%, 4% and 12% (Lukuyu *et al.*, 2009). It is in

this context that compound animal feeds can play an active role in supporting national development, as the production of high quality animal feed is important for both feed manufacturers and livestock keepers. An optimal combination of ingredients ensures a rational use of available resources whilst meeting the nutritional requirements of the animal. Therefore, the feed manufacturer can reduce costs and the livestock keeper can maximize profitability through increased productivity (Babic and Peric, 2011). Optimizing ingredient blends can be achieved quickly and efficiently using mathematical linear programming (LP) methods, but for this to be of any value, it is vital that the nutrient content of the available feed resources are fully known and are crop, location and season specific. However, this is not an overnight process, and requires the coming together of numerous stakeholders. For example, funds and expertise at a national level are needed to carry out studies to determine the local feed resource base (and explore non-conventional sources of feed), whilst reliable laboratory facilities for chemical analysis are essential to determine the nutrient composition of feedstuffs on a frequent basis (Safalaoh, 2002).

Concurrently it is equally important to characterize the genetic resources such that the nutrient requirements of the animals can be precisely established. The large livestock numbers means that there are immense genetic resources of different livestock species. The a wide variation of genotypes and genetic heterogeneity in livestock populations in Tanzania, offers unique genetic attributes such as adaptation to heat and drought and a more efficient utilisation of low-quality forages (Mwambene *et al.*, 2014). Although this does provide an opportunity for breeding and selection, there is an urgent need to clearly define breeds in Tanzania, which would enable feed manufacturers to produce feeds which are accurately formulated to match the nutritional requirements of the target animal.

### **2.3.2 Nutrient requirements in animal feeding**

It is beyond the scope of this research to provide a detailed account of livestock nutrition, especially because this is a very specific subject area. Information regarding animal nutrition is well documented and there are several text books which provide extensive material of livestock's digestive physiology and metabolism (see for example D'Mello, 2000; Dryden, 2008 McDonald et al., 2011). Nonetheless, there are several underlying principles which must be given due attention when discussing the nutrient requirements and for different types of livestock in terms of energy, protein, minerals and vitamins (Parr, 1988). Table 1 below summarises these basic principles whilst keeping in mind the differences between ruminants and non-ruminants.

Table 1 Functions and sources of nutrients

<b>Nutrients</b>	<b>Description and key functions</b>	<b>Main sources</b>
<b>Fats</b>	<p>Fats are high in energy and provide about 2.25 times more energy than the same amount of carbohydrates, thus acting as a useful source of stored energy. Fat soluble vitamins are present in the lipid content of feeds, and therefore must be present in the feed, however excess fat lowers feed intake. Essential fatty acids within the oil fraction of feed ingredients are necessary for chick growth, egg production and milk with an adequate fat content. Stored fat also acts as a thermal insulator therefore maintaining body temperature (McDonald <i>et al.</i>, 2011). Typically, fats are sufficiently present in most feed ingredients and inclusion as true fat or oil is not common.</p>	<p>Oilseed by-products such as soya bean, cottonseed and sunflower.</p>
<b>Carbohydrates</b>	<p>Soluble carbohydrates consist of starch and sugars, which are easily digested, and are the main source of energy in animal feeds (Kellems and Church, 2010). Digestibility of starch and sugars is high and animals are able to utilize them well. Excess energy is stored as body fat (Lukuyu et al., 2009). In cereal grains, starch and sugars comprise up to 80%, serving as the main source of energy for maintenance and production.</p> <p>Crude Fibre (CF) consists of cellulose, hemi-cellulose and lignin and is found in the fibrous parts of plant material (Lukuyu et al., 2009). Ruminants are very efficient at digesting fibrous carbohydrates, and CF is essential for rumen functions and for the production of good quality milk (Parr, 1988) Contrarily, care must be taken with swine and poultry, as these are capable of digesting very little of the fibrous component in feedstuffs (Kellems and Church, 2010).</p>	<p><u>Soluble carbohydrates</u> Starches: Cereals, cereal by-products, tubers, roots. Sugars: Molasses</p> <p><u>Crude Fibre</u> Cereal by-products, maize stover, straw.</p>
<b>Protein</b>	<p>Proteins are one of the most important feed components and are an essential nutrient. Proteins are necessary for several functions within the animal body, and are a major constituent of most body tissues. Proteins are composed of amino acids which contain nitrogen (N), Protein is required every day for growth and development, maintenance, reproduction and lactation. Protein requirements tend to decline with age, nonetheless, requirements for amino acids are generally high. For non-ruminants, essential amino acids (e.g. lysine and methionine) cannot be adequately synthesised within the body and deficiencies limit the synthesis of proteins, which is why pre-mixes are commonly used in compounded feeds. This is not an issue for ruminants; rumen microbes are capable of converting non-protein nitrogen (NPN) into proteins, which are made available to the animal (Lukuyu et al., 2009; Parr, 1988).</p>	<p>Oilseed by-products Fish meal Blood meal.</p>

<p><b>Minerals</b></p>	<p>Mineral components should be considered individually during feed formulation, as these are important in body and tissue structure, digestion and absorption of nutrients and egg shell development. They can be classified into macro and micro-elements. Micro-elements are typically supplied as pre-mixes to be included in the ration, whilst the most important limiting macro-elements such as phosphorous (P), calcium Ca and sodium (Na), are typically supplied through the inclusion of inorganic material (Parr, 1988). Although the exact role that every mineral plays in an animal's metabolism is not clear, it is known that deficiencies of certain minerals cause symptoms which are relieved by adding the element to the diet (McDonald <i>et al.</i>, 2011). Minerals are commonly referred to as Ash, which is the inorganic material which remains after burning a feed sample (Lukuyu <i>et al.</i>, 2009).</p>	<p>Bone meal (P, Ca)  Cereal grain (P)  Fish meal (Ca)  Limestone (Ca)  Common salt (Na)  Dicalcium phosphate (Ca,P)</p>
<p><b>Vitamins</b></p>	<p>As with minerals, the natural dietary supply of vitamins provided by the raw materials must be considered before supplementing (Lonsdale, 1989). Although vitamins are required in relatively small quantities, they are very important in maintaining good animal health, especially because costs are low in relations to the consequences of a deficiency (such as a disordered metabolism and eventually disease) (McDonald <i>et al.</i>, 2011). Vitamin deficiency is less likely in ruminants, as they are capable of producing water-soluble vitamins within the gastrointestinal (GI) tract, whilst non-ruminants rely solely on feed for the supply of fat-soluble vitamins, meaning that vitamin supplementation is essential in non-ruminant feeding (Parr, 1988).</p>	<p>Cereals  Oilseed by-products  Manufactured pre-mixes</p>



## **2.4 Current status and challenges of the feed manufacturing industry**

### **2.4.1 Challenges faced by the industry**

The role of the industry should be that of providing high quality livestock feeds which meet the nutrient requirements of livestock in different stages of growth or production, whilst the production of such feeds remains economical, attainable only through the optimal blending of ingredients (Babic & Peric, 2011; Pathumnakul *et al.*, 2010). However, as it stands, the feed industry in Tanzania faces several constraints which ought to be addressed.

The lack of infrastructure means that there are few accredited laboratories which carry out chemical analysis of feeds. As a consequence, there is a little reliable data and information which results in animal agriculture being less competitively priced as compared to developed countries (de Jonge, & Jackson, 2013). The low confidence in the nutritional information of feed provided by suppliers' means that buyers (livestock farmers) are not guaranteed high quality feed. In itself, this suggests that the industry is under-developed, which can in part be explained by its infancy. As proposed by Safalaoh and Chapotera (2006), the absence of baseline data from which to anchor recommendations or development strategies, makes public and/or private sector interventions extremely difficult. Although this research was not set out to fill this information gap, it can be regarded as an important starting point in characterising commercial animal feed production in Tanzania.

Furthermore, formal quality control in Tanzania is uncommon both at the production site and at the selling point, a situation which is exacerbated by the reported presence of counterfeit labelling in the informal sector (Kurwijila *et al.*, 2011). This situation creates a lack of trust

between the various stakeholders. The agricultural sector in Tanzania is characterised by a high degree of informality (Skof, 2008), and it is assumed that the animal feed sector is no different. Although the informal sector typically has a strong presence in most of SSA, a recent study by Schneider et al. (2010) found that Tanzania is amongst a handful of countries which indicated a high level of informality, as it accounts for about 56% of the gross national income, 18% above the SSA average. However, the distinction between the formal and informal sector is not clear-cut, especially for smaller industries which are not closely monitored. Nelson & Bruijn (2005) define an informal activity as one which “has a formal counterpart” and “does not comply with the requirements of the regulatory system.” Therefore, for the purpose of this research, feed producers represented by the Tanzania Feed Manufacturers Association (TAFMA) will be considered formal, whilst those producers who are not part of the TAFMA will be considered informal.

As for the farmer, optimal feeding requires accurate information on the nutritional value of feeds in order to develop appropriate feeding strategies for different animals at various growth stages (Babic & Peric, 2011). A recent study by El-Sayed (2014) on the Egyptian aquaculture feed industry revealed some of problems which characterise animal feed sectors in developing countries, that is; over half of the feed producers do not carry out proximate analysis, 60% of producers do not receive quality control inspections, and less than half the samples analysed matched the values recorded on the labels. In addition to this, marketing supply chains are fragmented and underdeveloped. Transport systems are unreliable and inefficient which increases transaction costs and reduces the quality of perishable agricultural products (Mkenda & Van Campenhout, 2011). To further exacerbate matters, Tanzania covers a large area with

uneven population distribution, which makes it difficult for feed manufacturers to obtain the necessary inputs required for feed production.

#### **2.4.2 Role of the animal feed industry**

Despite being an important link in the livestock production chain, the animal feed industry is important to help ensure the safety of food for human consumption, and in order to achieve this, producers must adhere to good manufacturing practices in the procurement, handling, storage, processing and distribution of animal feed (FAO and WHO, 2008). Recent outbreaks such as bovine spongiform encephalopathy (BSE), *Escherichia coli* and *Salmonella* have highlighted the importance of the animal feed industry in public health, and although some curative measures may simply be improving staff training in feed mills (FAO and WHO, 2008), other measures are more complex require a strong and active institutional presence. For example, government bodies should be responsible for quality assurance and setting industry standards to be adhered to. Other more complex and long term duties may involve carrying out research on feed to attain an all-inclusive knowledge base of the nutritional characteristics of available feed ingredients, which also leads to the restriction or limited use of certain ingredients.

Developing the feed industry also presents an opportunity for the crop and livestock sectors to benefit from each other's production activities. Livestock and crop production have often been treated as mutually exclusive activities which compete for the same resources, and national development efforts have failed to integrate the two (Lwoga & Urio, 1987). However, the two sectors can go hand in hand. For example, feed manufacturers, through the use of crop residues, can add value to some of the major crops used for animal feed production. Furthermore, as a general rule, the animal feed industry cannot compete with the industries which produce food for human consumption, who pay higher prices for raw materials,

and only the remaining industry by-products which have satisfied their requirements, can be used in the animal feed industry (Shipton and Hecht, 2005). Thus, both crop producers and food manufacturing industries can benefit from the value addition generated from animal feed production.

The feed manufacturing industry also plays an important role in the socio-economic development in the country, making important contributions to employment, income-generation, and to linkages within the value chain. Furthermore, an efficient animal feed industry, producing affordable feed of high quality, can help ensure that smallholder livestock keepers are not excluded from the market opportunities presented by the socio-economic transformation taking place in Tanzania.

### **2.4.3 Feed manufacturers association**

Although literature and information regarding the Tanzania Feed Manufacturers Association (TAFMA) is almost non-existent, a scoping study carried out by ILRI (REF), found that the TAFMA, which had been previously set up, has been dormant for many years, but recently there has been growing interest to revive the association. A strong presence of the association is essential in protecting the interests of the animal feed industry within the country, and is also responsible in ensuring the quality and safety of compound feeds (FEFAC, 2013), which is achieved by setting clear rules and good manufacturing guidelines which ensure self-regulation and improved government regulation throughout the supply chain (Louw *et al.*, 2013). Furthermore, associations are useful in providing missing or inadequate services, improving bargaining strength with suppliers, and allowing a greater co-ordination of the flow of input supplies (Schmidt *et al.*, 2014). A feed manufacturers association is also required to address the

knowledge gaps within the sector, thereby setting the agenda for research and development (R&D) in order to enhance competitiveness and capacity to innovate, so as to ensure sustainable and resource efficient livestock production systems (FEFAC, 2013). Overall, the association has the duty to play a central role in the decision making process within the animal feeds industry (Louw *et al.*, 2013), acting as a link between all stakeholders in the sector, both public and private.

### **2.5 Value chain concept**

The value chain approach, which was first developed in the 60's and 70's (Kaplinsky, 2000), is increasingly being used in development research and practice in order to understand the interactions and relationships which occur in the dynamic and complex agricultural environments in developing countries (Rich *et al.*, 2011). A value chain includes all links, actors and activities that begin from the conception of a product through the intermediary phases of production and delivery through to when the product is consumed (Kaplinsky, 2000; Rich *et al.*, 2011). This process involves physical transformation and value addition. Although value chains are extremely complex and lack quantitative analyses, they provide a useful means of qualitatively characterising the interactions within livestock systems (Rich *et al.*, 2011), therefore providing a platform for key intervention areas. In relation to this study, an understanding of the value chain approach offers an opportunity for evaluating integrated intervention initiatives within the animal feeds sector. The use of the value chain makes this possible by recognising that compound feeds only form a single component of the value chain, whilst improved animal productivity through feed improvement depends on the efficacy of the entire value chain (Ayele *et al.*, 2012). Although this research will attempt to map the compound animal feed value chain, it makes no attempt to provide analysis of other sectors or actors within the value chain. This is

because there are many actors involved in the compound feed chain including farmers, raw material suppliers, manufacturers, distributors and farmers. All these actors influence the quality of a feedstuff but they also face their own individual challenges (Bishop, 2013), therefore each component merits individual analysis, which is far beyond reach of this research. This research will focus on the manufacturers' role, whilst taking into account broad considerations of the more general aspects regarding the compound animal feed value chain.

### **3. METHODOLOGY**

#### **3.1 Introduction**

The following section specifies how the research was conducted, including the methods of data collection and analysis. Firstly, the project background and study areas are described, followed by the research design for both the feed producer questionnaire and the feed sampling protocol. The procedure for chemical analysis is then explained, followed by the limitations of the methodology used in the study. It is worth noting that the data collection can be separated in two distinct parts; a feed producer questionnaire was used to characterise the animal feed industry in Tanzania, looking at issues such as production capacity and output, raw materials used, constraints faced etc. In this section, a mixed method approach is used to combine both qualitative and quantitative data. The second part of data collection describes the feed sampling protocol, which provides an account of the sampling procedure and chemical analyses.

#### **3.2 Project background**

The research was conducted on behalf of the International Livestock Research Institute (ILRI). The project on “enhancing dairy-based livelihoods in India and Tanzania through feed innovation and value chain development approaches” began in 2012, with the support of the International Fund for Agriculture Development (IFAD). The project is commonly known as MilkIT and falls under the CGIAR Research Program on Livestock and Fish, *“more meat, milk and fish by and for*

*the poor*” (CRP 3.7)<sup>4</sup>. The main aim of the project is to enhance dairy-based livelihoods in Tanzania by intensifying smallholder agriculture. The focus is on enhancing feeds and using innovation and value chain approaches (Diep Pham *et al.*, 2014)<sup>5</sup>.

### 3.3 Study sites.

The study was conducted in the cities of Morogoro, Tanga, Arusha, and Dar es Salaam (DSM).

The sites were selected by the MilkIT project based on several criteria:

- ✓ High cattle density
- ✓ High poverty level
- ✓ High population density
- ✓ Good access to market
- ✓ High production potential
- ✓ Deficit areas with the potential for increasing supply through feed interventions;
- ✓ Potential partners/stakeholders

Because Tanzania is a very extensive country with diverse people, cultures and agro-ecologies, the sites chosen for the project cannot be considered representative and as such it would be misleading and superficial to draw conclusions or make generic assumptions relating to Tanzania or East Africa. Instead, as explained by Sumberg (1996), due to the exploratory nature of the research, the aim was to use these areas to highlight the key issues which could be considered more generally. Having said this, the cities in which the study was carried out greatly differ in size and geographic location, which offers the opportunity to explore issues relating to scale, raw material availability, markets and prices.

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<sup>4</sup> For more information about “*more meat, milk and fish by and for the poor*”, visit <http://livestockfish.cgiar.org/>

<sup>5</sup> For more information about MilkIT, visit <http://milkit.wikispaces.com/>,



It is also worth noting that although the focus of MilkIT is on dairy based livelihoods, any intervention in the feed manufacturing sector must consider all animal feeds produced, especially because dairy feed constitutes a small percentage of manufactured feeds (Brown, 2013). Therefore, this project looks at the feed manufacturing sector from a holistic perspective.

### **3.4 Feed producer questionnaire**

In each study site, a facilitator was present in order to assist with translation. The facilitators were contacted (through project partners) several days before arrival in each location, and they were provided with a copy of the questionnaire and details about the project. This gave them the opportunity to familiarise themselves with the project and discuss any issues before proceeding with the interviews and sample collection. The questionnaire was piloted with one feed manufacturer and modified as necessary.

#### **3.4.1 Selection of participants**

The snowball sampling technique was used to conduct the interviews. This is a non-random sampling technique where “survey subjects are selected based on referral from other survey respondents” (Black, 2011). As stated by Katz (2006), “this sampling technique is often used in hidden populations which are difficult for researchers to access.” Although animal feed manufacturers who are represented by TAFMA are not hidden and are relatively easily located, the number and location of informal animal feed producers was unknown prior to the study. Therefore this technique was used to capture both the formal and informal producers. However, snowball sampling is non-random and subject to biases, as respondents who have larger networks are more likely to be recruited into the sample (Katz, 2006). In each of the four study sites, the first questionnaire was arranged, through contacts of the facilitator, with a respondent

which fitted the profile of the subject required for the study (i.e. animal feed manufacturers). Starting from the first respondent in each location, the subject was asked to provide the name, contact and location of other feed producers. A total of 14 formal and 11 informal producers were surveyed.

### **3.5 Feed sampling protocol**

The following protocol provides details of the feed sampling and analysis, which was developed following internationally accredited scientific guidelines for feed sampling and analysis (AOAC, 1990; FAO, 2011). The samples were collected from Morogoro, Tanga, Arusha and DSM.

#### **3.5.1 Feed selection**

The samples collected for this study can be divided into two distinct categories, raw materials and compound feeds.

*Compound feeds:* It is important that samples are representative of the whole, i.e. that the samples taken reflect the truth of what livestock farmers are buying. Therefore, the information provided by the feed producer surveys regarding product distribution, was used to track down the finished feeds to the final selling point. Where producers stated that they sell feeds directly from the point of production, samples were collected directly from the manufacturer. Furthermore, raw materials were collected for sampling both from the animal feed manufacturers and from outlets such as general animal feed shops and veterinary shops. The compound feeds selected for sampling include all types of compound feed used in livestock production, thereby excluding domestic and aquatic species. Therefore in each outlet and production site, one sample of each compounded feed for livestock production was collected. It is worthwhile mentioning that the number of different types of compound feeds for sale varied across producers and outlets.

*Raw materials:* The raw materials selected for sampling were the main ingredients, of plant and animal origin, used in compound feed production. It was not possible to define the target population prior to the study, as the raw materials used in the animal feed industry were not known. The feed producer questionnaire was used to provide information regarding raw material usage. The final sample set consisted of 169 compound feeds and 131 raw materials.

### **3.5.2 Procedure for sample collection**

*Compound feeds:* Where the feeds were sold in small packages (<2kg), the whole package was bought, and the quartering technique was used to reach the desired sample size (figure 2). Where feeds were sold by the kilo from a 50kg batch, several increment (hand grab) samples were taken from the open bag and combined in a clean container. Once again, the quartering technique was used to reach the desired size of the composite sample. Because settling of feed is common, handfuls were taken from the lower and upper end of the sack. It is important to take a sufficient number of increments in order to obtain a sample representative of the lot sampled. In some outlets, feed is only sold in 50kg bags, therefore a probe was used in order to avoid damaging the bag (appendix 6). Both the price per kg and the price per 50kg bag were recorded.

*Raw materials:* When samples of raw materials were taken from feed manufacturers, the random sampling technique was used and several increments (4-5) were taken from different bags using a probe. However, it must be noted that bags were sometimes stacked in piles, meaning it was only possible to take increments from the outer bags. When raw material samples were taken from outlet stores, in which they are sold in small quantities from open bags, several hand grabs were taken, as explained above.

The sample weight for both categories was of approximately 200g, which allows for sufficient material for analyses and back up, as well ease of storage and handling.

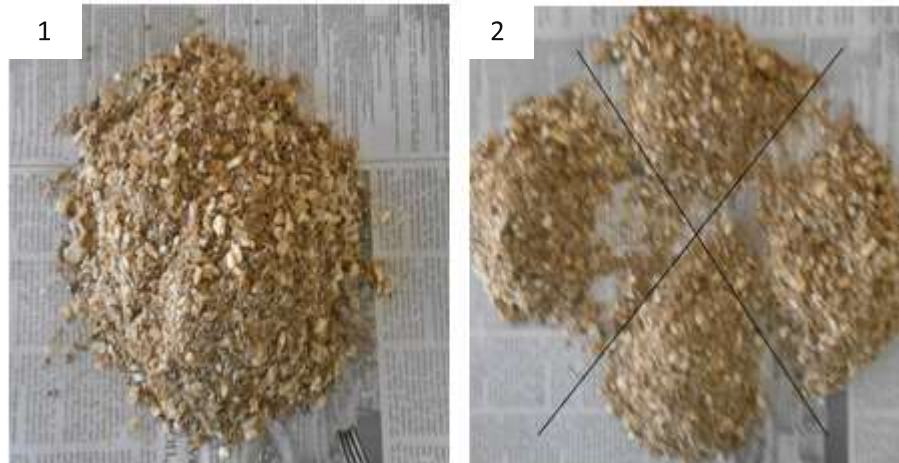


Figure 2 Quartering technique

- 1) Mix the sample and pour it into a pile, creating a cone.
- 2) Divide into four equal parts, saving the opposite quarters and discarding the rest. Repeat the process until the desired sample size is reached.

### 3.5.3 Sample handling and identification

This stage is very important in order to allow the samples to reach the laboratory as quickly as possible, without deterioration. Upon collection, the samples were placed in a polyethylene press-seal bags, of a size so that they are almost completely filled by the sample; the air is then removed by squeezing and sealing tightly, such that the laboratory can determine a dry matter concentration similar to that in the sample when it was collected. Samples were accurately labelled with a unique code using a permanent marker pen immediately after collection. In a separate log book, specific details of the samples were recorded (Appendix 3).

### 3.5.4 Sample preparation: storage, grinding

Sample preparation is required in order to achieve a homogeneous and consistent the sample for further analysis. To achieve good analytical data, sample integrity must be safeguarded

during transport to the laboratory and during preparation (drying and grinding) in order for the samples to remain representative of the whole and reduce the chance of chemical damage. The samples were stored in dry, cool facilities at the TVLA prior to DM determination. A mechanical mill was used to grind the samples (Appendix 4), until the particle size was such that it passes through a sieve with a 1mm aperture. This procedure was performed as fast as possible in order to minimise atmospheric exposure and to avoid generating excessive heat. After each sample was ground, the grinding machine was carefully cleaned to avoid contamination.

### **3.5.5 DM determination**

Dry matter (DM) content, which is the non-moisture portion of the feed, was determined by heating a weighed sample of feed (3g per sample) in a drying oven at 103°C, until a constant weight is reached.

The DM tests were performed by trained personnel at the Tanzania Veterinary Laboratory Agency (TVLA) in DSM. Subsequent nutrient contents of feeds will be appropriately compared on a DM basis. Each step in the DM procedure is explained below:

- i. Number the crucibles, rinse in water and dry the crucibles at  $103 \pm 2$  °C for at least 2 hours.
- ii. Place the crucibles in a desiccator and immediately cover desiccator and allow dishes to cool to room temperature. (Do not allow dishes to remain in the desiccator for more than 2 hours).
- iii. Weigh the empty crucibles to nearest 0.1 mg and record the weight on the work sheet as W1 (Appendix 5), removing each crucible one at a time from the desiccator and keeping the desiccator closed between dish removals.

- iv. Use tongs to handle crucibles and weigh about 3.0000g of sample into the tare weighed crucible to the nearest 0.1 mg. Record this as W2. Shake the dish gently to uniformly distribute the sample and expose it to the maximum surface area for drying.
- v. Insert samples into a preheated oven at  $103 \pm 2$  °C and dry for at least 2 hours, start timing once oven has reached the required temperature (dry to constant weight, may need to check this for various sample types once confirmed use that drying time).
- vi. Place samples in a desiccator and close the desiccator in order to allow cooling to room temperature. Do not allow samples to remain in the desiccator for more than 2 hours.
- vii. Weigh the dish with the dried sample (recorded as W3), recording the weight to nearest 0.1 mg.
- viii. DM is then calculated as:

$$\% \text{ DM} = (W3 - W1) \times 100 / (W2 - W1)$$

Where,

W1 = weight of empty dish (g),

W2 = weight of dish and sample (g), and

W3 = weight of dish and sample after drying (g).

The dried portion was then returned to polyethylene press-seal freezer bags with the rest of the sample. The final step of sample preparation was that of reducing the sample size to be sent for NIRS analysis. Each sample was thoroughly mixed and the quartering technique was used to reduce each sample to two samples of 30g each. The duplicate samples were required as a risk mitigation in case any sample is lost or ruined during transport, and were stored at the TVLA in DSM.

### 3.6 Near-Infrared Reflectance Spectroscopy

The samples were dispatched from the TVLA on the 6<sup>th</sup> of August using an express courier service. The Near-Infrared Reflectance Spectroscopy (NIRS) Method (AOAC, 1990) was used to estimate the composition of feeds, in Hyderabad, India. This methodology is increasingly used as it requires minimal sample preparation, it is rapid and non-destructive, allows for simultaneous measurements of multiple parameters, and enables a large quantity of sample analysis at a low cost per sample (Corson *et al.*, 1999; De Boever *et al.*, 1993; Kellems & Church, 2010; McDonald *et al.*, 2011). NIRS is based on the absorption of electro-magnetic radiation in organic compounds present in the sample, in the wavelength region of 1100-2500 nm (Corson *et al.*, 1999; McDonald *et al.*, 2011). All samples were analysed and calibrated against conventional laboratory analyses. The NIRS instrument used was a FOSS Forage Analyzer 5000 with software package WinISI II. Out of a total of 294 samples<sup>6</sup>, 147 were selected for calibration and 147 for validation procedures using the WinISI II samples selection programs. Validation procedures were based on blind-predictions of laboratory measurements by the NIRS equations developed in the calibration procedures. Relationships between blind-predicted and measured variables were described by R<sup>2</sup> and standard error of prediction (SEP) (see appendix 7 for calibration statistics). The NIRS analyses was used to determine Crude protein (CP) (which was by multiplying the N content by 6.25), ash, fat and *In Vitro* organic matter digestibility (IVOMD). It is important to note that IVOMD was calculated using *in vitro* prediction equations which relate to ruminants and most of the feeds in this project feeds concern monogastrics, particularly chicken. For this reason, this component will be excluded from the data analysis.

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<sup>6</sup> Includes samples collected from a project on animal feeds in Ethiopia.

### 3.7 Data analyses

Microsoft Excel (2013) will be used to produce simple descriptive statistics with the data generated from the feed producer survey. In order to gain a more complete and coherent understanding of the animal feeds sector, qualitative data will be mixed with the quantitative data within the analysis. GenStat 17<sup>th</sup> Edition was used to analyse data relating to product quality. Due to the unbalanced design generated by random feed sampling, the restricted maximum likelihood (REML) method was used to estimate variance components in order to estimate the effects of source of feed supply (market or feed producer), type of producer (formal and informal), and frequency of feed analysis, on feed quality parameters. REML was used as it is a preferred method of estimation as it is a mixed effects model well suited for unbalanced data (Blanche *et al.*, 2006; Marchenko, 2006). A regression analysis was performed in order to establish possible price quality relationships per unit of CP in compound feeds. P values of < 0.05 were considered as significant.



## **4. RESULTS AND DISCUSSION**

### **4.1 Mapping the value chain**

The information and understanding gathered during the entirety of this project has been used to map the value chain of the compound feeds sector in Tanzania, as shown in Figure 3. However, it must be noted that this is a simplistic representation which is specific to this study. This will serve as an introduction to several themes which will be discussed in greater detail further on. The flow of processes in the chain are presented horizontally, with the direction of the arrows indicating linkages and functions.

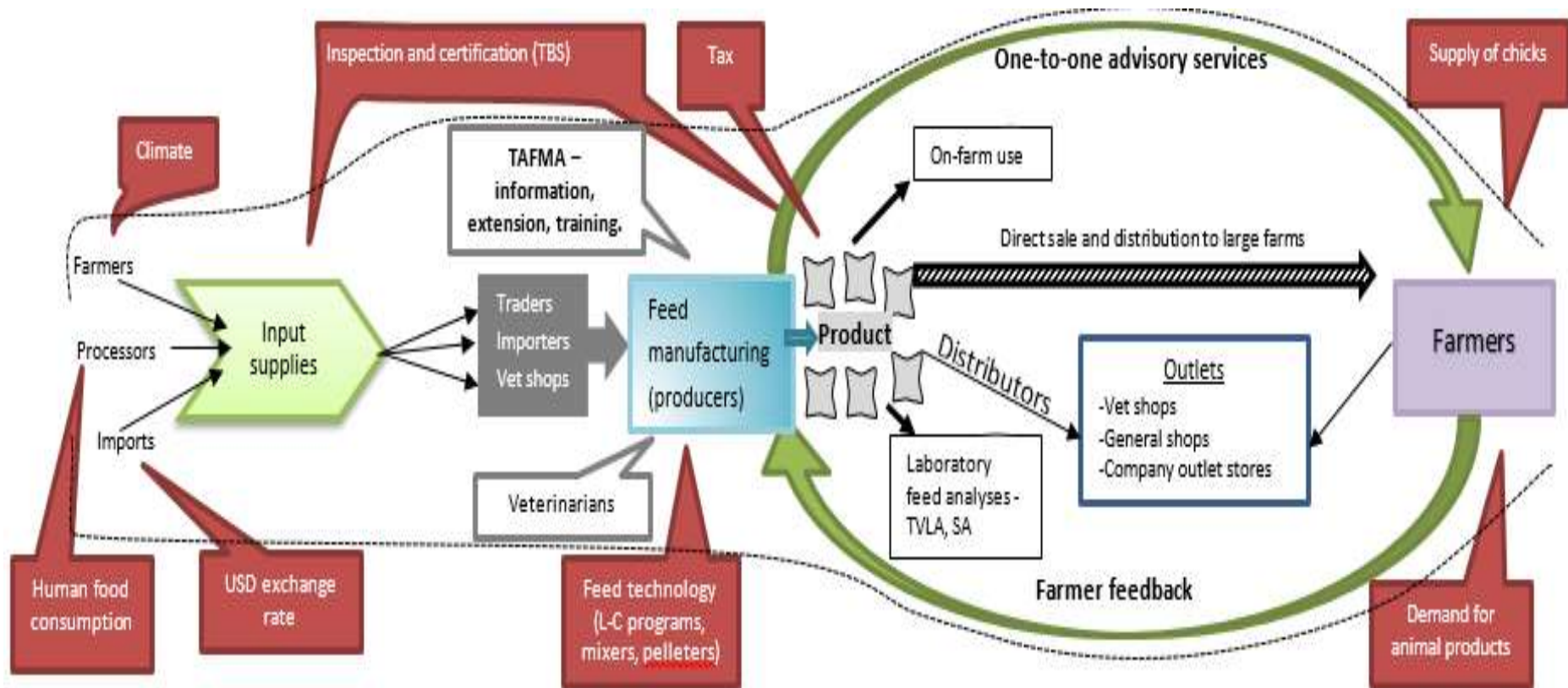


Figure 3 Map of the animal feeds in Tanzania.

Note: Everything outside the dotted line represents external factors which have an impact in the industry. These are structures and institutions beyond direct control of participants in the animal feed chain (Legese et al., 2008).

Figure 3 provides a snapshot of the animal feeds industry in Tanzania. Most plant and animal based ingredients are sourced in Tanzania, with the exception of soybean, which is in part imported from Zambia and India. Producers do not commonly deal directly with farmers. Brokers (locally known as *dalalis's*) act as middlemen and negotiate transactions between farmers and feed manufacturers. The *dalali's* are key actors and do not share market information. They form loyal relationships with feed producers and are an important form of quality control. Large companies (mainly in DSM) which process materials for human consumption supply by-products to the animal feed sector. Premixes, additives and minerals are mainly imported (e.g. Belgium, Holland, China and Tunisia), but there a few companies who produce in Tanzania. There are very few importers of premixes, feed additives and minerals, who distribute throughout the country. Manufacturers buy these micro-ingredients from veterinary input shops.

Most producers use small, locally produced mixers, with an output of 1 to 1.5 t/hour. Only two of the larger companies use imported mixers (from India and the UK) whilst one company uses pelleters (from China). Several companies use a least-cost (L-C) computer programmes from Holland. Quality inspection and certification schemes are the responsibility of the Tanzania Bureau of Standards (TBS), whilst the manufacturers that analyse their feeds do so at the TVLA and the TBS (a few use laboratories in South Africa). Some companies outsource veterinarians for feed formulation, whilst others have veterinarians within the company. It is also common for mills mix on request, where farmers either bring their own ingredients (and formula specifications), or buy the raw materials from the manufacturer, paying a fee for the mixing service. Few companies market their product by handing out leaflets and conducting seminars with farmers on appropriate feeding practices.

Once the finished feed is produced, producers tend to integrate forward into the value chain by delivering feed directly to farmers (usually only in quantities >10 bags=500kg), as profit margins are higher. The final product is also distributed to various outlets for sale. Some larger companies operate their own distribution system with appointed agents throughout the country. A number of feed producers also run their own commercial poultry operations, therefore producing feed for on-farm use and for sale.

Once the farmer uses the product, they provide feedback to the manufacturers. If they have complaints, they phone the number labelled on the bag. Farmers often complain about poor quality feeds, but feed manufacturers claim that farmers dilute the finished feed with cheap energy sources such as maize bran. For this reason, it is common for feed manufacturers to provide one-to-one support to farmers, carrying out personal farm visits when necessary and providing knowledge about animal nutrition and management.

#### **4.2 Employment**

The following section discusses the employment in the compound feeds sector. This only relates to those directly employed by the feed producing companies. The total number of people employed by the feed companies surveyed is 375.

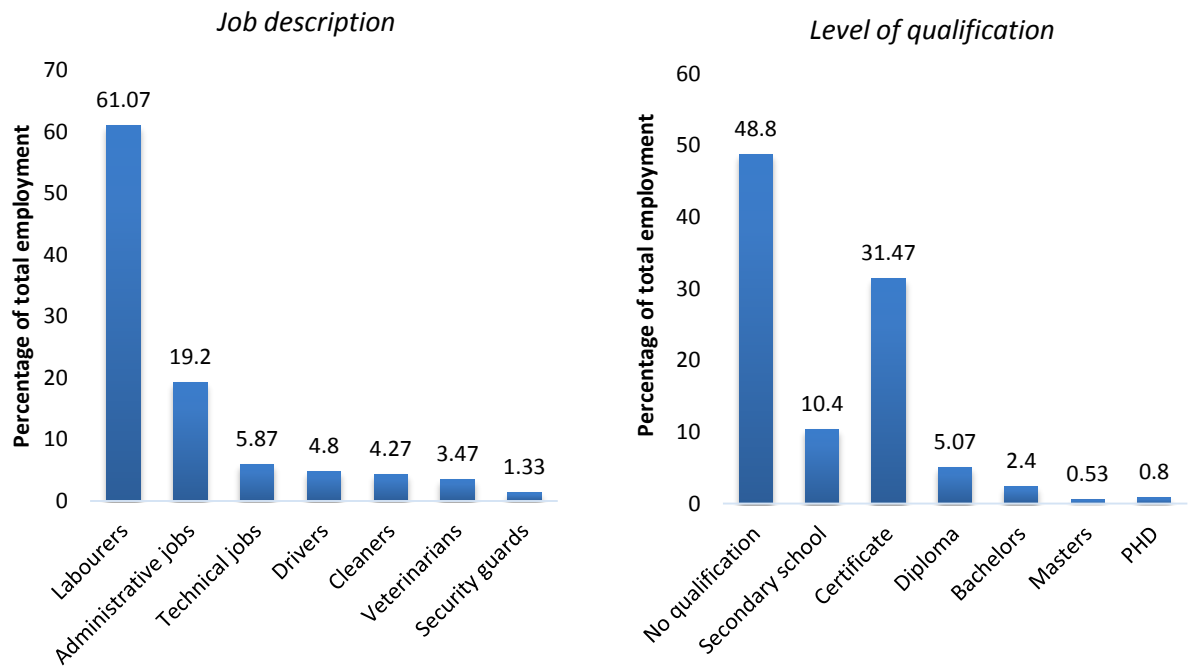


Figure 4 Employment and level of qualification in the compound feeds sector

Note: Administrative jobs include directors, managers, assistants and supervisors (relating to production, sales and supply). Technical jobs include technicians, engineers and mechanics. Total respondents of 24, as one respondent was unable to provide employment information.

As shown in Figure 4, the dominant form of employment is labour (61% of total). Manual labourers are commonly referred to as day labourers, performing duties such as loading raw materials. This unskilled labour explains why almost half of the total workforce in this study are not qualified. Although this does show that the sector is labour intensive and characterised by a low degree of mechanisation, it also highlights the importance of the industry in job creation. Furthermore, these figures only refer to those directly by the feed manufacturing companies, however the compound feeds sector indirectly creates additional jobs to other actors in the value chain (e.g. suppliers, traders, distributors etc.)

It is also worth noting that there appears to be a shortage of qualified experts with the sector. This is clear when looking at the level of qualification within the sector. The lack of expertise within the sector was also reported by a few respondents, not in terms of numbers but in terms of availability. According to one respondent, there are plenty of highly qualified experts, but

most of them have been absorbed by the government. Although there is no recent evidence to support this, Minga *et al.*, (2000) found that of the 400 veterinarians available at the time, most are employed by the government, whilst others are private practitioners or own drug distribution businesses. The results from this study supports this as only 3.7% of the total employment are veterinarians.

### 4.3 Product distribution

Product distribution (fig. 5) describes how companies get their products to the final consumer. The majority of compound feeds are sold through distribution channels (73.2%). Some companies operate their own distribution system whilst other pass their products through a retailer before being sold to the consumer.

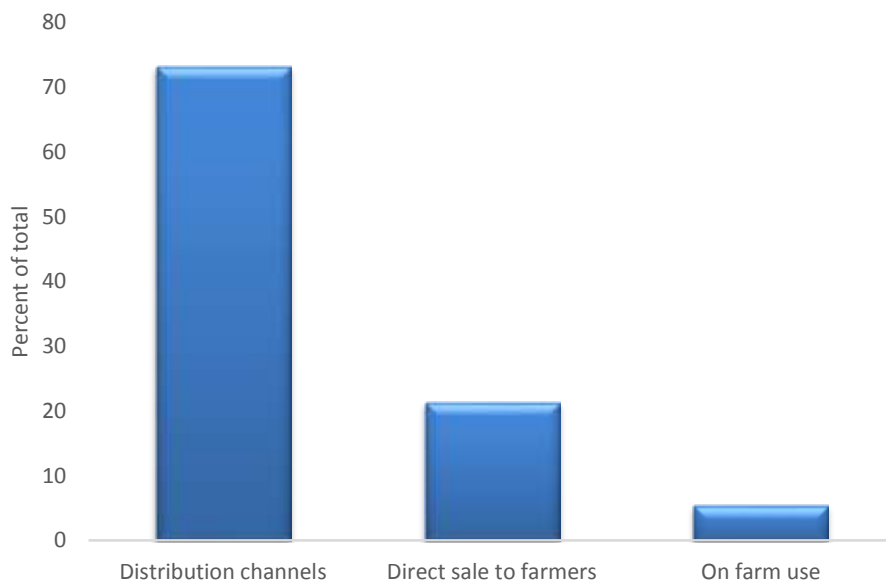


Figure 5 Product distribution

The fact that several companies are vertically integrating within the value chain by selling directly to farmers may indicate that feed production in Tanzania is becoming increasingly market-oriented. Strong customer relationships are an important source of market-related knowledge, whilst at the same time producers are more service oriented, offering consultancy to

farmers with regards to animal nutrition and husbandry (Bröring, 2010), which seems to be an attempt to establish loyal relationships with the client base.

#### **4.4 Production**

##### **4.4.1 *The Production Process***

The representation below highlights the main flows in the production process of animal feeds (Figure 6). However, this schematic depiction is that of a typical animal feed producer. This cannot be generalised to say that all companies follow the same production process. For a few of the producers that were surveyed, it was clear that the production process was more complex and elaborate than what is presented below.

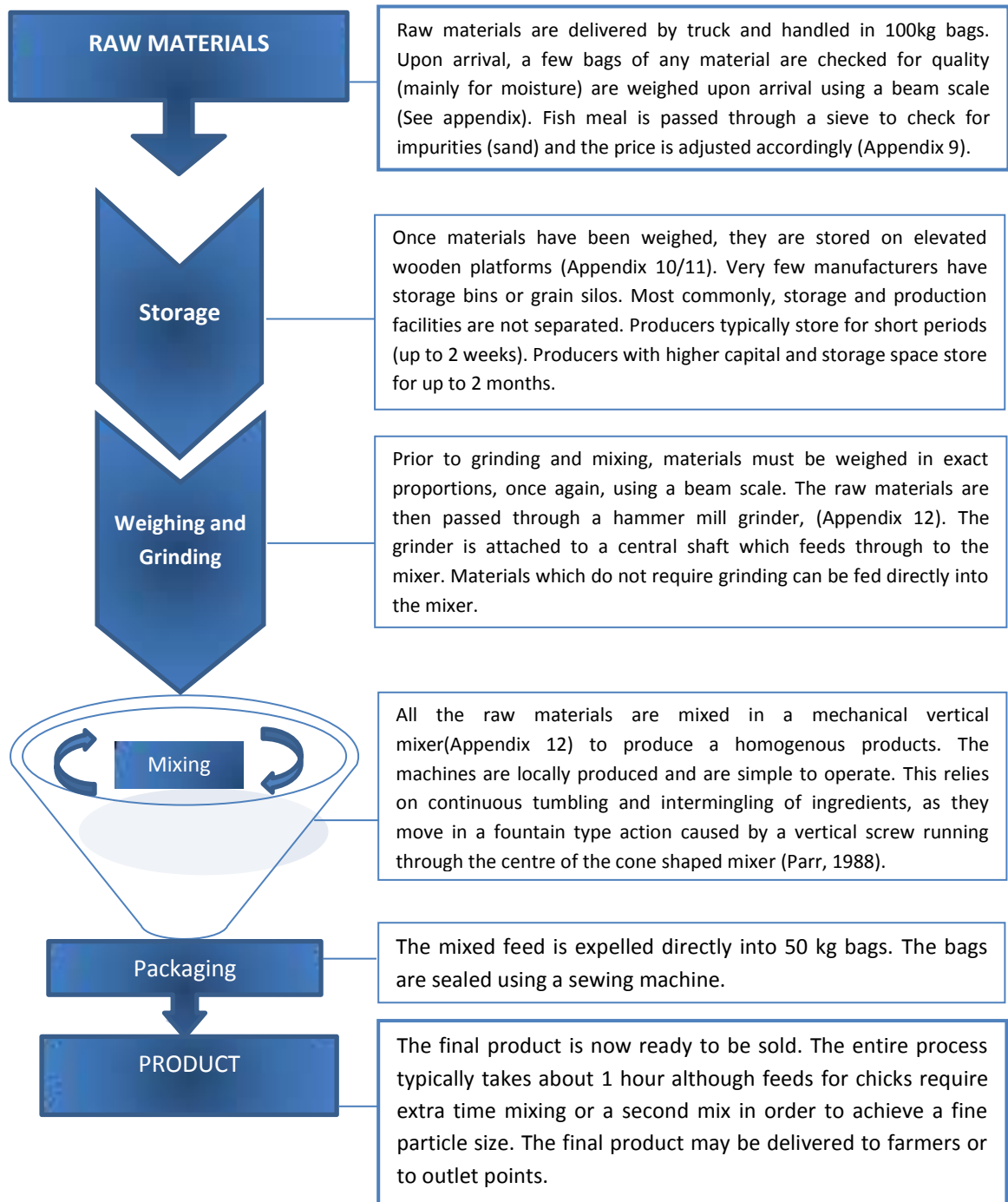


Figure 6 The production process



#### **4.4.2 Total production**

This study revealed that the 25 manufacturers surveyed produce an average of 227.2 t/working day, and the average production per manufacturer was of 9.09 t/day. Although this study by no means attempts to quantify national production of compound feeds, a global feed summary compiled by Alltech (2013), suggests that the production of feed in 2012 in Tanzania totalled 258,000 tonnes, ranking the country 98<sup>th</sup> out of the 134 countries assessed. Although Alltech does recognise that “numbers for developing countries may be less accurate” (Alltech, 2013), the figures do indicate that animal feed production in the country is relatively low, especially when compared to neighbouring Kenya, which is a country of similar history, geography and population (Miguel, 2004), yet produced 955,000 tonnes of animal feed in 2012 (Alltech, 2013), almost four times more than Tanzania.

#### **4.4.3 Production Capacity**

Figure 7 shows the installed and actual production of all the feed companies surveyed. It was found that on average, feed mills operate at 48.9% of their installed capacity, whilst hardly any companies operate close to full capacity. Although not presented below, the average quantity produced per company is of 9.1t/day.

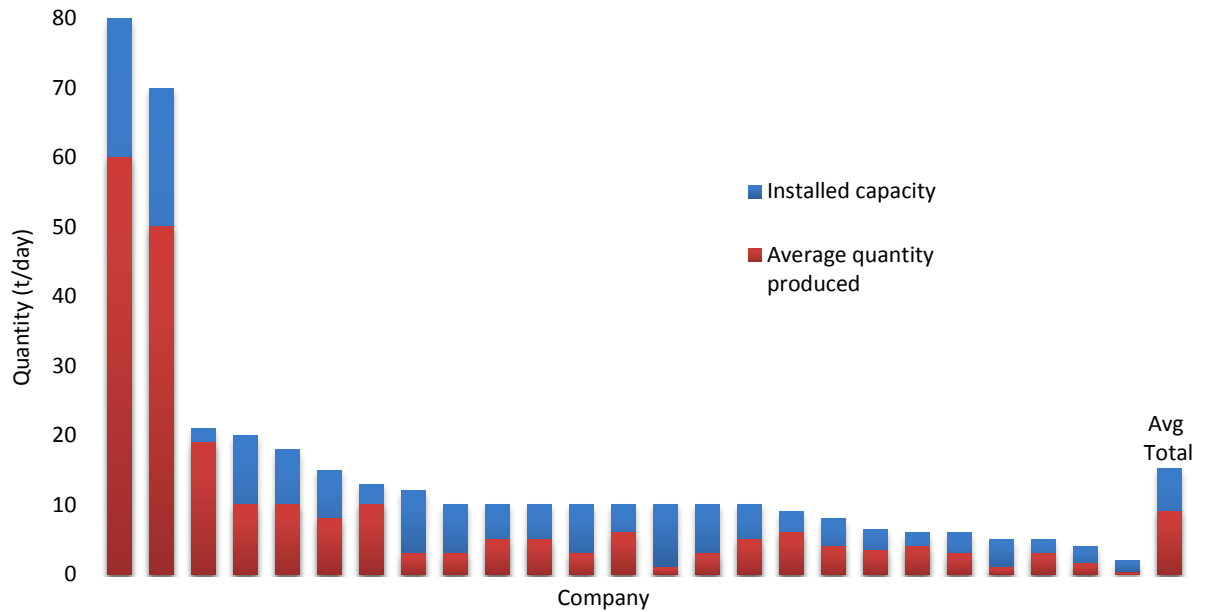


Figure 7 Installed vs actual production

Note: figures are estimates because most manufacturers were not able to provide accurate output figures.

The results presented in figure 7 highlight a phenomenon which is common in Tanzania. That is that livestock sub-sectors operate far below full capacity. In the dairy sub-sector, most of the processing plants operate at less than 30% of the installed capacity (TAMPA, 2011), whilst slaughtering facilities also operate below 50% capacity (UNIDO, 2012). Similarly, Egbinike and Ikpi (1988) found that feed mills in Nigeria were operating at 36.52% of the installed capacity, whilst a more recent study of the feed milling industry in neighbouring Kenya found that feed mills operate at 44.8% of the installed capacity (Githinji *et al.*, 2009). Although this is a cause for concern as it implies production inefficiencies, it also offers an opportunity for growth in the use of animal feeds, as feed millers would be able to absorb extra demand.

#### 4.4.4 Production by species

The section below presents the production of compound feeds according to livestock species. It was revealed that the compound feeds sector in Tanzania is dominated by poultry feed products.

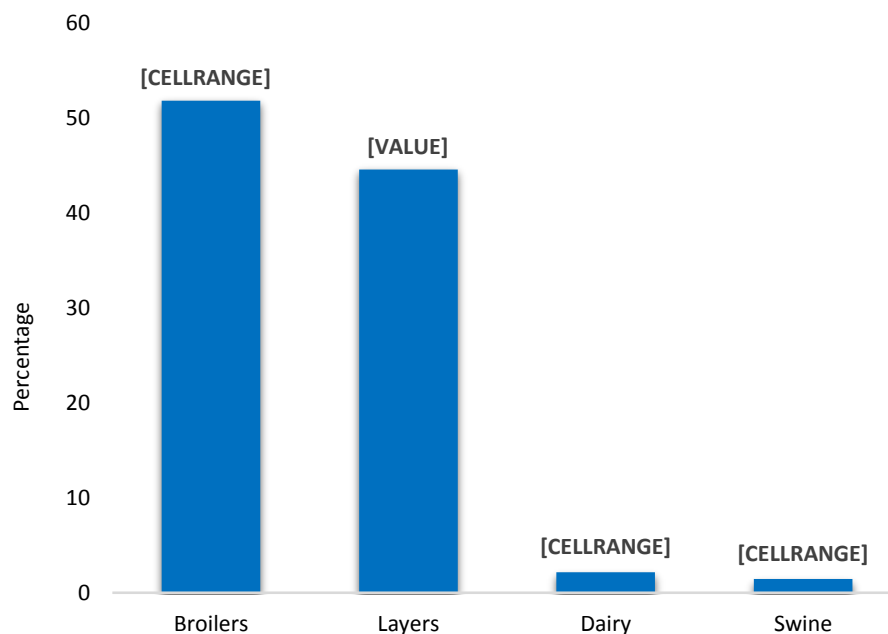


Figure 8 Compound feed production by livestock species

Note: Figures are estimates. Three of the 25 respondents were unable to provide estimates as they reported a large amount of seasonal variation.

As shown in Figure 8 combined poultry products (broiler and layer feeds), make up 96.41% of animal feed products, whilst dairy and pork products are almost absent, and beef compounds are completely non-existent. Once again, these findings are comparable to neighbouring Kenya, where poultry feeds form roughly 90% of feed mill products (Githinji *et al.*, 2009). These findings further confirm the trend which characterises East Africa, as the low usage rates of dairy feed production and utilisation technologies in neighbouring Kenya, Uganda and Rwanda were of 33%, 4% and 12% (Lukuyu *et al.*, 2009). In contrast, recent data published by the Department for Environment Food and Rural Affairs (DEFRA) paints a different picture regarding the production of animal feeding stuffs in a developed country. In Britain, cattle and calf feed products make up 39.8% of the total production followed by poultry, pig and sheep feed at 31.3, 16.4 and 6.8% respectively (DEFRA, 2014), whilst in 2006, Poultry represented 32% of global feed production (Bröring, 2010).

This findings above the dissimilarities in feeding and management systems between SSA and Western Europe. Despite the large cattle population in Tanzania, it is clear that very few farmers provide their cattle with compounded feeds for both beef and dairy cattle. Informal conversations with farmers at a milk collection centre in Tanga revealed that farmers do not feed compounds because of the high cost. The farmers stated they supplement their cattle mainly with maize bran, cottonseed cake and sunflower seed cake, whilst the mineral requirements are met through the provision of mineral lick blocks (MLB's)<sup>7</sup>. As stated by Mlay *et al.*, (2005), farmers use these raw materials as they are widely available and low cost sources of energy and protein. Moreover, the dairy farmers claim that their cattle are of low genetic potential, due to the fact that artificial insemination (AI) is costly and unreliable. These findings are consistent with those of Gillah *et al.* (2013), who found that AI services are not commonly used for the same reasons mentioned above, and that supplementation of dairy cows in Morogoro and DSM occurs with protein rich concentrates during times of low feed availability. It is likely that the low genetic potential perceived by farmers' implies they do not justify the returns to investment of feeding dairy meal.

#### **4.4.5 Raw material usage in the sector**

The following section presents details on raw material usage in compound feed production, and when possible respondents also provided information regarding the source of ingredients used. Respondents were also asked in what quantities they use each ingredient (per week). This was used to show levels of incorporation in compound feeds.

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<sup>7</sup> MLB's contain several minerals, and are provided with the assumption that animals will regulate their mineral intake thereby avoiding deficiencies (Zervas *et al.*, 2001).

Table 2 Raw material usage and origin

	Ingredient	Quantity used (t/week)	Number of mills using the ingredient	Level of incorporation in formulation (%)			Source of ingredient
				Average	Min	Max	
<i>Energy sources</i>	Maize grain	98.1	24	39.87	14.68	80.90	Dodoma, Mbeya, Tanga, Iringa, Manyara, Songea
	Maize bran	23.908	24	10.33	2.39	25.69	Local maize millers
	Wheat pollard	1.31	8	3.59	0.76	6.96	Flour milling industry DSM
	Wheat bran	1.936	6	5.49	1.47	15.25	Flour milling industry DSM
	Chick wheat	0.82	3	4.76	2.94	8.25	Flour milling industry DSM
	Rice polishing	5.086	15	5.34	0.49	16.38	Rice milling industry Morogoro
	Broken rice	0.82	2	0.36	0.07	0.65	Rice milling industry Morogoro
	Rice bran	2.2	1	14.12	14.12	14.12	Rice milling industry Morogoro
	Sorghum	0.732	2	6.23	0.18	12.27	NA
	Cassava flour	0.006	1	0.07	0.07	0.07	NA
<i>Protein sources</i>	Fish meal	20.392	22	8.14	1.46	19.06	Mwanza, Musona
	Cottonseed cake	17.608	22	7.14	1.28	17.70	Mwanza, Shinyanga, Kahama
	Sunflower seed cake	20.94	23	11.19	0.52	30.95	Dodoma, Singida
	Soybean meal (toasted)	9.966	17	5.69	1.26	13.40	Mbeya, Morogoro, Uganda, India (processed in DSM).
	Soybean meal (full fat)	1.56	3	4.37	2.82	7.15	NA
	Blood meal	3.42	17	2.95	0.40	8.56	Mazizini processors (DSM)
	Coconut cake	1.08	2	4.12	1.10	7.13	NA
	Palm oil cake	0.058	1	0.79	0.79	0.79	NA
	Lentil bran	0.2	1	0.55	0.55	0.55	NA
	Brewery yeast	0.2	1	0.94	0.94	0.94	Brewery industry (Arusha & DSM)
<i>Minerals, additives and premixes</i>	Bone meal	4.448	22	2.91	0.16	11.01	Mazizini processors (DSM)
	Limestone	7.328	23	4.51	1.20	11.93	Coast region
	DCP	2.602	21	1.03	0.13	7.70	Holland, Germany, India, China, Tunisia
	Methionine	0.642	24	0.41	0.03	5.16	Holland, Tunisia
	Lysine	0.492	24	0.31	0.03	3.87	Holland, Tunisia
	Common salt	0.732	21	0.41	0.02	2.58	Coast region

Oyster shells	0.766	5	2.15	0.09	3.67	Coast region
Poultry premix	1.564	23	0.77	0.06	3.67	DSM, Thailand, Tunisia, Arusha, DSM.
Toxin binders	0.134	7	0.13	0.03	0.38	Holland, Belgium
Enzymes	0.026	5	0.06	0.01	0.17	India, China
Growth promoters	0.026	3	0.32	0.03	0.84	India
Molasses	0.126	3	0.31	0.15	0.47	Sugar refineries (Morogoro, DSM)
Coccidiosat	0.002	1	0.09	0.09	0.09	NA
Carotenoids	0.01	1	0.03	0.03	0.03	NA

*Note: The above data was gathered from 24 feed manufacturers. 1 respondent was unable to provide estimates. Several respondents claimed that they only deal with suppliers and are unaware of the source of certain ingredients.*

Figure 9 provides a visual breakdown of the various products used in feed compounding. Maize products were by far the most used ingredients (53.20% of the total).

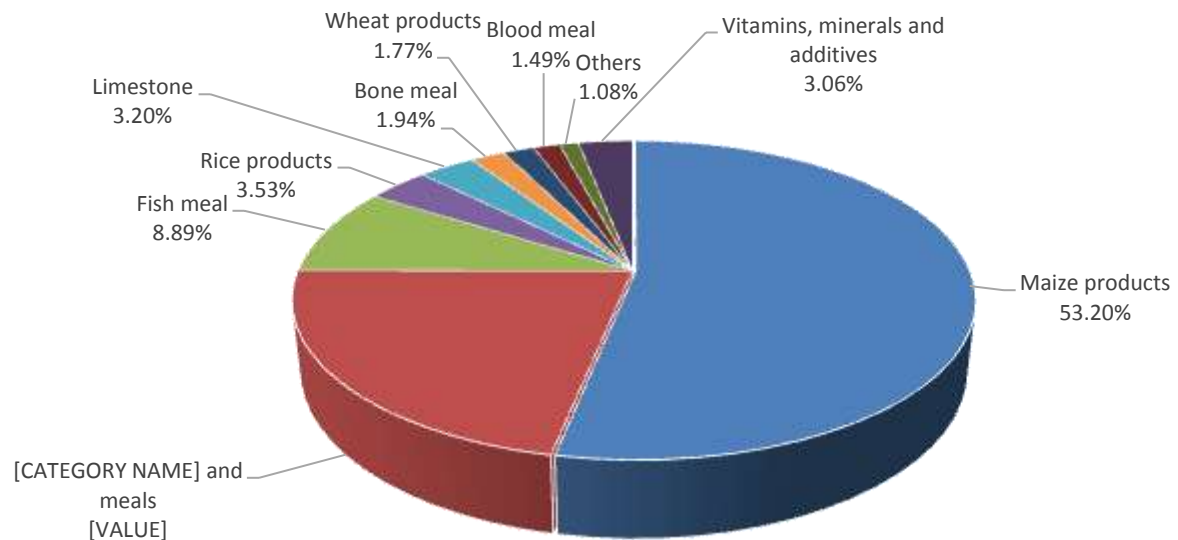


Figure 9 Breakdown of ingredient usage in feed compounding

It is by no means a surprise that maize is by far the most used input in the animal feeds sector in Tanzania. In fact, maize products (maize grain and maize bran), represent 53.20% of all inputs used by feed compounders, which is very similar to the South African and Kenyan feed industry, where maize represented 54% and 50 to 65 % of inputs used respectively (Githinji *et al.*, 2009; Louw *et al.* 2013). In Tanzania, maize accounts for 32% of total food production and it serves as a source of income for 85% of the population (Chile and Talukder, 2014). Similarly, this study shows that the compound feed industry relies heavily on maize. One key issue is that Tanzania is dependent on rain-fed maize production as a source of national supply (Cooksey, 2011), leading to large variations in price and supply. This situation is likely to be exacerbated by the expected increase in climate variability in the future (Rowhani *et al.*, 2011). This this is an issue which the animal feed industry ought to address, possibly through exploring the use of non-traditional and locally available feed sources.

The use of soya in Tanzania does merit significant consideration. Despite the promising potential of soya bean for its use in human and livestock feeding mainly due to the high protein and oil content compared to other plant protein sources (Foley *et al.*, 2013; Friedman & Brandon, 2001; Oliva-Teles *et al.*, 1994; Palić *et al.*, 2011), soybean has remained a minor crop in Tanzania and production has been far below its potential, which has been attributed to the lack of knowledge on its use in animal feeding (Malema, 2005). The fact that soya bean is not widely used in the animal feed industry is made clear by the fact that 17 out of 24 manufacturers use it in formulating diets (70.83%). This is low when compared to South Africa, where 60% of the national crop is used in the animal feeds sector (Dlamini *et al.*, 2014). On a global scale, soybean demand for the animal feed industry has been driving worldwide expansion of this crop (Steinfeld *et al.*, 2006), such that soybean meal is the most dominant of all animal protein sources globally. In 1999 soybean meal accounted for 46% of the total volume of protein used in the EU animal feed sector (Brookes, 2001). However, the situation in Tanzania is different, as this study revealed that the use of fish meal is almost double that of soybean meal (table 2).

The relatively low usage rates of soybean in Tanzania is likely due to a shortage of supply within the country, as the availability and price of raw materials is most important in influencing ingredient use (Brookes, 2001). In fact, it is interesting to note soybean is the only imported raw material (excluding minerals, additives and premixes) in the animal feed industry. This is an issue which requires consideration as the increased national production of soybean would help overcome the shortage and lower prices, whilst reducing the dependency on fishmeal, which is a highly volatile product in terms of both price and supply (Sitjà-Bobadilla *et al.*, 2005). Furthermore, Chianu Jonas *et al.* (2008) reported that fishmeal from Mwanza is variable and the protein content can be as low as 32%, and contamination with inorganic materials (sand) is



common. The problem of sand contamination was also frequently mentioned by respondents (Appendix 13). This further suggests the need to pursue cheaper and more reliable protein sources in the industry. Sunflower seed cake and cottonseed cake were the most used plant protein ingredients in this study, however, these oilseeds are typically of lower protein and higher fibre (consequently lower energy levels) compared to soybean (Jagadi *et al.*, 1987; Mutayoba *et al.*, 2011). Issues relating to quality will be further discussed in section 4.7.3.

#### 4.6 Constraints in animal feed production

Respondents were asked about the constraints they face in their feed manufacturing business (fig.10). Credit was the most frequently mentioned constraint (78.26%).

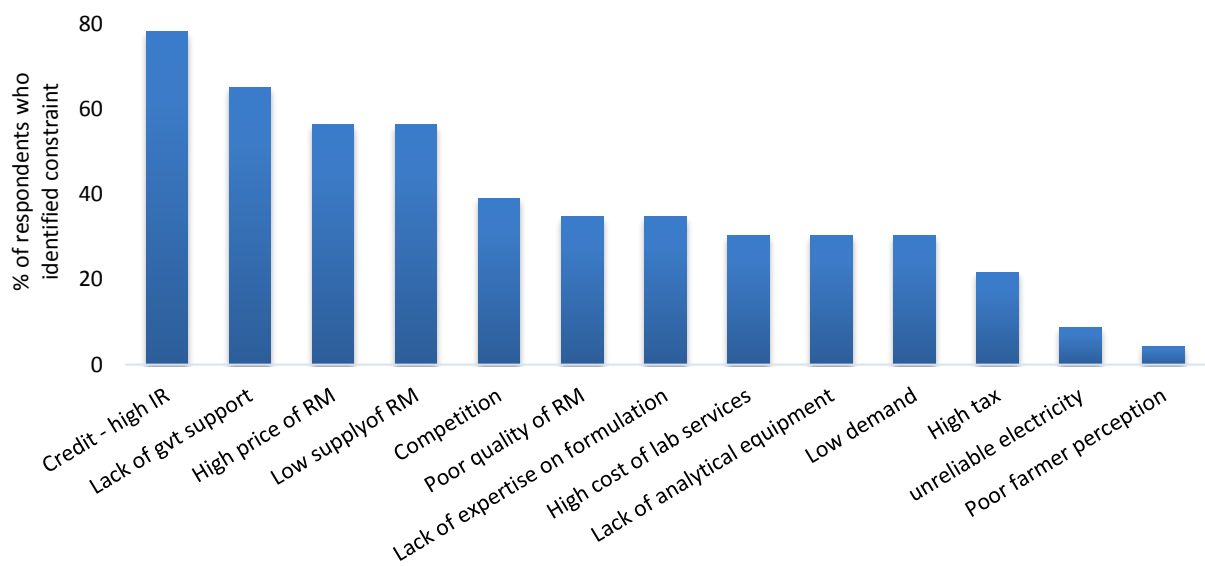


Figure 10 production constraints identified by respondents.

Note: 2 of the 25 respondents chose not to comment on the constraints. Both were production managers and claimed to be unaware of the challenges involved in running the business. One respondent claimed not to have had any constraints in the short time he has been operating (less than one year).

Specifically, respondents commented that interest rates (IR's) are high (typically over 20%).

Although there are credit services which offer much lower IR's, these are very difficult and take a long time to obtain. These claims can be confirmed by what was found by Weber and Musshoff

(2012), that is, that although micro-finance institutions do exist, agricultural firms do face higher obstacles to get credit. Lack of government support, was the second most mentioned constraint, and all of the respondents claimed that they have never received any form of government support such as extension services, training of feed formulation, or subsidies.

Respondents were then asked to rank the constraints they identified in descending order of importance. What is important to notice is that although high tax was only mentioned five times as a constraint, it ranked as the most important constraint four of the five times (figure 11). As an agricultural input, animal feed companies are exempt from Value Added Tax (VAT) (MOF, 2005), but several respondents voiced their concern that VAT exemption on agricultural inputs may be removed. It is therefore likely that those who mentioned high tax as a constraint were referring to the threat of the introduction of VAT in the animal feeds sector.

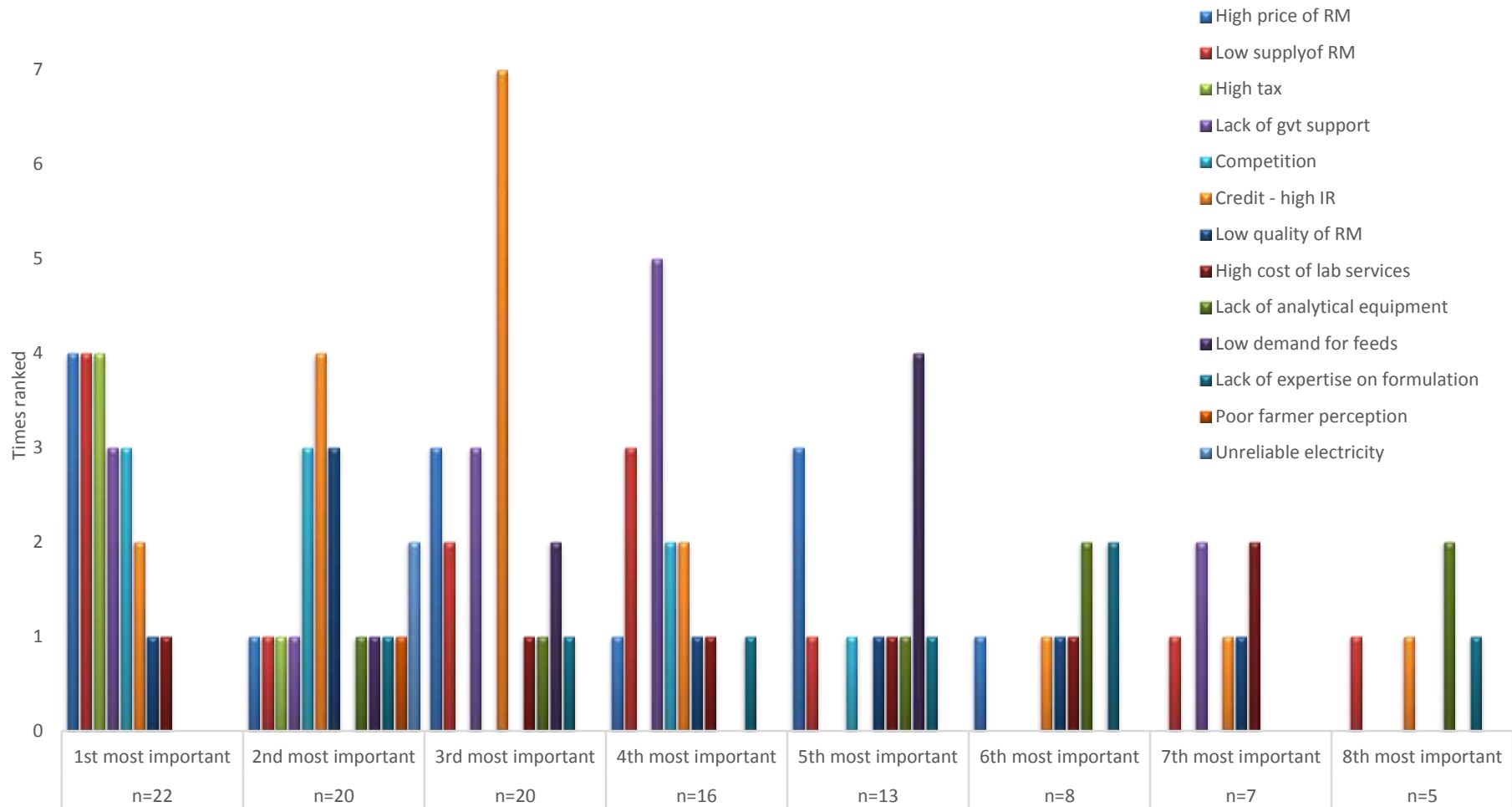


Figure 11 Ranking of constraints faced by feed producers

Note: n indicates the number of responses, which differs due to the fact that the number of total constraints mentioned varied between respondents. For example, two respondents identified only one constraint whilst five respondents identified 8 constraint

## 4.7 Product standards

### 4.7.1 Feed analysis

Figure 12 below shows how often feed manufacturers perform proximate analysis of their finished products and raw materials. Seven manufacturers never analyse their compound feeds, and it was often stressed that farmer feedback is the most important form of quality control, and 15 manufacturers never analyse raw materials. It is worth noting that all of the companies that never analyse their feeds produce 3 t/day or less. On the other end of the scale, the three companies that analyse their feeds most frequently (once a week) produce 10 t/day or more. Nonetheless, even several of those who do carry out proximate analysis claimed that farmer feedback is an important part of quality control.

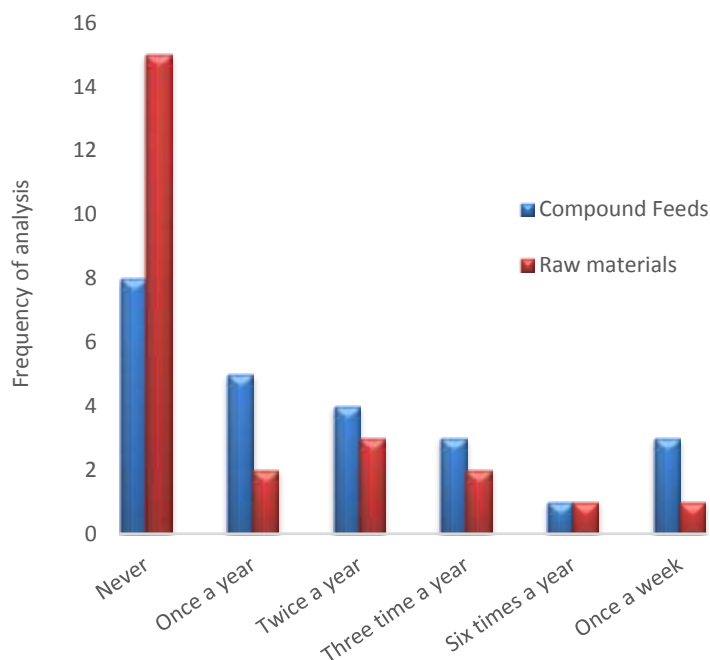


Figure 12 Proximate analysis of compound feed and raw materials

Note: number of respondents was 24, as one respondent was unable to respond as the subject claimed that only the company owners are aware quality control.

These findings indicate that many small scale manufacturers do not justify the cost of feed analysis (at 15,000 TSH = 9 USD per sample at the TVLA laboratory), as it is clear that small

producers incur a disproportionate increase in unit costs relative to larger producers. Another problem which emerged was the fact that the TVLA (which is the main laboratory used for feed analysis) do not perform analysis of raw materials, although there is a plan to calibrate the NIRS with raw materials, so that it can be deployed in the animal feed industry (Maulaga, personal communication, 2014). Furthermore, it is clear that the industry lacks statutory regulation and monitoring as only 3 out of 25 respondents had received one quality control inspection, whilst none of the producers label the nutrient contents of their feeds. Manufacturers seem to have no legal obligation to monitor the quality of their feeds, an issue which is brought about by the lack of enforcement of regulations. It was revealed that the TBS, which is the national standards body responsible for quality control, has outdated quality standards which have not kept up with international standards and ought to be reviewed. However, setting appropriate standards requires significant research in order to establish the nutritional requirements according to species, inherent genetic potential, environment, raw material availability, stage of livestock production and management factors (Mandal *et al.*, 2005; Vaidya, 2001).

This study showed that 9 of the 25 interviewed use L-C computer programs, 10 use feed tables and 6 formulate rations solely based on experience. For feed products to be competitively priced and for manufacturers to maximise profit, L-C ration formulation software is very important. Considering the fact that that feed can constitute up to 80% of total costs, it becomes clear that L-C formulation can provide manufacturers with an opportunity to minimise the cost of inputs used, whilst farmers can be guaranteed efficient feed at a minimum diet cost (Kellems & Church, 2010; Pesti & Miller, 1993).

#### 4.7.2 Price and quality

A linear regression analysis, which plotted price as the response variable, showed that there is a significant positive correlation between price per kg and CP ( $p < 0.01$ ), however, a low  $R^2$  value (0.17) shows a poor predictive value of the data (fig. 13).

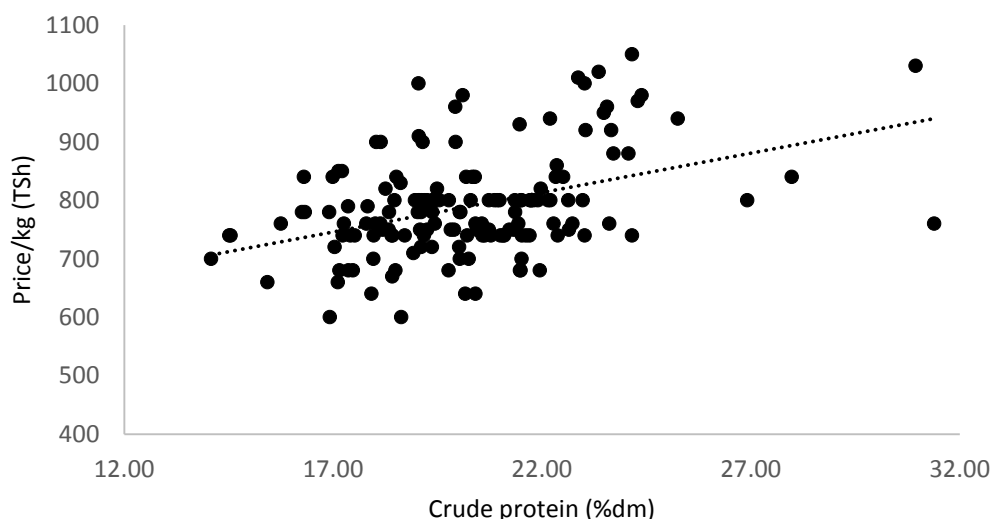


Figure 13 CP and price of compound feeds

These findings indicate that despite the lack of statutory control product labelling, and large amount of variability, there appears to be a system self-regulation within the industry, which may be explained by the competitive nature within the industry, meaning that manufacturers are forced to competitively price their products in order to retain their clientele. In order to explore issues relating to product quality. Although competition was mentioned as a constraint by 39% of the respondents, farmers may be benefitting from the competitive environment as producers strive to maintain the quality of their products.

Because several respondents had mentioned the fact that adulteration of feeds with maize bran, and counterfeit packaging has been a problem in the past, a REML analysis was run in order to establish whether there are differences in CP further down the supply chain. The results showed that despite there being a significant difference ( $p < 0.01$ ) between the supplier type (point of

manufacturer and open market), there was no significant difference between the mixed effect of supplier type and sample type on cp. This is due to the fact that different categories of compound vary in their optimal nutrient composition, for example, the protein requirement for layers is lower than that for broilers. The REML was also used to look at differences in CP between formal and informal producers. Once again, the factors were significant on their own, but there was no interaction between the factors. The same outcome was again attained in assessing whether there are difference in CP between producers who never analyse their feeds and those who do.

### 4.7.3 Nutrient composition of compounds and ingredients

Table 3 Mean ( $\pm$ SD) nutrient composition of compound feed samples

Feed type	N	%				
		DM	Fat	Ash	CP	IVOMD
Broiler Starter	36	89.95(0.52)	2.46(1.49)	10.27(1.34)	20.68(3.01)	NA
Broiler finisher	41	90.01(0.49)	2.99(2.12)	8.75(1.27)	20.25(2.35)	NA
Chick feed	17	89.56(0.66)	3.29(2.65)	10.53(1.48)	20.80(3.22)	NA
Growers mash	19	90.14(0.43)	3.23(1.87)	10.62(1.40)	18.72(1.96)	NA
Layers mash	35	89.94(0.53)	2.79(1.86)	10.93(1.73)	19.52(2.01)	NA
Dairy meal	6	90.71(0.46)	3.90 1.80)	12.16(1.72)	19.61(2.03)	62.62(3.07)

*N = number of samples; DM = dry matter; CP = crude protein; IVOMD = In vitro organic matter digestibility; NA = not analysed.*

*Note: all parameters (except DM) are expressed on a dry matter basis.*

Table 4 Mean ( $\pm$ SD) nutrient composition of common ingredients used in the animal feeds sector in Tanzania

Feed type	N	%			
		DM	Fat	Ash	CP
Cottonseed cake	27	91.15(0.39)	5.54(2.83)	7.97(1.19)	31.38(4.92)
Sunflower seed cake	27	91.98(0.28)	10.94(2.97)	7.83(0.84)	28.64(2.36)
Fish meal (Mwanza)	32	90.14(0.67)	5.13(2.65)	14.21(2.90)	49.23(3.45)
Fish meal (sea)	9	88.36(0.70)	1.72(1.52)	19.47(2.85)	39.45(1.94)
Soybean meal (toasted)	15	91.17(0.28)	6.15(5.08)	9.82(2.42)	39.34(5.56)
Soybean meal (FF)	5	91.11(0.11)	15.58(0.88)	9.86(0.48)	37.46(1.38)
Maize bran	36	90.22(0.45)	6.11(3.08)	7.94(1.26)	14.58(1.40)
Maize grain	33	88.95(0.31)	3.50(1.41)	4.53(1.31)	11.17(1.40)
Wheat bran	7	90.31(0.25)	1.85(0.67)	9.42(1.02)	18.81(0.98)
Wheat pollard	6	90.15(0.24)	1.97(0.63)	8.55(1.31)	17.46(1.67)
Rice polishing	10	90.26(0.65)	5.01(2.91)	14.86(3.28)	14.87(3.25)
Lentil bran	8	90.72(0.70)	2.09(3.65)	10.67(1.87)	19.21(4.71)

*N* = number of samples; *DM* = dry matter; *CP* = crude protein; *IVOMD* = *In vitro* organic matter digestibility; *NA* = not analysed.

Note: all parameters (except *DM*) are expressed on a dry matter basis.

The *DM* content of all compound feeds and raw materials were within acceptable ranges, and had a low standard deviation. As stated by Kaijage *et al.* (2014), this suggests that all feeds analysed are appropriate for use and storage in animal feeds. High *DM* contents control the growth of mould in feeds (Akande *et al.*, 2006), thereby reducing deterioration which is particularly important in tropical countries (Kaijage *et al.*, 2014).

The high levels of ash recorded in the fish meal may indicate a high mineral content, however further analysis would be required in order to determine the proportion of acid insoluble ash (RAO and Xiang, 2009), so as to detect the presence of undesirable materials such as sand, as this was a problem frequently mentioned by feed producers.

Crude protein (*CP*) is the most important quality indicator in animal feeding (Dale *et al.*, 2012) and therefore merits considerable attention. At a glance, the figures related to *CP* in Table 3 are



twofold; whilst the mean CP of all compound feed categories can be considered satisfactory, there appears to be large variation, as indicated by the standard deviation (SD). The satisfactory levels of CP can be appreciated when the means of CP are compared to statutory requirements in other countries. For example, the mean CP of Broiler finisher feeds in this study was of 20.68%, whereas the minimum recommended levels of CP in Broiler Starter feed in Kenya, Malawi, and India are of 22%, 22%, and 20% respectively (De Groote *et al.*, 2010; Safalaoh & Chapotera, 2006; Vaidya, 2001), and the typical value of CP in broiler starter feeds is of 23% (Bregendahlet *al.*, 2002; Miller, 2004). Although there are a limited amount of studies which have assessed the quality of compound feed in SSA, these results do contradict what has been revealed by several authors. For example, Safalaoh & Chapotera (2006) found that the mean CP in broiler starter, growers mash and dairy meal was of 16.96%, 12.54% and 11.34% respectively, several percentage points below the averages presented in table 3. El-Sayed (2014) and Eze (2011) have also suggested sub-optimal protein contents in compound feed products in Egypt and Nigeria respectively. On the contrary, the results show that the mean CP in dairy meal (19.61) fall within the ranges reported by Lukuyu and Blummel (2010) of 18-23% in neighbouring Kenya. All other quality parameters in this study also show acceptable values in various countries (for examples of such measures, see Carew *et al.*, 2005; De Groote *et al.*, 2010; Safalaoh & Chapotera, 2006; Vaidya, 2001)

As for raw materials, despite the high CP content of fish meal (49.23% from Mwanza) relative to other protein sources, several other studies have shown that fish meal CP can be as high as 60% Nadeem *et al.*, 2005; Nalwanga *et al.*, 2009). Nonetheless, the high CP in fish meal relative to other protein sources does justify the high rate of inclusion within the industry (discussed in

section 4.4.5). The average CP in both full-fat and toasted<sup>8</sup> soybean meal was of 37.46 and 39.34% respectively, which is lower than the typical ranges of between 40 to 50%DM (Foley *et al.*, 2013; Friedman & Brandon, 2001). Furthermore, studies conducted in Tanzania by Jagadi *et al.* (1987) and Mutayoba *et al.* (2011) revealed higher CP values in soybean meals (52.4% and 46.26% respectively). In addition to this, soybean meal (toasted) had a large amount of variation, as the standard deviation of CP in was the highest amongst all samples, but this is likely due to the fact that the product is sourced from different countries (e.g. India and Uganda) and is likely to have been subject to different processing methods. The other oilseeds (cottonseed cake and sunflower seed cake) had mean CP of 31.38 and 28.64% respectively. As for sunflower, Mlay *et al.* (2005), found that the CP of sunflower seed cake in Morogoro was of 23.6%, whilst a feed database collated by ASARECA suggests that cottonseed cake values in Tanzania range from 24,9 to 48,6% (Mgheni *et al.*, 2013).

Rather than providing extensive discourse on each raw material, it is clear that raw materials greatly vary in their composition, as is clear by the high SD's in table 4. This is by no means an abnormality, as composition is affected by a range of factors including cultivar, soil type, growing conditions and processing method (Dale, 1996). Although variation in raw material composition is inevitable, it is clear that feed manufacturers encounter difficulties in achieving consistency in product quality, a problem which is exacerbated by the fact that 62.5 percent of the company's surveyed never analyse raw materials.

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<sup>8</sup> Toasted soybean meal has undergone processing for the removal of oil either mechanically or by using solvents. Full-fat soybean meal is where the oil contained has not been extracted. Both products must undergo heat processing to reduce the presence of anti-nutritive factors such as Trypsin inhibitors (Maclsaac *et al.*, 2005; Subuh *et al.*, 2002).

## **5. CONCLUSION**

Overall, it seems that there is a concerted effort by producers to provide quality feeds, but it appears that producing a product of consistent quality is not easy to achieve, as the composition of the raw materials is what ultimately determines the quality of the finished feed. The results from the feed analyses showed that despite the fact that the sector is characterised by a high degree of informality, few expertise, the lack of government regulation, and very few laboratories for feed analysis, the compound feeds produced are of satisfactory quality. However, it can also be concluded that there is a large amount of variability in the compound feeds, which means that farmers are still not guaranteed a high quality feed on a frequent basis. This places a greater emphasis on the importance of raw material analyses, both for the producer and at a national level, in order to vast database of the available feed resources. The increased confidence about nutritional quality would allow farmers to use this information in order to develop feeding strategies for improved animal performance and income. However, this could not be successfully achieved without improving knowledge and training on livestock nutrition management.

### **5.1 Limitations of the study**

Although this research does provide valuable insight and data relevant to the compound feed sector, the data must be treated with caution for several reasons;

One limitation of the study is the short time period in which the data was collected. The feeds were sampled over a 20 day period which therefore does not address issues relating to seasonal variation both in terms of quality and quantity. Furthermore, the samples were collected towards the end of the rainy season, which coincides with the beginning of harvest. This means that the strong seasonality of available quality and quantity of feeds which is typical in Tanzania,

is likely to translate into better than average marketed feed products during the time of sample collection, with likely effects on price. This warrants further research into the effect of seasonal variation on raw material availability and composition feed in Tanzania.

The most significant limitations of this study was the lack of several nutritional components. Due to the fact that the IVOMD and ME were calculated using *in vitro* prediction equations which relate to ruminants, they are not applicable to the majority of compound feeds, which were mainly poultry products. The lack of accurate energy components is severely limiting due to the fact that energy is one of the most important indicators of feed quality, since it is required for the execution of metabolic processes and animal activity, essential for maintenance and production (McDonald *et al.*, 2011; Palić *et al.*, 2012). This means that knowledge of this parameter is extremely important in diet formulation and in assessing the quality of a given feed. In addition to this, a break-down of mineral components present in the ash component of the feed would have been useful providing regarding the mineral supply within feeds in Tanzania (Kaijage *et al.*, 2014), whilst at the same time it may have offered an opportunity to explore issues relating to adulteration.

Another problem which was encountered was the small number of samples for different feed types. This made it difficult to achieve statistical significance when performing REML variance analyses. This problem may have been avoided by collecting more samples, or by replicating the initial samples, in order to improve the quality of the input data (Rowhani *et al.*, 2011).

## **5.2 Policy implications**

The findings of this research suggest at least 4 overarching policy implications, intertwined around the absence or deficiency of institutions at various levels.

First, credit has been found to be the most common constraint to production in Tanzania. In order to address the credit issue, policy needs to first assess what are drivers behind the lack of viable access to credit, and act accordingly by developing customised solutions. Microfinance has for long represented a valuable and effective tool to enhance credit accessibility – being known for bringing benefits that expands beyond credit, such as empowerment and promotion of gender equality. Yet, this research found that microfinance in the Tanzanian context may not be the best solution to address credit constraints, and there is need for developing credit and savings models that provide flexibility, responsiveness and self-direction.

This issue, in particularly impellent as the possible introduction of VAT tax on agricultural inputs may further exacerbate the limited finances of the producers in Tanzania, in turn negatively affecting production operation and outcomes. Ultimately, the benefits resulting from the enhancement of the status-quo of livestock feed production in Tanzania would not be confined to this only sector, but contribute to pro-poor growth and following spill-over effects positively influence the wider well-being.

Widespread lack of laboratories facilities hampers systemic and frequent analysis of feeds, especially for smaller producers who cannot incur in large costs, which would jeopardise their situation. As a result, the potential for ameliorating the sector performance is significantly hindered. Therefore, policy should address the lack of infrastructure, perhaps by public-private partnerships.

Extensive lack of statutory regulation within the sector implies the pressing need to develop a system of formal regulations and guidance, which comply with internationally accredited

standards. This would have to be monitored through on-going research on quality and safety issues in animal feeds.

It is self-evident that all these issues are embedded in the lack of institutional presence, and accountability. Governance poses the basis of a sound system both economically and socially, and therefore could benefit animal feed production, and ultimately the farmers, through a wide range of trajectories and means.

These all-encompassing remarks inform a multi-dimensional and holistic approach, which should aim at strengthening research, availing credit to the industry, and create, monitor and enforce rules and regulation to govern the industry.

The role of TAFMA will prove critical in bringing together the stakeholders needs and capabilities. In addition to pragmatically offer advisory services to the producers, TAFMA should also provide voice and momentum to the producers' perspectives across the boundaries of institutions and organisations. TAFMA represent a grassroots informed actor, with the great potential of merging the public and the private sector, and contribute to both by lobbying for legislative framework, and by increasing market opportunity, which will ultimately engender development in Tanzania.

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# APPENDICES

## Appendix 1 – Ethical clearance

Required	pprover
Notepaper	✓
you	✓
qualification any University	
responsibility project.	
easily by	
:	
given opinion	
participation you	
anonymous	
you pervisor quality	
sheet/questionnaires	

dated  
please and  
stated  
amend

make  
info sheet and  
survey

Alexander W.M. Geerts



specify degree: Agriculture and Development  
specify

Alistair Murdoch

proj

to the quality and of central feeds sold on the market in Tanzania

description

Feed producers will be visited the pt of in person. Also, commercial feed products will be collected and to analyse

~~14/07/201~~ 14/07/20  
~~29/07/201~~ 29/07/201

funded by: Research related expenses funded by ILRI  
funded by:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Feed producers

Yes   
No

If yes, give brief details below:

---

---

7. Where is the research to be undertaken?

Reading area   
UK outside Reading area   
Outside UK (specify) Tanzania

8. What forms of data collection does the research involve?

Group discussions   
Personal interviews   
Telephone interviews   
Postal/fax/e-mail survey   
Other (specify): \_\_\_\_\_

9. Who will undertake the collection and/or analysis of data?

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10. Does the research require participants to consume any food products?

Yes   
No

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Yes   
No

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12. Are participants offered a guarantee of anonymity and/or that the confidential?

Yes   
No

If yes, give brief details of the procedures to be used to ensure this below:

The responses will be treated in confidence and aggregated with data from other respondents such that individual response cannot be identified. Findings will be anonymised.

Participants should be provided with the guidance given on pages 3

Will participants receive written documentation?

Yes  if so, it must be attached for clearance  
No

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participants be required to complete a separate consent form?

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15. Will participants be offered any form of incentive for undertaking the research?

Yes  If funds are to come from a University account, specify project code: \_\_\_\_\_  
No

If yes, give brief details below:

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16. Has the research been subject to any other form of ethical review?

Yes   
No

If yes,

*It has been subject to review by the institutional research ethics committee (IREC)*

17. Is there any other information that should be taken into account in providing ethical clearance for this research?

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[Signature]

supervisor

[Signature]

05/07/2014

Email: A.W.M. Geerts@student.reading.ac.uk  
ethical clearance decision should be sent) PLEASE MAKE THIS LEGIBLE !

For group projects, names and email addresses of all participating students:

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

### Ethical Approval

Note: The process of obtaining ethical approval does not include an assessment of the scientific merit of the questionnaire. That is the responsibility of the academic supervising your project, or your Principal Investigator.

Status:

- Clearance refused \_\_\_\_\_
- Clearance granted as presented \_\_\_\_\_
- Clearance granted subject to revisions suggested  \_\_\_\_\_

Committee

[Signature]

1000

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Signature:

[Signature]

14 14



## Appendix 2 - Feed Producers Questionnaire

### Feed producer survey

#### 1. General Information

Company name: \_\_\_\_\_.

Website \_\_\_\_\_.

Cell-Phone(s) \_\_\_\_\_.

Landline \_\_\_\_\_.

Name of respondent \_\_\_\_\_.

Title of respondent \_\_\_\_\_.

Ownership (tick appropriate):

Sole proprietor	<input type="checkbox"/>	Limited liability	<input type="checkbox"/>	Co-operative	<input type="checkbox"/>	Group	<input type="checkbox"/>
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Others (specify) \_\_\_\_\_.

Key Contact person (Managing Director, Marketing manager, others) Name \_\_\_\_\_.

#### 2. History of the company

i) When did the company start business in the feed milling industry? \_\_\_\_\_

ii) For how long has the company been in the business? \_\_\_\_\_

iii) Does the company have other branches? \_\_\_\_\_

If yes, how many branches does the company have? \_\_\_\_\_

iv) List the branches (if more than one) in the descending order of production capacities

No	Branch name	Branch location	Contact person	Cell No.
1				
2				
3				

v) Do you consider other feed producers as competitors for a limited market or is the demand for feed greater than the ability to supply?

\_\_\_\_\_

\_\_\_\_\_

vi) Can you list any other feed manufacturers in the area?

No	Branch name	Branch location	Contact person	Cell No.
1				
2				
3				
4				
5				

### 3. Employment

i) What is your total staff? \_\_\_\_\_

ii) What are their qualifications in numbers?

a) Master's degree \_\_\_\_\_ (b) Bachelor's degree \_\_\_\_\_ c)

Diploma \_\_\_\_\_ (d) Certificate \_\_\_\_\_ (e) No qualification \_\_\_\_\_

Other qualifications (please specify) \_\_\_\_\_

\_\_\_\_\_

iii) What is the following employment in numbers?

a) Administrative job \_\_\_\_\_ (b). Technical jobs (Technicians, engineers, etc) \_\_\_\_\_ (c)

Labourers \_\_\_\_\_ (d) Others (mention) \_\_\_\_\_

\_\_\_\_\_

Additional comments \_\_\_\_\_

\_\_\_\_\_

### 4. Production Capacity

i) What is the company/branch's average installed capacity? \_\_\_\_\_ Tonnes per day?

ii) What is the company's average actual production? \_\_\_\_\_ Tonnes per day?

iii) Can you comment on the production trend over the last? Has it been increasing/decreasing?

\_\_\_\_\_

\_\_\_\_\_

## 5. Product distribution.

Adopted distribution system (circle appropriate)			% of company's products
1. Distributors	Yes	No	
2. Direct to farmers	Yes	No	
<b>Others – please specify below</b>			
1.			
2.			

i) Where is the final product sold?

Area of feed product distribution		% of total
Region	District	
1.	1.	
	2.	
	3.	
	4.	
2.	1.	
	2.	
	3.	
	4.	

## 6. Production

i) Products

produced by the  
company/branch.

Poultry			Pigs			Cattle			Others		
Products	T/ week	Price/kg	Products	T/ week	Price/kg	Products	T/ week	Price/kg	Products	T/ week	Price/kg
Chick mash			Sow & weaner			Dairy meal					
Growers mash			Finisher								
Layers mash			Creep								
Broiler starter											

Broiler finisher		
Layer pellets		
Broiler pellets		

ii) List the raw material usage.

<b>Ingredient</b>	<b>Avg. quantity used (t/week)</b>	<b>Source of supply (e.g. farmers, suppliers)</b>	<b>Source of ingredient (e.g. local, imported)</b>
Maize grain			
Maize bran			
Wheat bran			
Wheat pollard			
Broken Rice			
Rice polishings			
Sorghum			
Cassava flour			
Cottonseed cake			
Soybean cake			
Sunflower cake			
Blood meal			
Bone meal			
Fish meal			
Limestone			
Molasses			
Oyster/sea shells			
Premixes			
Common salt			
Methionine			
Lysine			
DCP			
<b>Others</b>			

iii) In what quantities do you sell compound feeds? \_\_\_\_\_

Additional comments \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**7. Price**

i) Does the price of ingredients vary seasonally? \_\_\_\_\_.

If yes, how?

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

ii) What are the most important factors in determining the price of feed?  
(Price of ingredients, traders/wholesalers, machinery, livestock farmers, other factors (specify). Arrange in descending order of importance)

\_\_\_\_\_  
\_\_\_\_\_

iii) Are feed products subject to governmental price control?

\_\_\_\_\_  
\_\_\_\_\_

Additional comments \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

**8. Product standards**

i) How do you formulate rations (least-cost computer programs, or using preset formulae, feed composition tables)?

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- ii) Do you perform regular proximate analyses of raw materials \_\_\_\_\_ and compound feeds\_\_\_\_\_.

If not; If not, why? And what provisions are made for quality control?

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If yes; How often? Compound feeds \_\_\_\_\_ Raw materials \_\_\_\_\_

- iii) Do you have your own lab or use external labs?

\_\_\_\_\_

- iv) Can you comment on the analytical service in terms of a) credibility of results (b) time taken (c) price.

a) \_\_\_\_\_

b) \_\_\_\_\_

c) \_\_\_\_\_

- v) Is the chemical composition of your products labelled on the packaged feed?

\_\_\_\_\_

- vi) Do you use sensory techniques to assess the quality of raw ingredients when they are delivered?

\_\_\_\_\_

If yes, describe the techniques used and if you reject orders?

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- vii) How do you ensure that the product quality is maintained throughout the supply chain?

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- viii) Do you receive any support from governmental or non-governmental organisations (such as extension support, training of feed production practices, quality control subsidies etc.)? If yes,

describe the type of service, and how often.

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ix) Have you ever received a quality control inspection from the government? \_\_\_\_\_  
If yes how often? \_\_\_\_\_

x) Are you a member of TFMA? \_\_\_\_\_

xi) Are your feed products TBS certified? \_\_\_\_\_

Additional comments \_\_\_\_\_

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## 9. Machinery and storage

i) What machinery do you use to produce feeds and for how long have you used them?

\_\_\_\_\_ years  
\_\_\_\_\_ years  
\_\_\_\_\_ years  
\_\_\_\_\_ years

ii) Can you comment on the services available for the machines? (i.e. spare parts, trained engineers, servicing etc.)

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iii) Is the energy supply reliable? \_\_\_\_\_

iv) Do you use a generator? \_\_\_\_\_

v) Do you store raw materials as a mitigation strategy against high prices? \_\_\_\_\_

If no, please state why? (I.e. storage facilities, cash flow etc.)

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If yes, briefly describe the storage facilities.

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Additional comments \_\_\_\_\_

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### 10. Constraints

What are the major constraints in your feed manufacturing business?

No.	Constraints	Tick Constraint	Rate importance (1= most important and 10 = least important)
1	Lack of analytical equipment		
2	High cost of lab services		
3	Low/inconsistent supply of ingredients		
4	Low quality ingredients		
5	High price of ingredient		
6	Low demand for feeds		
7	Lack of technical expertise on feed formulation		
8	Credit		
9	Lack of government support		
	Other (specify)		
10			
11			
12			
13			

**Do you have any suggested solutions for the constraints listed above?**

1. \_\_\_\_\_

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2. \_\_\_\_\_

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3. \_\_\_\_\_

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4. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

5. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

6. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

7. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

8. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

10. \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

### Appendix 3 - Sample information form

Sample name:		
Collected by:		
Date Sampled:		
Sample code:	060	063
Type of feed:		
Name of supplier:		
Price paid per kg (Tzs):		
Supplier type: (e.g. open market/vet shop etc.)		
Sample name:		
Collected by:		
Date Sampled:		
Sample code:	061	064
Type of feed:		
Name of supplier:		
Price paid per kg (Tzs):		
Supplier type: (e.g. open market/vet shop etc.)		
Sample name:		
Collected by:		
Date Sampled:		
Sample code:	062	065
Type of feed:		
Name of supplier:		
Price paid per kg (Tzs):		
Supplier type: (e.g. open market/vet shop etc.)		

**Appendix 4 – Grinder at the TVLA**



**Appendix 5 – Dry matter worksheet**

S/N	LAB SAMPLE ID	CRC No:	CRC <sub>WT</sub>	SAMPLE <sub>WT</sub>	DRY-WT CRC SAMPLE	DM	%DM
			A	B	+	C-A/B	C-A/B*100

## Appendix 6 - Sample collection using a probe



## Appendix 7 -Calibration equation statistics for chemistry and NIRS variables

(n = 294)	Calibration samples statistics				Calibration equation statistics		
	Variable (%dm)	Min	Max	Mean	Std. Dev	SEC	R <sup>2</sup>
<b>Dm</b>	89.61	94.55	92.21	0.81	0.15	0.96	0.16
<b>Ash</b>	0.03	39.92	7.60	3.57	0.57	0.95	0.61
<b>Crude Protein</b>	1.12	41.62	17.85	7.86	0.51	0.99	0.56
<b>ME</b>	5.83	10.19	8.60	1.12	0.09	0.99	0.11
<b>IVOMD</b>	39.02	71.20	60.84	7.47	0.92	0.98	1.23

**Appendix 8 - Delivery and weighing of raw materials using a beam scale.**



**Appendix 9 - Sieving of fish meal to check for impurities**



**Appendix 10 - Example of a typical small-scale production and storage facility.**



## **Appendix 11 - Example of storage facilities**

Example of poor storage conditions which is not kept clean



Example of clean storage facility



## Appendix 12 – Example of mixers

Locally produced vertical mixers (and grinders) commonly used by feed manufacturers



1. Materials are loaded into the hammer mill, which grinds the materials and feeds through to the mixer.
2. Materials which are already ground or do not require grinding (e.g. minerals and premixes), can be loaded directly into the mixer.
3. The mixer homogenises all the ingredients.
4. The mixed feed is ejected from this point, where 50kg's of compound feed is bagged.



**Appendix 13 - Example of impurities after sieving fish meal.**



## **Appendix 14 – Linear regression output**

### Appendix: Linear Regression

## Regression analysis

Response variate: Price\_kg  
Fitted terms: Constant, CP\_dm

### Summary of analysis

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Regression	1	262042.	262042.	24.65	<.001
Residual	161	1711775.	10632.		
Total	162	1973817.	12184.		

Percentage variance accounted for 12.7  
Standard error of observations is estimated to be 103.

## **Appendix 15 - REML Output**

### Variance CP outlet Compounds

## REML variance components analysis

Response variate: CP\_dm  
Fixed model: Constant + Sample\_name + Type\_of\_supplier +  
Sample\_name.Type\_of\_supplier  
Random model: Sample\_name.Rep  
Number of units: 159

Sample\_name.Rep used as residual term

Sparse algorithm with AI optimisation  
Analysis is subject to the restriction on CP\_dm

### Residual variance model

Term	Model(order)	Parameter	Estimate	s.e.
Sample_name.Rep	Identity	Sigma2	5.420	0.648

### Tests for fixed effects

Sequentially adding terms to fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name	48.86	9	5.43	140.0	<0.001
Type_of_supplier	11.18	1	11.18	140.0	0.001
Sample_name.Type_of_supplier	7.49	8	0.94	140.0	0.488

Dropping individual terms from full fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name.Type_of_supplier	7.49	8	0.94	140.0	0.488

## Variance CP outlet Raw materials

### REML variance components analysis

Response variate: CP\_dm  
 Fixed model: Constant + Sample\_name + Type\_of\_supplier +  
 Sample\_name.Type\_of\_supplier  
 Random model: Sample\_name.Rep  
 Number of units: 231

Residual term has been added to model

Sparse algorithm with AI optimisation  
 All covariates centred

### Estimated variance components

Random term	component	s.e.
Sample_name.Rep	0.00	0.00

### Residual variance model

Term	Model(order)	Parameter	Estimate	s.e.
Residual	Identity	Sigma2	10.60	1.07

### Tests for fixed effects

Sequentially adding terms to fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name	4459.33	21	209.07	118.6	<0.001
Type_of_supplier	1.78	1	1.78	196.8	0.183
Sample_name.Type_of_supplier	15.24	10	1.52	196.2	0.133

Dropping individual terms from full fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name.Type_of_supplier	15.24	10	1.52	196.2	0.133

*Message: denominator degrees of freedom for approximate F-tests are calculated using algebraic derivatives ignoring fixed/boundary/singular variance parameters.*

## Proximate analyses of feeds

### REML variance components analysis

Response variate: CP\_dm  
Fixed model: Constant + Sample\_name + Times\_analysed + Sample\_name.Times\_analysed  
Random model: Sample\_name.Rep  
Number of units: 154

Residual term has been added to model

Sparse algorithm with AI optimisation  
All covariates centred

### Estimated variance components

Random term	component	s.e.
Sample_name.Rep	-0.001	0.000

### Residual variance model

Term	Model(order)	Parameter	Estimate	s.e.
Residual	Identity	Sigma2	5.155	0.632

### Tests for fixed effects

Sequentially adding terms to fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name	15.65	7	2.22	90.2	0.039
Times_analysed	23.78	2	11.89	131.3	<0.001
Sample_name.Times_analysed	7.27	9	0.81	131.9	0.611

Dropping individual terms from full fixed model

Fixed term	Wald statistic	n.d.f.	F statistic	d.d.f.	F pr
Sample_name.Times_analysed	7.27	9	0.81	131.9	0.611

*Message: denominator degrees of freedom for approximate F-tests are calculated using algebraic derivatives ignoring fixed/boundary/singular variance parameters.*