# ASSESSMENT OF THE EXTENT OF UTILIZING CROP RESIDUES AS RUMINANT FEED IN CROP – LIVESTOCK FARMING SYSTEMS IN BABATI DISTRICT, TANZANIA

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN TROPICAL ANIMAL PRODUCTION OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.**

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## ABSTRACT

Two experiments were conducted in Babati district to assess types and quality of crop residues and other feed resources available for feeding livestock, crop residue handling, quantity fed, milk yield and manure handling and use within the farming system. Experiment one covered three different villages across different agro-ecological zones, involving 143 farmers in six focused group discussion and 54 farmers in individual quantitative questionnaire while experiment two involved 24 farms. It was observed that 0.52 to 8.25Mt./Ha of different crop residues were produced annually. About 14.6% of the crop residues were included in the animals' diet yearly, hence contribute 1.44%, 1.36% and 1.63% of Dry matter (DM), Metabolizable energy (ME) and Crude protein (CP), respectively in the diet. All the respondents used maize stover to feed animals, while 81.5% used beans haulms and 59.3% fed pigeon pea chaffs. The average milk yield of the lactating cows under zero grazing was 11.2 kg/cow/day. The nutrient content of analyzed crop residues ranged from 4.31 to 13.9% CP and 28.8 to 65.3% *In-vitro* dry matter digestibility (INVDMD). Higher levels of CP were observed in leguminous than cereal crop residues. The analyzed diets from the monitored farms had a nutritive value range of 6.99 to 10.5% CP and 36.6 to 49.9% INVDMD; and the ME range of 5.69 to 8.61 MJ ME/kgDM. Considerable amounts of crop residues were available in Mid-March to May where irrigated maize was harvested and in July to October which was the major crop harvesting season. It was observed that 83.3% of household hipped manure under trees, 66.7% used manure to fertilize homestead farms and vegetable gardens while 12.5% used manure for animal beddings. It is concluded that more of the available crop residues could be used as animal feed while manure could be used for nutrient recycling, when proper technologies are impacted to farmers.

## DECLARATION

I, **HAULE INNOCENT ALPHONCE**, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted for a degree award in any other institution.

______________________________ ________________________

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The above declaration is confirmed by:

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**Prof. A. E. Kimambo** **Date**

(Supervisor)

## COPYRIGHT

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## DEDICATION

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## LIST OF ABBREVIATIONS

| | |
|---|---|
| a.s.l | Above sea level |
| ADF | Acid detergent fibre |
| ADL | Acid detergent lignin |
| ANOVA | Analysis of variance |
| AOAC | Association of official analytical chemists |
| CaO | Calcium oxide |
| CF | Crude fibre |
| CP | Crude protein |
| CPD | Crude protein digestibility |
| Cu | Copper |
| DAICO | District agriculture, irrigation and cooperative officer |
| DAARS | Department of Animal Aquaculture and Range Sciences |
| DLFO | District livestock and fisheries officer |
| DM | Dry matter |
| DMI | Dry matter intake |
| DOMD | Digestible organic matter in dry matter |
| EE | Ether extract |
| FEAST | Feed assessment tool |
| FGD | Focused group discussion |
| FYM | Farm yard manure |
| GLM | General linear model |
| Ha | Hectare |
| HI | Harvest index |

| | |
|---|---|
| ILRI | International livestock research institute |
| INVDMD | *In-vitro* dry matter digestibility |
| INVOMD | *In-vitro* organic matter digestibility |
| L | Litre |
| MAFF | Ministry of agriculture food and forestry |
| MALD | Ministry of agriculture and livestock development |
| MALF | Ministry of livestock and fisheries |
| ME | Metabolizable energy |
| MJ | Mega-joules |
| Mt | Metric tones |
| N | Nitrogen |
| NA | Not applicable |
| Na | Sodium |
| NaOH | Sodium hydroxide |
| NDF | Neutral detergent fibre |
| NFE | Nitrogen free extract |
| OM | Organic matter |
| OMD | Organic matter digestibility |
| P | Phosphorus |
| PRA | Participatory rural appraisal |
| SUA | Sokoine university of agriculture |
| TAP | Tropical animal production |
| TLU | Tropical livestock unit |
| VAEO | Village agriculture extension officer |
| VALEO | Village agriculture and livestock extension officer |

| | |
|---|---|
| VEO | Village executive officer |
| WP | Work package |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background

Farmers are more attracted to crop-livestock system due to variety of economic and biological interactions. Mixed farming is a risk coping strategy of small scale farmers. From this system, livestock produce manure to sustain crop yields, while crop residues and forage on fallowed land provide feed for livestock (Williams *et al.*, 1997). Crop residues are plant materials remaining after food crops have been harvested. They form important part of feed resources under crop-livestock system particularly during the dry season. They provide forage at low cost since they are by products of existing crop production activities (Lanné and Thomas, 2006). They are generally grouped as poor quality roughages extensively used for feeding cattle. The poor quality of the crop residues is due to different factors such as climate and managerial practices. Ndemanisho *et al.* (1998) reported that high temperatures within the tropics burns the available crop residues and worsen their low nutrient levels by enhancing lignification.

Leaving the crops in the field for drying for prolonged period of time also contribute to more lignification. The deficit of essential nutrients has a consequence of reducing rumen digestibility and subsequently, reduced animal performance. On the other hand, Lanné and Thomas (2005a, b and c) reported that crop residues such as cereals, legumes, vegetable and root crops are high quality livestock feeds, but are currently underutilized and often poorly managed. In Babati district the practice of crop-livestock farming system also include intercropping where pigeon pea is often intercropped with maize. Common beans are also used in intercropping both with maize and sunflower. Due to increased production of various crops, crop residues are abundant and wide spread within the district after crop harvest but they currently contribute only 14% of the fodder available to livestock (Mangesho *et al.,* 2013). The less contribution is due to the practice adopted by farmers in Babati of grazing the crop residues *in situ,* where animals graze on maize stovers after grain harvest. This practice is inappropriate because it often results into wastage of stovers and bean haulms due to animal trampling and soling, termite's damage, leaching and wind shattering (Fredrik, 2005). A proper way of utilizing crop residues is by harvesting and storage of stover for use as feed in cut and carry system (Guo *et al.,* 2002). This practice is adopted in some parts of Kenya and Tanzania in Kilimanjaro, Arusha and Southern Highlands (Kimoro, 2003). Similarly, the use of farm yard manure as crop fertilizer is poorly managed. It is possible that proper management and utilisation of farm yard manure for crop production and improvement on the utilisation of crop residues as livestock feed will improve farm productivity and household income of small scale farmers.

## 1.2 Problem Statement and Study Justification

Babati district in Manyara region is a high potential area producing food for major urban areas in Northern Tanzania. It receives bi-modal rainfall; short rains occur between October and January while the long rainy season lasts between February and May. The increasing human and livestock population in this region and the subsequent increasing demand for food and feeds has led to permanent cultivation of more land, reduction of grazing and forest lands to expand crop production. This has led to the disappearance of traditional practices that allowed land to fallow. This situation has increased pressure on land and aggravated the competition between crops and livestock for land. Although farmers in Babati district already practice diversified farming system, the crop and livestock components co-exist more or less independent from each other. A recent study in three villages of Babati district (Long, Sabilo and Seloto) showed that the crop production (comprising mainly of maize, pigeon pea and beans) dominates the economic activities (Mangesho *et al.*, 2013). This resulted in an abundance of crop residues following harvest of food crops. The average area committed to various crops ranges between 0.3 - 0.7 ha per household, while the area committed to forage is hardly 0.04 ha, with cultivated pastures contributing only 20% of the overall feed requirements for livestock, and the remaining 80% comes from communal grazing areas and from crop residues. However, the same study showed that there was poor storage, processing and utilization of crop residues as animal feed, which lead to wastage (Mangesho *et al.*, 2013).

Crop residues of cereal grains are generally of poor quality due to high fibre contents while those from grain legumes are of higher quality and improve intake and digestibility when combined with other feed resources (Males, 1987). Williams *et al.* (1997) reported that, cattle can derive up to 45% of their total food intake in a year from crop residues and up to 80% during the critical periods. Overall, crop residues do provide a sizeable contribution to the total available feed supply during the dry seasons. However, there is little documentation on the amount of the crop residues produced in the district, quality and quantity of the crop residues fed to ruminants and managerial practices which are involved in handling the crop residues in Babati district. As a result there is a need to explore strategies that will enhance feed and nutrient availability from crop residues in Babati district.

## 1.3 Objectives

### 1.3.1 Overall objective

The objective of this study was to assess the possibility of utilizing more of the different crop residues available in Babati district as livestock feeds.

### 1.3.2 Specific objectives

i. To assess the quantities of different types of crop residues and other feed resources available for livestock feeding in Babati district,

ii. To assess the quality of available crop residues used for livestock feeding in the study area,

iii. To assess crop residues use and performance of lactating cows in the study area.

### 1.3.3 Research hypotheses

The study was governed by the following hypotheses:

Null hypothesis;

- Most of crop residues produced in Babati district are not used to provide enough nutrients to ruminants kept within the district.

Alternative hypothesis;

- Most of crop residues produced in Babati district are used to provide enough nutrients to ruminants kept within the district.

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Crop-livestock-soil Interactions in Babati

Much of the land in Babati is already under cultivation. Increased production is most likely to come from improving productivity per unit area. Dual purpose crops that provide both food (grain) and feed (residues) are attractive options to meet household needs under this current and likely future scenario. In Babati district cropping and livestock keeping is practiced by about 60% of the farmers (Babati profile, 2002).

Intercropping is done where pigeon pea (*Cajanus cajan)* is often intercropped with maize (*Zea mays)*. Common bean (*Phaseoulus vulgaris)* is also used in intercropping with both maize and sunflower (*Helianthus annuus)*. In the irrigated areas, rice/paddy (*Oryza sativa)* and sugar cane (*Saccharum officinarum)* are grown in large quantities, while in most dry lands sorghum (*Sorghum bicolor), cassava (Manihot esculenta),* sweet potatoes *(Ipomoea batatas)* and groundnuts (*Arachis hupogaea)* are grown. Soils are not fertile in areas where nutrient recycling is not a common practice.

According to Fredrik (2005), apart from land shortage for crop cultivation and grazing, poor soil fertility is the second limiting factor in crop production in the district. This may be due to poor use of farm yard manure (FYM) and also due to poor soil conservation practices which do not allow nutrients recycling in the farms (Rufino *et al.*, 2007). Crop-livestock integration is and has been efficient way for intensification of agriculture in developing countries. Lanné *et al.* (2003) suggested that, there is a clear benefit from food-feed crop: human food, livestock feed, manure and draft power.

## 2.2 Availability and Current use of Crop Residues in the Farming System

Increasing research activity in improvement of different crop productivity has been done in Babati district for several years. There has been a notable increase in crop production and more cultivation of leguminous crops as cash crop. These increase in production was necessitated by the increased population within the district hence the need to meet demand for food. Karlsson (2008) reported that since Babati town was appointed as the regional headquarters of Manyara region in 2002, there has been an increase of immigrants who wanted to purchase land and many new buildings especially for business were built. The author further reported that the field estimate for inhabitant in the district has increased from 31 077 in 2003 to 90 000 – 100 000 in 2014. This increase in population has led to increase in crop production in surrounding villages; and hence increased production of crop residues. According to Mangesho *et al.* (2013), there is abundance of crop residues during the period of crop harvesting after the long rain cropping. Maize stover, pigeon pea haulm, rice straw and common bean haulm are produced in the district in large quantities at the harvesting periods although the amount has not been quantified. Also there is a reasonable production of root and tubers in the district.

Currently, in Babati district, farmers feed crop residues to their livestock *in situ*. However, some farmers feed their livestock in door hence they gather and carry the crop residues to where the animals are kept. This practice depends very much on the distance from the main field and transportation facilities that are available in the household (Fredrick, 2005). The extent of use of crop residues to feed dairy cattle vary from place to place depending on the major crops grown in the area and also largely influenced by the distance from the field to where the animals are kept (Massawe and Mruttu, 2005). Hence, many farmers feed their animals *in situ*. Mangesho *et al.* (2013) reported that, only 14% of crop residues is used for feeding livestock; this is very small amount since it is suggested that cattle can derive up to 45% of their total intake in a year from crop residues and up to 80% during the critical periods (Williams *et al*., 1997).

### 2.3 Quantity of crop residues produced in Babati

Production of crop residues is directly influenced by a number of factors including grain yield, field management practices within the farming system, climate and physical characteristics of the soil (Linden *et al.,* 2000). High grain yields are result of high vegetative growth which is associated with high production of crop residues (Keftasa, 1987). Quantity of crop residues is normally expressed as straw: grain (S: G) ratios.

On the other hand, reliable data on residues mass can come indirectly, from studies of harvest index (HI) which is the ratio of crop yield (be it edible seeds, stalks or roots) to the total crop mass above the ground (Smil, 1999). Therefore, according to Smil (1999) the residual mass expressed as a multiple level of harvested yields can be obtained by the formula; Crop residues = Crop yield *[(**1 – HI)/HI**]. However, calculations may be substantially increased by the inclusion of crop processing residues such as husks and brans (which is approximately 13% for example in ripe rice) and in sugar cane bagasse which amounts to 15 – 18% of fresh weight of the cane plant (Linden *et al.,* 2000). It is estimated that over 60% of all residues mass is produced in low income countries and close to 45% of it originates in the tropics (Owen and Jayasuriya, 1989). Kivaisi (1997) reported that in Tanzania about 5280 metric tons (Mt.) of maize stovers, 1089 Mt. of sorghum straws, 600 Mt. of rice straws, 367 Mt. of millet and 39 Mt. of wheat straw are produced. Kangalawe (2014) reported a range of 0.78 to 8.28 Mt/Ha on different crop residues harvested in Tanzania, while Ndwasinde (2013) reported an average of 3.76Mt/Ha of rice straw production in Morogoro. Ndwasinde (2013) reported that the quantity of rice straw is highly affected by soil type, availability of irrigation water, variety (local varieties have dense vegetative growth) and number of tillers of the grown crop. However, there is a potential increase in crop residues production in Tanzania following improvement in agronomic practices (Mtengeti *et al.*, 2015). Following different calculations on crop residues production in Tanzania, several authors have reported a range of crop residue production. Table 1 show global harvest of crop residues and Table 2 shows crop residues production in Tanzania as reported by different authors.

**Table 1: Annual global harvest of crops and crop residues in the mid – 1990 (all figures are X $10^6$ tonnes)**

| Crop | Harvested crops | | Crop residues | Harvest Index |
|---|---|---|---|---|
| | Fresh weight | Dry weight | (Dry weight) | |
| Cereals | 1900 | 1670 | 2500 | 0.40 |
| Sugar cane tops | 1450 | 450 | 350 | 0.56 |
| Roots, tubers | 650 | 130 | 200 | 0.40 |
| Vegetables | 600 | 60 | 100 | 0.38 |
| Fruits | 400 | 60 | 100 | 0.38 |
| Legumes | 200 | 190 | 200 | 0.49 |
| Oil crops | 150 | 110 | 100 | 0.52 |
| Other crops | 100 | 80 | 200 | 0.28 |
| **Total** | **5450** | **2750** | **3750** | **0.42** |

Source; Smil (1999)

**Table 2: Different crop residue production from different parts of Tanzania**

| Crop residue | Crop residue production (Mt./Ha) | Source |
|---|---|---|
| Cassava | 8.28 | Kangalawe (2014) |
| Common beans | 0.89 | Kangalawe (2014) |
| Cow pea | 1.45 | Marandu *et al.* (2014) |
| | 1.07 | Kangalawe (2014) |
| Finger millet | 1.34 | Kangalawe (2014) |
| Ground nuts | 0.75 | Kangalawe (2014) |
| Maize stovers | 5.33 – 15.4 | Mtengeti *et al.* (2015) |
| | 3.71 | De Groote *et al.* (2013) |
| | 1.82 | Kangalawe (2014) |
| Pigeon pea | 0.65 | Marandu *et al.* (2014) |
| | 1.59 | Kangalawe (2014) |
| Rice straw | 3.81 – 7.41 | Mtengeti *et al.* (2015) |
| | 4.09 | Ndwasinde (2013) |
| Round potatoes | 0.99 | Kangalawe (2014) |
| Sorghum | 1.41 | Kangalawe (2014) |
| Sugar cane tops | 0.78 | Kangalawe (2014) |
| Sunflower | 1.45 | Kangalawe (2014) |
| Sweet potatoes | 0.53 | Kangalawe (2014) |

The recently obtained data from Babati district agriculture office shows that several tones of grains are produced from variety of crops and hence edible residues from these crops. Tables 3 and 4, shows yearly production of crop grains and residues from season 2005/06 to 2013/14.

**Table 3: Crop and crop residues for season 2005/06 – 2009/10; Babati district**

| | Yearly grain and crop residues production (metric tons) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Year | 2005/06 | | 2006/07 | | 2007/08 | | 2008/09 | | 2009/10 | |
| Crops | Grains | Crop residue | Grains | Crop residue | Grains | Crop residue | Grains | Crop residue | Grains | Crop residue |
| A: Cereals | | | | | | | | | | |
| Maize | 129 176 | 193 764 | 63 439 | 95 158.5 | 98 728 | 148 092 | 69 089 | 103 633.5 | 120 000 | 180 000 |
| Paddy | 6 799 | 10 198.5 | 8425.8 | 12 638.7 | 9675 | 14 513 | 8836 | 13 254 | 14 928 | 22 392 |
| Sorghum | 17 272 | 25 908 | 11 220 | 16 830 | 10 876 | 16 314 | 2020 | 3030 | 5216 | 7824 |
| Finger millet | 466 | 699 | 640 | 960 | 275 | 413 | 414 | 621 | 398 | 597 |
| Wheat | 5370 | 8055 | 2414 | 3621 | 3300 | 4950 | 3865 | 5797.5 | 4902 | 7353 |
| B: Legumes | | | | | | | | | | |
| Common beans | 1264.3 | 1315.9 | 4272 | 4446.4 | 5417 | 5638.1 | 2366 | 2462.6 | 3708 | 3859.4 |
| Pigeon pea | NA | - | NA | - | 7521.8 | 7828.8 | 7279 | 7576.1 | 8011 | 8337.9 |
| Lablab beans | NA | - | NA | - | 244.8 | 254.8 | 649.8 | 676.3 | 374 | 389.3 |
| Cow pea | 62 | 64.5 | 265 | 275.8 | 36 | 37.5 | 50.4 | 52.5 | 201.7 | 209.9 |
| Chick pea | NA | - | NA | - | 66 | 68.7 | 190 | 197.8 | 261 | 271.7 |
| C: Oil seeds | | | | | | | | | | |
| Sunflower | 4199 | 3876 | 2282 | 2106.5 | 3209 | 2962.2 | 2961 | 2733.2 | 3184 | 2939.1 |
| Ground nuts | NA | - | NA | - | 207 | 191.1 | 232.5 | 214.2 | 546 | 504 |
| D:Roots and tubers | | | | | | | | | | |
| Sweet potatoes | 1945.6 | 2918.4 | 2512 | 3768 | 1916 | 2574 | 4124.8 | 6187.2 | 1128 | 1692 |
| Cassava | 5236 | 7854 | 1355 | 2033 | 1728 | 2592 | 1208 | 1812 | 1153 | 1730 |
| E: Vegetable | | | | | | | | | | |
| Vegetables | NA | - | NA | - | 1837.5 | 299.03 | 1223 | 1995.4 | 590 | 962.6 |
| F: Sugar crops | Cane | Tops* | Cane | Tops* | Cane | Tops* | | | Cane | Tops* |
| Sugar cane | NA | - | NA | - | 5200 | 4085.7 | NA | - | 1304 | 1024.6 |

Source: DAICO office crop files 2005/06 – 2013/14

Tops* - Sugar cane tops residues

**Table 4: Crop and crop residues for seasons 2010/11 – 2013/14; Babati district**

| | Yearly grain and crop residues production (metric tons) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Year | 2010/11 | | 2011/12 | | 2012/13 | | 2013/14 | |
| Crop | Grain | Crop residue | Grain | Crop residue | Grain | Crop residue | Grain | Crop r residue |
| A: Cereals | | | | | | | | |
| Maize | 89 813 | 134 719.5 | 55 909 | 83 863.5 | 83 200 | 124 800 | 139 125 | 208 687.5 |
| Paddy | 9908 | 14 862 | 5293 | 7939.5 | 13 440 | 20 160 | 8276 | 12 414 |
| Sorghum | 7408 | 11 112 | 3224 | 4836 | 3875 | 5812.5 | 6516 | 9774 |
| Finger millet | 238 | 357 | 478 | 717 | 648 | 972 | 147 | 220.5 |
| Wheat | 4800 | 7200 | 6525 | 9787.5 | 8015 | 12 022.5 | 4022 | 6033 |
| B: Legumes | | | | | | | | |
| Common beans | 1510 | 1571.6 | 7612 | 7922.7 | 13 000 | 13 530.6 | 9144 | 9517.2 |
| Pigeon pea | 5013.6 | 5218.2 | 7346 | 7645.8 | 37 725 | 39 264.8 | 18 338 | 19 086.5 |
| Lablab beans | 952 | 990.9 | 1368 | 1423.8 | 3836 | 3992.6 | 502 | 522.5 |
| Cow pea | 101 | 105.1 | 650 | 676.5 | 73 | 75.9 | 110.5 | 115. |
| Chick pea | 322 | 335.1 | 325 | 338.3 | 291.50 | 303.4 | 640 | 666.1 |
| C: Oil seeds | | | | | | | | |
| Sunflower | 6531 | 6028.6 | 7653 | 7064.3 | 7050 | 6507.7 | 7975 | 7361.5 |
| Ground nuts | 408 | 376.6 | 432 | 398.8 | 217.5 | 200.8 | 502.5 | 463.9 |
| D:Roots and tubers | | | | | | | | |
| Sweet potatoes | 2735 | 4102.5 | 3060 | 4590 | 6412 | 9618 | 4081.5 | 6122.3 |
| Cassava | 2316 | 3474 | 4928 | 7392 | 6088 | 9132 | 1804 | 2706 |
| E: Vegetable | | | | | | | | |
| Vegetables | 1107 | 1806.2 | NA | - | NA | - | 705 | 1150.3 |
| F: Sugar crops | Cane | Tops* | Cane | Tops* | Cane | Tops* | Cane | Tops* |
| Sugar cane | 1200 | 942.9 | 1600 | 1257.1 | 2220 | 1744.3 | 1995 | 1567.5 |

Source: DAICO office crop files 2005/06 – 2013/14

Tops* - Sugar cane tops residues

## 2.4 Quality of Crop Residues with Reference to Ruminant Feeding and Performance

Feed quality can easily be determined in most places by its potential to support animal performance from feeding the materials to a target animal. Coleman and Moore (2003) commented that when feed is offered alone and of free choice to animal having production potential, feed quality can be defined in terms of such animal performance, example in daily gain. Major nutrients required by ruminant animals include protein, vitamins and minerals. Energy is required but it is not a chemical entity as energy is a unit of work and may be supplied by different nutrient constituents including starch, sugar, fibre, lipids and protein (Kellems and Church, 2002). Therefore, quality of feed resource is been ranked on how such a feeding material is capable of supplying the nutrients to support the performance of the animal when given as a sole diet or with minimum supplementation (Mahesh and Mohini, 2013). Feeds such as residues and stovers from plants primarily harvested as crops when mature, are often severely deficient in one or more of primary nutrients, such as protein. Hence, when such feeds are fed as sole feed source other aspects of quality may be masked (Coleman and Moore, 2003).

The quality of a feed and in most cases of crop residues can be described on its nutritive value. Nutritive value of a feed material include nutrients composition (protein, carbohydrates, vitamins and minerals) of the feed, availability (digestibility) of nutrients and energy and efficient of nutrient and energy utilisation. But as it was observed by Coleman and Moore (2003) that most common forages, fodders and crop residues are ranked as low quality feed because energy substrate, largely fibres make up a greater proportion and it is less available to the targeted animal. Kimoro (2003) also commented that plant maturity is often accompanied by increase in cell wall concentration and decrease in digestibility as well as decrease in crude protein (CP).

However, several treatments can improve its availability to animals. Mahesh and Mohini (2013) reported that biological treatments can be employed for improving the feeding value of low quality fibrous crop residues.

### 2.4.1 Chemical composition of crop residues

There is a wide variation in the chemical composition of different feedstuffs, most of which are attributed to plant maturity, post-harvest treatment, plant part (leaf, stem or pods), season, soil types and state of hydration (Hindrichsen *et al*., 2002). In tropical areas where there is a distinct wet and dry season, wide seasonal variation in chemical composition of forage is common. The CP content is normally higher during the rainy season and decreased during the dry season; Mtui (2004) reported a range of 4.72 – 5.03% CP in different forages used as livestock feed in Turiani division during the dry season and 5.69 – 6.31% CP in wet season, while on the other hand Selemani *et al*. (2013) reported a range of 8.77 – 13.91% CP in natural forage during the rainy season and 3.57 – 12.27% CP in dry season in Meatu district.

Crop residues are characterised by low levels of one or more key nutrients, which limit their utilization by the livestock (ILCA, 1990). Cereal straws and stovers are inherently low in palatability, low CP (26g/kgDM), low in readily fermentable carbohydrates, low ME (about 7.5MJ/kgDM), (Nicholson, 1984; Sundstøl and Owen, 1984), low in available minerals particularly Na, P and Ca (Little, 1985) and are low in vitamins. They contain high levels of structural carbohydrates or fibre which results into a very slow passage rate through the alimentary canal leading to low dry matter intakes between 10 – 15 gDM/kg live weight/day (Sibanda and Abdullah, 1991). The chemical composition gives the chemical concentration in the feed stuff and does not give biological availability and nutrient intake by the animal (Winugroho, 2000). Chemical composition of some crop residues found in Babati district is described here under;

- *Maize stovers*

The chemical composition value of maize stovers is highly variable and influenced by agro-climatic conditions, management factors, dominating maize varieties, soil type, stage of harvest and storage methods (Tolera and Sundstøl, 2000). These factors act either singly or in combination to bring about the variations. Several authors reported a range of chemical composition of maize stovers with DM range from 46 – 93.4% and CP ranges from 2.90 to 8.34% on dry matter basis. Either other chemical components are indicated in Table 5.

**Table 5: Chemical composition of maize stovers**

| Parameters (% in DM) | | | | | | |
|---|---|---|---|---|---|---|
| DM | CP | NDF | ADF | ADL | Ash | Source |
| 90.2 | 4.00 | 79.2 | 46.4 | 4.40 | 7.82 | Kilongozi (1992) |
| 93.1 | 2.90 | 78.1 | 48.3 | 5.46 | 5.81 | Kimbi (1997) |
| 91.8 | 3.90 | 80.2 | 49.3 | 2.90 | - | Nherera *et al.*(1998) |
| 92.6 | 3.70 | 78.9 | 39.9 | 4.80 | 8.10 | Tolera *et al.* (1998) |
| 93.4 | 3.10 | 80.1 | 53.1 | 8.30 | 6.90 | Tolera and Sundstøl (2000) |
| - | 4.40 | 77.6 | 43.7 | 3.60 | 7.50 | Giger-Reverdin (2000) |
| 80.0 | 6.00 | 70.0 | 40.0 | - | 7.00 | Stanton and LeValley (2006) |
| 46.0 | 8.34 | 73.3 | 69.1 | - | 7.70 | Wambui *et al.* (2006) |

- *Pigeon pea residues*

Pigeon pea is useful in various ways both as human food and animal feed. Pigeon pea leaves, parts of stalks and haulms are used as dry or green fodder; dry leaves and the left over pods at threshing of the crop are used as feed for animals. About 50% of the plant is edible forage. Foster (2008) reported that, pigeon pea contains 13.2% CP for dried leaves and about 13.9% CP for green leaves before wilting on dry mater basis as more elaborated in Table 6 and 7. Whiteman and Norton (1982) reported that pigeon pea harvest trash contained leaf, stem, pods and 5 – 12% seeds but the ratio of components vary depending on plant type and maturity, environment and harvester separation efficiency. However, leaf ratio within the mixture has a major effect on CP content and nutritive value (Yousif, 2005). Due to this high level in nitrogen content, there can be a considerable focus on using pigeon pea as a fodder supplement (Singh and Diwakar, 1993). During dry season, pigeon pea residues can be a good source of energy and protein for the animals. Josh *et al.* (2001) reported that, when pasture quality is low, pigeon pea haulms can be used as protein supplement in mixture. Leaves of pigeon pea provide good substitute for alfalfa in animal feed (Singh and Diwakar, 1993).

**Table 6: Chemical composition of pigeon pea residues**

| Legume part | Parameters (% DM) | | | | | | | | | Source |
|---|---|---|---|---|---|---|---|---|---|---|
| | DM | CP | EE | CF | NFE | NDF | ADF | ADL | Ash | |
| Leaf | 96.7 | 19.8 | 7.3 | 23.2 | 43.7 | 61.1 | 29.4 | - | 6.0 | Cheva-Isarakul (1992) |
| Leaf | 89.1 | 24.3 | 8.8 | 11.2 | 45.5 | 28.4 | 16.5 | 8.4 | 8.3 | Cheva-Isarakul (1991) |
| Seeds | 87.5 | 20.0 | 2.3 | 9.6 | 63.7 | 51.7 | 17.5 | - | 4.4 | Cheva-Isarakul (1992) |
| Harvest trash | 93.9 | 19.3 | - | 6.4 | - | - | - | - | 3.6 | El hardalou *et al.* (1980) |
| Harvest trash | 93.5 | 21.7 | 2 | 12 | - | - | - | - | 4 | Fatima (2003) |

**Table 7: Chemical composition of pigeon pea forage before wilting and ensiling, and haylage forage**

| Chemical composition and in vitro true digestibility | | |
|---|---|---|
| Item (%DM) | Forage before wilting and ensiling | Haylage forage |
| Dry Matter | 29.6 | 46.9 |
| Organic Matter | 95.3 | 95.0 |
| Crude Protein | 13.9 | 13.2 |
| Neutral Detergent Fibre | 59.3 | 65.2 |

Source; Foster (2008)

- *Sorghum stovers*

Sorghum straws are good sources of feed for animals as they are grown in almost every agro-ecological region of Babati. This is because sorghum can tolerate a wider range of soil type and also can grow well even the area with low rainfall (Pande *et al.*, 2003). In most cases, farmers use sorghum as a risk coping crop especially during the low rainfall years. Reddy *et al.* (2003) mentioned that sorghum stubbles do not decrease in quality as rapidly as maize after physiological maturity. Nutritional value of sorghum varies greatly with maturity and plant parts. Vegetative parts of sorghum are good protein and energy sources (Lardy and Anderson, 2009). Savadogo *et al.* (2000) reported that leaf blades have higher CP content of 9.0 – 9.4% as compared to stem which had a CP range of 1.5 – 2.1%. However, the feeding value of sorghum is limited due to higher CF and lignin, and lower in vitamins and minerals (Akinfemi *et al.*, 2010). Lardy and Anderson (2009) reported that sorghum cut hay in vegetative state has nutritional value similar to good-quality grass hay, however selection of varieties with lower prussic acid and nitrate is important to avoid animal poisoning risk. Table 8 shows the chemical composition of sorghum (*Sorghum bicolor)* as reported by different researchers.

**Table 8: Chemical composition of sorghum stovers**

| Parameters (% in DM) | | | | | | | |
|---|---|---|---|---|---|---|---|
| DM | CP | CF | NDF | ADF | ADL | Ash | Source |
| 91.2 | 2.54 | 31.7 | 70.2 | 46.7 | 15.2 | 6.28 | Akinfemi *et al.* (2010) |
| 85 | 5.6 | 33 | - | - | - | 10 | Stanton and Le Valley (2006) |
| 91 | 6.6 | 31.3 | - | 42 | 17.8 | 5.9 | Lardy and Anderson (2009) |

- *Rice straw*

The nutritional value of rice straw is however dependant on various factors such as climatic condition, harvesting time, farm condition and residues management (Wanapat *et al.*, 2009). Chemical composition of rice straw varies between varieties and growing seasons with higher nitrogen (1.04% of the DM) and cellulose contents in the early-season rice compared to others (0.96% of DM in the late growing season) (Devendra and Thomas, 2002). Mtamakaya (2002) reported chemical composition in rice straw indicated in Table 9. Kimario (2003) on the other hand found that rice straw contain 3.86% CP, 23.53% Ash and 75.7% of NDF.

**Table 9: Chemical composition of rice straw**

| Parameters (% in DM) | | | | | | | | Sources |
|---|---|---|---|---|---|---|---|---|
| DM | CP | ADF | NDF | ADL | Cellulose | Hemicellulose | Ash | |
| 96.3 | 0.96 | 41.6 | 73.1 | 4.84 | 33.4 | 31.4 | 12.1 | Sarnklong *et al.* (2010) |
| 88.3 | 4.31 | - | - | 4.34 | 46.6 | 23.6 | 15.7 | Adegbola (2002) |
| 96.9 | 5.0 | 55.5 | 77.9 | - | - | - | 20.5 | Cheva-Isarakul (1992) |
| 94.1 | 4.41 | 53.1 | 64.5 | 4.47 | - | - | 17.8 | Mtamakaya (2002) |
| - | 3.86 | - | 75.7 | - | - | - | 23.5 | Kimario (2003) |

### 2.4.2 Intake and digestibility of crop residues

Voluntary intake and nutrient digestibility have been used to form indices for forage quality, and most feeding standards and models are based on assumptions that animal performance is related closely to intake and available nutrients (Coleman and Moore, 2003). Intake can be defined as the weight or quantity of feed that an animal can consume in a given period of time while digestibility of a feed is that portion which is not excreted in the faeces and which is therefore assumed to be absorbed by the animal (McDonald *et al.*, 2010). Daily intake is therefore influenced by time foods and their indigestible residues are retained in the digestive tract. Animals offered with roughages such as straws, increase time for digestibility hence reduce intake as there is a positive relationship between the digestibility of food, and their intake in ruminants; also the quality of feed offered have marked variation in both intake and digestibility (McDonald *et al.*, 2010). When ruminants are offered poorly-digested feeds like straws, their intake is governed by physical capacity of digestive system. Example crop residues are fibre-rich and low CP content, have restricted DM intake and digestibility. Shem (1993) and Ørskov and Ryle (1990) suggested that individual animals of the same group or class may vary in their intake and digestibility of the same roughage materials.

Since crop residues are the major components of dry season feeding; increasing their intake and digestibility is necessary to enhance better performance of the animal. These can be achieved by several ways including methods such as chopping, grinding, soaking in water and striping (Clark and Ipharraguerre, 2001). Furthermore, increasing the supply of rumen nitrogen through use of sunflower residues from ram-press oil production, through manipulation of particle size and other physical treatments so as to increase surface area of digestible materials exposed to the rumen microbes (Salem and Smith, 2008).

- *Intake and digestibility of maize stovers*

Maize stover is one of the most used crop residue to feed ruminants in Babati district. Nutrient content of maize stover is low, particularly energy and protein. Its intake is limited depending on the level of lignification (Lardy and Anderson, 2009). Improvement on its nutritive value encourages intake and digestibility. Ondiek *et al.* (2013) reported a dry matter intake of 294g/day by goats offered maize stover. The nutrient digestibility (g/kg DM) of 489, 559, 489, 530 and 604 for DM, OM, CP, ADF and NDF, respectively with a daily gain of 8.3g/day. Hence concluded that maize stover of good quality can be used as maintenance feed but supplementation to improve intake is necessary for optimum productivity. In an experiment with growing steers, Harding *et al.* (2016) reported a daily intake (kg DM/d) of 5.97, 5.20 and 3.62 in DM, OM and NDF respectively and digestibility (%) of 63.3, 66.35 and 44.8 of DM, OM and NDF respectively of a diet containing 60% maize stover. However; Harding *et al.* (2016) commented that physical and chemical treatment improves both intake and digestibility.

- *Intake and digestibility of pigeon pea*

About 50% of pigeon pea plant can be eaten by animals. When grown for forage, the plant must be cut at 0.15 or 0.3 above the ground as the woody part of the plant discourages intake by the animals (Singh and Diwakar, 1993). However, due to its higher CP content and less CF the intake and digestibility is higher (more than 50%) hence can be used as protein supplement with other residues to improve both intake and digestibility (Odeny, 2007). Ahamefule *et al.* (2006) reported an increase in intake of cassava peels based diet supplemented with pigeon pea meal up to 4.9% of the body weight of the West African dwarf goats, as compared to 4.48% of the control diet. The same authors reported an increase of apparent digestibility to 60.7% against 56.8% of the control diet. Winugroho (2000) reported digestibility of pigeon pea forage to be 70% and Foster (2008) reported *in vitro* true digestibility range of 45.4 to 55.4%. On the other hand, Whiteman and Norton (1982) reported a DM digestibility of 44% in pigeon pea harvest trash, which contained 10 – 25% broken seeds.

- *Intake and digestibility of sorghum stovers*

Sorghum stover as other cereal crop residue has limited utilization. Intake and digestibility by ruminants is low due to high content of lignocellulosic compounds and little nitrogen (Blümmel *et al.*, 2003). Bello and Tsado (2013) reported the intake of basal sorghum stover diet in growing rams of 583.3 g/day out of 2,000 g/day (29.2%) untreated sorghum offered to the experiment animals and the apparent *in vivo* digestibility (%) of 81, 76.8, and 70.8 for DM, CP and CF, respectively. Tedla (2014) reported *In-vitro* dry matter digestibility (INVDMD) of 45.3% and *In-vitro* organic matter digestibility (INVOMD) of 40.5% in un-treated sorghum straws. Yousuf *et al.* (2014) reported INVDMD of 50.1% and 57.5% in short and tall varieties of sorghum and concluded that the variation is due to considerable diversity in fibre and lignin concentration among the varieties.

- *Intake and digestibility of rice straw*

Rice straw is among the main crop residue which farmers in Babati district usually store and use as ruminant feed especially when natural forages are being in constraint. Rice straw is low in nutritional value with low levels of CP (2 – 5% DM), high fibre and lignin (NDF > 50%), thus has low voluntary feed intake (Wanapat *et al.,* 1994). However, Wanapat *et al.* (2013) reported DMI of 5 kg/day in lactating dairy cow fed on a rice straw basal diet and apparent digestibility (%) of 49 DM, 55 OM, 50 CP, 45 NDF and 43 ADF. Kimario (2003) reported the DM degradability of 30.5% by fistulated steers and Mtamakaya (2002) reported degradability of 38.5% at 48 hours. Mtamakaya (2002) also reported DMI of untreated rice straw of 5.56 kgDM/day and the DMD of 55.9% by steers. In an experiment with Thai native beef cattle, Cherdthong *et al.* (2014) reported a DMI of untreated rice straw of 2.1 kg/day with digestible organic matter intake (DOMI) of 1.8 kg/day and the nutrients digestibility coefficients (%DM) of 65 DM, 69 OM, 63 CP, 54 NDF and 43 ADF.

### 2.4.3 Animal performance on crop residues based diets

A sound indicator of forage or feed quality is animal performance. Feed evaluation generally describes feed on how it is related to performance of the animal offered such feed (Hvelplund, 1999). The indicator may be useful as relative comparison among forage given to growing or lactating animals. Coleman and Moore (2003), reported that in describing the quality of forage on animal performance, the prediction may be less accurate due to some causes, such as nutrient in balance, environmental constraints on the animal used for measurements and individual animal differences.

- *Performance on maize stover based diet*

Maize stover has low nutritive value but forms a bulk of dry season feeds in most of tropical countries. Bal *et al.* (2000) found no difference in milk yield by lactating dairy cow fed on three different varieties of maize stover (Pioneer 3563, Mycogen TMF 106 and Yellow corn). In another research conducted using Holstein lactating cows, Bal *et al.* (2000) found that the performance of the cows in terms of milk yield was significantly different when there was supplementation of 50% concentrate and 50% forage diet (contained maize stovers and Alfalfa hay), the animals increased milk production to 33.4 kg/day as compared to control un-supplemented animals that produced 32.4 kg/day. In another study, Ondieki *et al.* (2013) offered maize stover as a basal diet supplementing it with either *Balinites aegyptiaca* or *Acacia tortilis* with CP percentage of 11.7 and 13.5 respectively. The authors found that there was potential daily weight gain of 20.3g/day in the growing Small East African goats when supplemented with *B. aegyptiaca*. Harding *et al.* (2015) also reported a higher average daily body weight gain of 716.7g/day in growing cattle fed with corn stover treated with Calcium oxide (CaO) as compared to those fed on un-treated diet which had the average daily body weight gain of 263.1g/day. The diets contained 50% roughages and 50% by products and were both fed at the rate of 2% of the body weight of the growing cattle.

- *Performance on pigeon pea*

Pigeon pea is best when used as supplement to low quality roughages. Its higher content in CP and digestibility improves performance of the low quality diets. Cheva-Isarakul (1992) reported that sheep fed with pigeon pea leaf meal in a rice straw basal diet, there was an increase in body weight by 2.7%. However, he commented that, pigeon pea leaves has unpleasant smell so animals might need a longer adapting period to get acquainted with the feed. Shenkute *et al.* (2013) supplemented free grazing/browsing Arsi-Bale kids during the dry season with different levels of dried pigeon pea leaves and reported increase in body weight of up to 92.7 g/day when the kids were fed 90 g/day of the meal as compared to daily gain of 4.93g/day of un-supplemented kids. Therefore, pigeon pea residues can be used as a cheap source of protein supplement to improve poor quality dry pastures or crop residues.

- *Performance on sorghum based diet*

When sorghum straw is fed alone during the dry season there are greater possibilities for the animals to lose body weight. Abdul *et al.* (2008) reported that animals fed on sorghum straw alone were found to lose weight by -55.5 g/day. But on supplementation with different levels of poultry litter, there were gain in body weight from 27.8 to 61.1 g/day. Anandan *et al.* (2010) reported an increase in milk yield from buffalo fed on sorghum basal feed from 7.0 kg/day to 8.6 kg/day. However, the straw had to be supplemented. Also it was reported that sheep fed on basal sorghum feed that contained 50% sorghum straw, 18% maize bran, 18% oil seed cakes, 8% molasses and 6% maize grain had an increase in growth rate of up to 90 g/day as compared to 45 g/day of the normal farmer feeding practice (Anandan *et al.,* 2010). However stover quality is an important attribute in deciding the animal performance (Savadogo *et al.*, 2000).

- *Performance on rice straw based diet*

High levels of lignification and silfication, the slow and limited ruminal degradability are the main deficiencies of rice straw (Sarnklong *et al.*, 2010). By supplementing animals fed on the straw with protein, milk yield was enhanced as compared to feeding untreated rice straw alone (Fadel Elseed, 2005; Wanapat *et al.,* 2009). Wanapat *et al.* (2009) reported an increase in milk yield by 20 – 24% of the normal daily milk yield in dairy cows, fed on rice straw supplemented with soy bean meal, cotton seedcake meal and urea-molasses-mult- nutrient block. In addition, it was reported by Promkot and Wanapat (2005) that when a rice straw basal diet is supplemented with cotton seedcake and contain cassava chips, there was an increase in milk yield as the level of CP raises. The reported increase in milk yield was from 10.7 kg/day to 12.4 kg/day when CP increased from 10.5% to 14.4%.

## 2.5 Crop Residues Handling and Feeding

The quality characteristics of crop residues are determined by the genetic makeup of the crop, growing conditions and harvesting, threshing and storage methods. There is a marked diversity in crop residue management practices depending on farming system of the locality and pressure on land which can be used for grazing. Valbuena *et al.* (2012) reported that following increased pressure on land and feed resources, there have been influences on crop residues management. In Kenya for example, stall feeding and stubble grazing have increased. This reflect a mounting demand for crop residues as livestock feed, and consequently, amount of crop residues left in the field has decreased (Valbuena *et al.*, 2012). In the Ethiopian highlands, practice of feeding livestock with straws in the morning and evening around homestead has become a common practice (Bogale *et al.*, 2008). These has steered the change in crop residue management practices because it necessitate storing the residues for livestock use rather than direct grazing in the major crop fields.

In many developing countries storage and handling of crop residues has been faced with several difficulties including lack of space (on small farms), weather proofing, pest infestation and fire risks. Nevertheless, there are examples of well-developed systems of storing straws in Ethiopian Highlands, Bangladesh and Thailand such as hipping under a well-constructed shed, chopping and bailing for easy storage for future use. Several types of simple machines such as pulverisers have been developed (Owen and Jayasuriya, 1989). Use of wooden boxes (75 x 50 x 40 cm) was reported as the best method of bailing maize stover in Highlands of Northern Tanzania (Massawe and Mruttu, 2005). In Babati district, following the survey to assess the crop yield and crop residue management, it was reported that majority of farmers (78%) leave crop residues in the fields hipping under nearby trees, for site grazing. This was reported to be caused by lack of proper crop residue management skills such as chopping and bailing (Kihara *et al.*, 2015), while about 12% of the crop residues was stored in a built barns. High quality stovers can easily be obtained from the plant by stripping of leaves and sheath and balling for easy storage (Massawe and Mruttu, 2005).

### 2.6 Manure quality, Handling and Use

Extensive areas in Africa and Babati in particular have soils that are poor in organic matter, nitrogen (N) and phosphorus (P), where nutrient recycling is critical to maintain productivity of the land (Fredrik, 2005). Smallholder farmers in Africa recognise the important role of manure in maintaining soil fertility. For small holder farmers who use little fertilizer, efficient management of nutrients in manure is the key for increased crop production (Rufino *et al.*, 2007). Bebe *et al.* (2003) found that farmers in the highlands of Kenya keep cattle mainly for milk production, for family subsistence or to generate income. In Makambako division (Njombe district), Jackson (2005) reported that 78.4% of the dairy keepers do composite manure in a wooden barn so as to maintain the quality of manure for more crop production while the remaining percentage either decompose in a pit, pile outside or leave in the kraal to increase beddings.

Manure was perceived as a non-marketable product that was used for crop production and was not a priority in farming management. Baijukya *et al.* (2005) and Mapfumo and Giller (2001) reported that in Bukoba district of Tanzania and some African farming systems, manure production was indicated as a major reason for keeping cattle by smallholder, whereas in other systems such as arid areas of Zimbabwe, manure is a potential resource for nutrient recycling that is hardly used.

Cattle excreta may be left in the rangeland or croplands where the animals graze, or collected. Losses during collection and handling of excreta are common; example urine which is rich in N cannot be collected from grazing animals, and is often physically lost from stalls (Rufino *et al.*, 2006). Fresh faeces are generally referred to as manure after decomposition. For the best quality and better use of manure in the farming system, manure can be stored alone or mixed with urine, feed refusals or other organic materials. Then it can be left for some days to undergo decomposition (maturation) and when applied to the crop land, the N becomes available for the plant uptake (Rufino *et al.,* 2007). Several methods can be used for manure decomposition such as use of wooden barn, pilling under the shade or decomposing in a covered pit. According to Jackson (2005), use of wooden barn gives high quality manure within a period of six months.

Success in long-term agriculture production in resource poor farming system relies on the efficiency on how nutrients are conserved and recycled (Fredrik, 2005). How much of the nutrients are lost depends much on management and handling of manure within the farming system. Jackson and Mtengeti (2005) reported that 30 – 40% of manure produced in Njombe district is used in the crop field while 91% of farmers keeping local cattle use manure as bedding and 78.4% of the dairy cow keepers do composting of the manure in the burn before they use it in the maize farms. Rufino *et al.* (2006) concluded that nutrient recycling can be increased when;

i. Livestock is also considered as source of manure (faeces and urine) and not only for milk, meat production and for drought purposes,

ii. Manure collection and handling: housing and management determine what proportion of animal excreta may be collected,

iii. Manure storage: manure can be composted with or without additional plant materials.

Manure contribute to increase (or at least maintain) the soil organic carbon pool. Making most efficient use of animal manures depends critically on improving manure handling and storage and on synchrony of mineralisation with crop up take (Fredrik, 2005).

## 2.7 Milk Production Trend in Tanzania

### 2.7.1 Dairy industry in Tanzania

The dairy industry is dominated by the traditional sector in which milk production is a second reason for keeping livestock (MALD, 1988). Reports shows that about 67.6% of all milk produced in the year 2013/14 came from traditional livestock (MLF, 2014). It is estimated that there are about 300 000 dairy cattle in Tanzania and these (pure-breed and cross-bred cattle) are distributed in three main subsection namely large scale commercial farms (commercial or parastatal farms), institutional dairy farms and small holder dairy farms (private) (Kurwijila and Kifaro, 1998). In most cases farmers in Babati district fall under small holder dairy farms; Bee (2007) reported that 99.8% of the farmers who keep dairy cattle owns 1 – 10 animals which are improved breeds of dairy cattle for milk production and the remaining 0.2% of dairy farmers are from large farms. The size of animals held by the farmers in smallholder dairy farming subsector and management practices are usually the major constraints in production. Dairy production is more efficient when genetic potential is better exploited due to general and better animals' husbandry practices that are followed by smallholders (Kurwijila, 1991). Smallholder dairy farming is an important part of household economy of some parts of Tanzania particularly where land is a limiting factor for agriculture (Mdoe and Nyange, 1993).

### 2.7.2 Performance of smallholder dairy cattle in Tanzania

Several researchers have reported different levels of milk yield in smallholder dairy cattle in Tanzania. However; several studies also report influence of environmental factors on productivity of dairy cattle in the tropics. These factors include location, herd, temperature, rations, and seasons (Kifaro, 1991). The feeding systems practiced in dairy sector include zero grazing, partial and full grazing. Partial grazed cows in Morogoro, out yield zero and full grazed cows by 1.2 and 3.2 kg ((i.e. 9.8 ± 2 vs. 8.6 ± 1.4), and 6.6 ± 1.3 kg per cow per day, respectively) (Sarwatt and Njau, 1990). In Zanzibar, Biwi (1993) reported that zero grazed cows out yielded partial grazed ones by 2kg (i.e. 8 vs. 6). Nkya *et al.* (2015) reported milk yield range of 6.4 ± 0.44 to 7.3 ± 0.66 kg by small holder farms in Morogoro and commented that this could be increased if there were proper feeding in the late gestation period. Nkenwa (2009) reported the daily overall mean milk yield (kg/day) from zero grazed and full grazed lactating cows in Kongowe and Mlandizi wards of 6.59 kg/day and 5.45 kg/day respectively while in some parts of Tanzania, a range of 11.7 to 12.4 kg/day was reported (Bareeba, 2003). However, the production of milk in the smallholder dairy farms could be improved if the constraints affecting the sector were identified and controlled (Smith and Akinbamijo, 2000). Table 10 shows milk production in Tanzania in a five year time.

**Table 10: Milk production trend in Tanzania in years 2007/08 to 2012/13**

| Milk production Litres ‘000’ | Year | | | | | |
|---|---|---|---|---|---|---|
| | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 |
| Traditional herds | 980 000 | 1 012 436 | 997 261 | 1 135 422 | 1 255 938 | 1 297 775 |
| Improved dairy herds | 520 000 | 591 690 | 652 296 | 608 800 | 597 161 | 623 865 |
| Total | 1 500 000 | 1 604 126 | 1 649 557 | 1 744 222 | 1 853 099 | 1 921 640 |

Source: MLF (2014)

Milk production is the major use of the kept cattle. From the secondary data of years 2011, 2012 and 2013 in Babati district, it was observed that production during the wet season ranges between 9.9 to 10.5 litres per cow and 6.3 to 7.2 litres of milk in dry season making an average production of 8.4 litres per day per cow as elaborated in Table 11.

**Table 11: Milk yield from improved dairy cattle in wet and dry seasons in Babati district during the years 2011 - 2013**

| Season/Year | Number of cows | Average milk production (litres) Total milk production (kg) | Average production in 7 months' time kg/cow | Average production kg/day |
|---|---|---|---|---|
| Wet | | | | |
| 2011 | 1785 | 3 701 927.8 | 2 073.9 | 9.9 |
| 2012 | 2263 | 4 797 352.4 | 2 119.9 | 10.1 |
| 2013 | 3078 | 6 765 600.2 | 2 198.1 | 10.5 |
| Dry | | | | |
| 2011 | 1785 | 2 416 237.5 | 1 353.6 | 6.5 |
| 2012 | 2263 | 2 987 222.9 | 1 320.03 | 6.3 |
| 2013 | 3078 | 3 679 217 | 1 520.2 | 7.2 |

Source: DLFO office 2014/15

### 2.7.3 Factors affecting performance of dairy cattle

Inadequate feeding and poor supplementation of dairy cattle for high milk production are the major constraints in dairy industry. Butler (2000) reported that high milk yield is dependent on higher levels of dietary protein (CP) as well as energy. Nkenwa (2009) reported the total daily nutrients intake of 10.8 kg DM, 657.9 g CP, 26.1 g Ca and 18.8 g P for a lactating dairy cow weighing the average of 394.2 kg hence recommended improvement on supplementation during dry season. However, Urassa (2012) suggested that a dairy cow producing 15 kg/day would require 116MJ ME/day with 1235g CP/day. Thus efficient feeding and supplementation to dairy cows improves milk production. In most of the tropical countries, forage and feed resources vary greatly both in quality and quantity; therefore in order to improve productivity of smallholder dairying in the tropics it is necessary to improve quality of natural forages (Mele *et al.*, 2006). According to Mele *et al.* (2006), supplementation can be done in the following ways; by incorporating legumes in pastures or by supplementing with balanced concentrates and minerals. Boitumelo (1993) observed that supplementing dairy cattle with improved forages, crop residues and milling by products was beneficial strategic techniques for increased milk yield. Similar benefits of supplementary feeding of cows and does has been reported by Urassa (1999) and Malau-Aduli (2004) respectively. Therefore, dairy cows become most efficient when she is fed for a level of milk production that approaches her maximum genetic potential. For cows with the potential for high production, this usually involves the feeding of locally available forages and substantial supplementation with concentrates (Miller, 2012). In Tanzania, milk production is constrained by inadequate nutrition (Massawe *et al.*, 1997) and inadequate control of epidemic diseases, unreliable input supply, management and environmental conditions (Msechu *et al.*, 1995). Shekimweri (1982) commented that infestation with internal and external parasites, clinical and sub clinical diseases, diet comprising of poor quality roughages and low levels of livestock management worsen milk production in Tanzania. On the other hand, Gillah *et al.* (2014) reported also that genotype of the cow, environmental and the interaction of the two has higher influence on milk production. Variation between lactation is due to maternal additive gene effect which influence all yield traits.

## 2.8 Conclusions from Literature Review

From the literature reviewed, it can be concluded that different types of crop residues are produced in substantial amounts in different parts of Babati district and elsewhere. These can potentially be used to improve livestock productivity especially during the dry season.

There is possibility of using different crop residues such as pigeon pea as supplement to another due to amounts of nutrients contained in different crop residues. However, proper handling of crop residues needs to be observed for enhanced livestock productivity.

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 Location of the Study

The study was carried out in Babati district. Babati district is one of the five districts in Manyara region and it is in the Northern zone of Tanzania between latitude 3$^{o}$ and 4$^{o}$ South of Equator and the longitude 35$^{o}$ and 36$^{o}$ E of Greenwich. The district lies in the part of the Great Rift Valley, it has a total area of 5069 km$^{2}$, of which 4969 square kilometres is land area, while the remaining square kilometres are covered by water bodies of Lake Babati, Lake Burunge and Lake Manyara. The landscape is characterised by mountains, undulating hills and plains. There are five different agro ecological zones in the district varying from humid highlands (2150 – 2450 m a.s.l) to semi-arid lowlands (950 – 1200 m a.s.l), Table 12 shows the details of agro ecological zone of Babati district while Figure 1 depict the study village location. The district consists of 25 wards and 96 villages (Babati district profile, 2002).

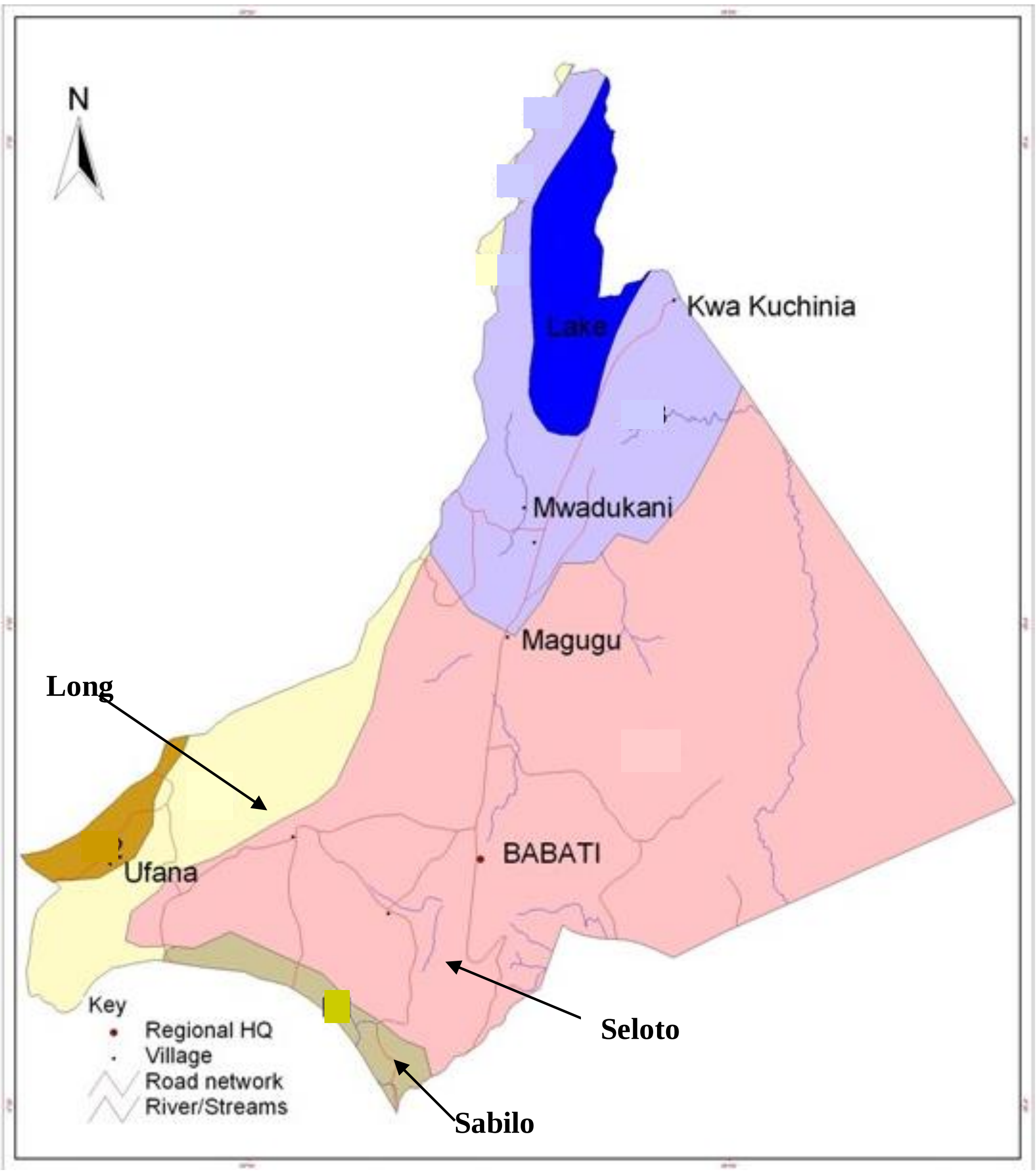


**Figure 1: Babati district portraying study villages**

The rainfall pattern is bimodal. The long rains begin in February and ends in May. The short rains and long rains are often connected. Precipitation is related to the altitude and ranges from 1200 mm/year in the highlands down to 500 mm/year in the lowland as indicated in Table 12.

**Table 12: Agro ecological zones of Babati district**

| No. | Agro-ecological zone | Altitude (m a.s.l) | Rainfall (mm/year) |
|---|---|---|---|
| 1 | Humid highlands | 2150 – 2450 | 1200 |
| 2 | Sub humid highlands | 1850 – 2150 | 1100 – 1200 |
| 3 | Semi humid uplands | 1500 – 1850 | 900 – 1100 |
| 4 | Semi humid arid midlands | 1200 – 1500 | 750 – 900 |
| 5 | Semi-arid lowlands | 950 – 1200 | 500 – 750 |

Source: Babati district profile (2002).

## 3.2 Methodology

### 3.2.1 Research design

The study was conducted in three villages in Babati district. The villages were those selected based on agro-ecological zones representatives of Babati district and adopted by the Africa RISING project (WP3) which cut across different ecological zones. The three villages were Long village, which is located in the humid highlands zone, Seloto village, which is located in the Sub humid highlands and Sabilo village, which is located in Semi-arid lowlands.

The villages were selected after critical analysis of the agro-ecological zones of Babati following discussion with District Agricultural Officer (DAICO) and Livestock officer (DLFO). Prior confirmation of the selected villages, a field trip was conducted to familiarize with the land scape, agro-ecological conditions, land use, as well as agricultural production for both crops and livestock. Special emphasis was put on scoping livestock production system, feed and feeding system.

### 3.2.2 Study phases

Two phases of the study were involved so as to ensemble the objectives of the study. Phase one involved survey which tackled preliminary survey, and the second phase was monitoring. These phases enabled the collection of information which met the assessment of types and quantity of crop residues and other feed resources available for feeding livestock and also assessment on crop residues handling, quantity fed, milk yield and manure handling and use within crop-livestock farming system.

Laboratory work (chemical analysis) was done for samples collected from the major crop residues within the study area and other areas within the district. Laboratory work explains procedures on sample collection, sample preparation and sample analysis under different laboratory techniques. Metabolizable energy and nutrient intake were also calculated.

## 3.3 Phase 1: Survey

### 3.3.1 Pre survey

The study areas were pre-visited for secondary data collection, selection of hamlets to participate in the study and familiarization with local authorities. Main source of secondary data were DAICO and DLFO offices, Village Executive Officers (VEOs) and Village Agriculture/Livestock Officers (VAEO/VALEO) offices.

Survey was also used to set criteria for selecting hamlets and farmers who participated in the study. The set criteria were;

i. The selected hamlets represented a big portion of the villagers, activities carried in the villages and those which were far enough from each other to avoid prevailing common activities due to bordering effect.
ii. The farmers who participated in the focused group discussion (FGD) and household interview were the residents of the selected villages as well as the hamlets.

iii. Farmers who are involved in crop-livestock farming system and produced at least one of the crops which its residues was used as livestock feed.

iv. Farmers who keep one of the livestock (ruminants) found in the locality.

Discussion with the key informant were carried; first in the Agriculture and Livestock office and then in each village so as to set the research modalities. Key informants involved were DLFO, DAICO, extension officers and village leaders. The discussion aimed at getting an overview on types and quantities of crop production in the district, different services offered by the livestock sector within the district, support to livestock sector (by different actors), constraints and opportunities for intervention to enhance productivity of livestock in the farming system. Discussion with extension officers and village leaders; aided in selection of hamlets to be involved in the study. The prepared guideline (Appendix 1 and 2) was used to get the general overview related to crop-livestock farming system, crop production trend and general utilization and management of crop residues within the district and the secondary data was obtained from the office reports. The discussion also aided in modification of the FGD survey tool (Appendix 3) so as to get the best results in the research procedures.

### 3.3.2 Sampling procedure

From each village two hamlets were selected based on the fact that they are located far apart from each other. Crop farming and livestock keeping is being practiced and there is utilization of different types of crop residues as livestock feed. From each hamlet 18 – 36 farmers were selected depending on the number of the resident of the hamlet making a total of 143 farmers (Table 13) from the three villages who participated in PRA. Nine (9) farmers per hamlet were selected to supply information through structured questionnaire. The nine farmers were representing three farming categories which were large scale farmers, (possessing more than 10 Ha of land), medium scale farmers (possessing 5 – 10 Ha of land), and small scale farmers (possessing up to 5 Ha of land).

### 3.3.3 Questionnaire design and pre-testing

Structured questionnaire was formulated in English (Appendix 4) but administered in Kiswahili, a language commonly spoken by all respondents. The questionnaire was pre-tested using twelve farmers to make it more relevant in obtaining the intended information.

**Table 13: Farmers who participated in PRA**

| VILLAGE | HAMLET | GENDER | | TOTAL (Group size) |
|---|---|---|---|---|
| | | Male | Female | |
| Long | Long | 16 | 4 | 20 |
| | Haylot | 18 | 8 | 26 |
| Sabilo | Dulaghang | 15 | 6 | 21 |
| | Bariyomot | 15 | 3 | 18 |
| Seloto | Daktara A | 24 | 12 | 36 |
| | Haesam | 17 | 5 | 22 |
| **TOTAL** | | **105** | **38** | **143** |

### 3.3.4 Data collection

Participatory Rural Appraisal (PRA) techniques were employed using focused group discussions to collect information on types and quantity of crop residues and other feeding resources available for feeding livestock, crop residues handling, milk yield and manure use on different farms in Babati district. Tools such as structured questionnaire, farmers' feed calendar and direct matrix ranking were used to obtain information on feed availability and farmers criteria in feed evaluation respectively. In addition, informal discussion and personal observations gave valuable information and knowledge on the study.

### 3.3.5 Crop residues and other feed resources availability and patterns

Identification of crop residues and other feed resources for developing an inventory was organized through walking around the sites with local key informants selected during PRA and through personal observation. Key information involved in the inventory included scientific names of feed resource, site and relative abundance in different seasons. Patterns of crop residues and other feed resources availability were covered through FGD aided by farmers' feed calendar that was drawn on manila sheets by the respondents (Appendix 5, 6 and 7). The identified natural grasses and forages were grouped as natural occurring pastures, and some are clarified in Appendix 6. Ranking was done by giving scores (range from 0 to 3). Zero symbolized unavailability, one score symbolized scarcity, and two score meant average while three score symbolized availability in large quantities.

In order to obtain the quantity of residues produced in the district, secondary data for the past nine years' crop harvest in different production seasons from 2005/06 to 2013/14 (Appendix 8) were obtained from DAICO's office and the quantity of crop residues produced was calculated using the harvest index (HI), which is expressed as the ratio of crop yields (be it edible seeds, stalks or roots) to the total crop above the ground mass (Smil, 1999).

### 3.3.6 Assessment of the farmers perception on the quality of available crop residues and other feed resources for livestock feeding

After identification of available feed resources including all types of crop residues and other feed resources, direct matrix ranking and score were employed by groups in the study villages to show the criteria used to select different feed materials. In the first place, farmers in group discussion listed important common feed materials, and later on, identified and listed criteria for ranking the quality of feed materials including crop residues. The scale of scores for both crop residues and feed resources as well as criteria used ranged from zero to three: zero indicated not used, one meant poor, two symbolized good and three symbolized very good. The groups ranked the feeds in terms of quality by putting many scores for the most outstanding feed material. Overall assessment reflected general subjective quality of the feed resource and the most outstanding criteria for selecting the best feed resource by the group.

## 3.4 Phase 2: Assessment of Crop Residues Use and Performance of Lactating Cows

To achieve objective iii, a detailed monitoring study was conducted for 30 days using 8 farmers from each village representing each of the agro-ecological zones. The aim was to give detailed measurements of crop residues types and quantity fed, form and mixture fed, storage and handling of crop residues; milk production, manure management and manure use.

### 3.4.1 Crop residues types and quantity fed

The samples of most used crop residues were collected from the farmer's stores to ensure that a big portion of it was what the farmers planned to feed to the animals. The residues were grouped as residues from cereals, legume and oil seeds. A kilogram of each sample was taken from each of the three villages, making a replicate of three samples for each residue. The samples were packed and labeled ready for laboratory analysis. Other samples of crop residues were collected in areas where they are produced in large quantities, mixed and taken to the laboratory for analysis. Samples from the bundle of forage prepared for feeding the animal on each day were harmonised and required amount taken for laboratory analysis. The collected fresh samples were frozen to prevent rotting. The collected samples from farmers who participated in monitoring study were bulked and thoroughly mixed, then subsampled in three replicates in each village for laboratory analysis. The collected samples of feed and feed refusals were weighed. Each sample weight was recorded prior to pre-dried in oven at a temperature of 60 - 70° for 48 hours in Mrara hospital laboratory and the dried samples were taken to SUA for further analysis.

### 3.4.2 Measurement of feed intake and estimation of nutrient intake

Feed offered to the selected lactating cows under zero grazing was weighed for 30 days. A 50 kg spring balance with units 0.5 kg was used for weighing feeds at each farm. Samples of feed were sorted and weighed by plant species types to establish proportions mixed by farmer to form daily ration for the animals. Refusals were collected and weighed early in the morning before the ban was cleaned. Daily nutrient intake by the lactating cow was determined by calculating the nutrient offered less that in the refusals.

### 3.4.3 Milk yield

Milk yield was measured from zero grazed cattle by use of measuring jars and buckets. A total of 24 lactating cows were identified (8 from each village and 1 cow per farmer) and information were recorded by farmers in a well-designed recording sheet after every milking (Appendix 9). Milking was done twice a day, in the morning hours depending on farmers time table and in the evening. The yield was summed to get the day's total yield. A spot milk yield was done by the researcher once per week to check for the validity of the data recorded by the farmer.

### 3.4.4 Measurement of body weights

Body weights of cows were estimated by taking the length of heart girth using weighing band tape at the start of the monitoring study.

### 3.4.5 Laboratory work

The laboratory work was done at the Department of Animal Science and Production (DASP), Sokoine University of Agriculture (SUA) for the analysis of crude protein (CP), dry matter (DM), Ash content, neutral detergent fiber (NDF), and *in-vitro* digestibility of dry matter (INVDMD and organic matter INVOMD). Mineral composition in feeding materials and diets were determined at Soil Science Laboratory of SUA.

#### 3.4.5.1 Sample analysis

**a. Proximate analysis**

Dry matter (DM %), Ash and Crude Protein (CP %) were analyzed according to procedures of Association of Official Analytical Chemists (AOAC, 1990; 2006). The Neutral Detergent Fiber (NDF) was determined according to the procedures by Van Soest *et al.* (1991). The phosphorus (P) and calcium (Ca) content were determined using atomic absorption spectrophotometry method described by AOAC (1990).

**b. *In-vitro* dry matter digestibility**

The value of INVDMD and INVOMD were estimated by the method of Tilley and Terry (1963) modified by Goering and Van Soest (1970). **Where: -**

INVOMD = *In vitro* Digestible Organic Matter in DM basis.

$$= \text{Sample OM} * \frac{(\text{Residue OM} - \text{Residue OM (blank)})}{(\text{Sample OM})} * 100$$

#### 3.4.5.2 Derived parameters

**i. Metabolizable energy**

Using the INVOMD, the Metabolizable Energy (ME), MJ/kg DM content of the samples was computed using MAFF (1975) formula where:-

ME, MJ/kg DM for forages = 0.016 × INVOMD

### ii. Crop residue yield

Crop residues yields were calculated from the formula;

Crop residues = Crop yield * [(1 – HI)/HI]

**Where: -** HI = is the established ratio of the crop yield (edible seeds, stalks or roots) to the total crop mass above the ground (Smil, 1999).

## 3.5 Data Analysis

Collected data was summarized and recorded by using Microsoft excel 2010 data sheet for arrangement and computation of totals and means.

### 3.5.1 Data from the survey

PRA techniques were employed in the evaluation of the survey data whereby varying levels of inductive and deductive protocols were used (Saunders *et al.,* 2003; Saunders *et al.,* 2011). Two levels of analyses, on-site and off-site were adopted in analyzing data from the survey as proposed by Pretty (1995). On-site data analysis involved PRA tools especially direct listing, pair wise matrix ranking, and seasonal calendar. Off-site data analysis involved harmonization (clustering) of data between and within locations, relate the consistency and inconsistency of comments and the specificity of responses and drawing specific inferences. PRA data was used to describe main and important economic activities performed by smallholder farmers within the crop-livestock system, main livestock kept and importance of their farming system. Data collected through a questionnaire was coded and analyzed by the use of computer soft wares, FEAST (Feed Assessment Tool). This is a systematic method to assess local feed availability and use. It helps in the design of intervention strategies that optimize feed utilization and animal production (Duncan *et al.,* 2012), in addition a statistical package for social science

(SPSS) was employed for cross tabulations and descriptive statistics, that is frequencies, percentages and means.

### 3.5.2 Milk yield and DMI

Data for milk yield was analyzed for means and villages (location), DMI and body weight were considered as variable that are responsible for daily milk yield. While in DMI weight, location and quantity of feed offered to lactating cows were considered as source of variations in DMI between villages. The general linear model (GLM) of SAS (2004) was used as follows;

**a. Milk yield**

$Y_{ijkl}=\mu+L_i+D_j+W_k+e_{ijkl}$

**Where;**

$Y_{ijkl}$ = Milk yield of the $j^{th}$ cow as affected by $i^{th}$ location.

$\mu$ = Population (overall) mean,

$L_i$ = Effect of $i^{th}$ location

$D_j$ = Effect of $j^{th}$ DM intake

$W_k$ = Effect of $k^{th}$ body weight

$e_{ijkl}$ = Random error

**b. DMI**

$Y_{ijkl}=\mu+W_i+ Q_j + L_k+e_{ijkl}$

**Where;**

$Y_{ijkl}$ = DMI intake of the $k^{th}$ cow as affected by $i^{th}$ animal weight and $J^{th}$ Quantity of feed offered to the animal.

$\mu$ = Population (overall) mean,

$W_i$ = Effect of $i^{th}$ Weight,

$Q_j$ = Effect of $j^{th}$ Quantity of feed offered to animals

$L_k$ = Effect of $k^{th}$ location

$e_{ijkl}$ = Random error

# CHAPTER FOUR

## 4.0 RESULTS

## 4.1 Phase 1: Results from Survey

### 4.1.1 Economic activities within the study area

Figure 2 shows the contribution of different activities to the economy of the household within the study area. It was observed that the main activity in the study area is agriculture which contributes 92.1% of the livelihood activities to household income with crops contributing 46.4% while livestock contribute 45.7%. Other activities which contribute to the household's income are services/labour, off farm business, horticultural production and poultry keeping.

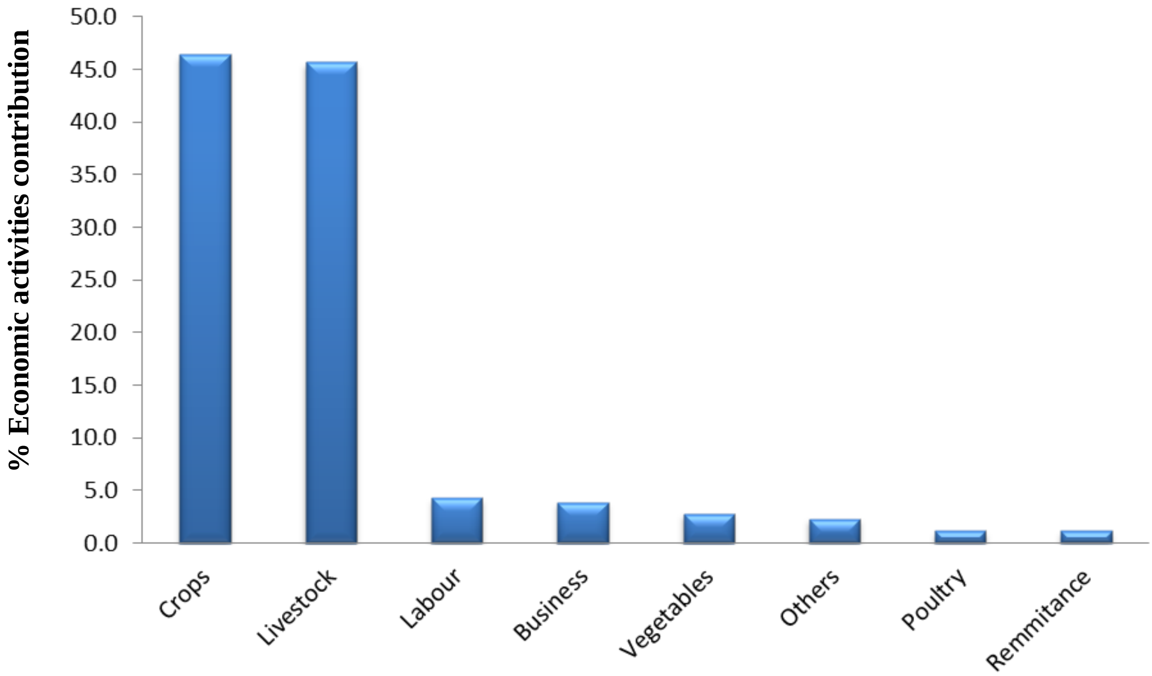


**Figure 2: Percentage contribution of economic activities to the household income**

### 4.1.2 Production systems prevailing in the study area

#### i. Common crops grown and farming methods

Two farming systems were identified in the study villages namely; homestead farming and lowland farming. In all cases two or more crops are often intercropped. Homestead farming involves small plots in the residence areas where crops farming and livestock keeping are practiced. Major crops are intercropped with horticultural crops and some fodder crops (grasses and fodder trees) planted along the contour strips. A number of livestock species such as dairy cattle, goats and sheep are kept. In the lowland faming, farms are located at a distance from homestead of about 1 to 10 km away from the homes where crops are grown intensively for food and cash purposes. Main crops grown are maize, pigeon pea, common beans, sunflower and groundnuts in lower altitude village (Sabilo). These crops are often intercropped in the same field. The commonly grown crops and average acreage per household is presented in Table 14.

**Table 14: Average area per household grown different crops**

| Crop name | Average area (Ha)/HH | % area growing this crop |
|---|---|---|
| Maize (*Zea mays)* | 1.50 | 41.2 |
| Common beans (*Phaseolus vulgaris)* | 0.99 | 27.2 |
| Pigeon pea (*Cajanus cajan)* | 0.80 | 22.0 |
| Sunflower (*Helianthus annuus)* | 0.22 | 6.04 |
| Groundnut (*Arachis hypogoea*) | 0.06 | 1.65 |
| Cow peas (*Vigna unguiculata)* | 0.03 | 0.82 |
| Potato (*Solanum tuberosum)* | 0.02 | 0.55 |
| Chick peas (*Cicer arietinum)* | 0.01 | 0.27 |
| Sorghum (*Sorghum bicolor)* | 0.01 | 0.27 |
| **Total** | **3.64** | **100** |

Some few fodder crops are grown in farm area for livestock feeding purposes; the commonly grown fodder crop is *Pennisetum purpureum* while mixed natural tropical grasses are also found in some reserved farm plots.

### ii. Livestock species, use and their order of importance

The major livestock species kept in the study area are cattle, goats, sheep, poultry and goats; others include donkey, rabbits and guinea pigs. Table 15 shows livestock species kept in the study area, their main use and the order of importance. Livestock are kept within the district for different reasons. The main uses of livestock species kept in the study area were observed to be for milk, beef and pork, drought power, manure, source of income and for some traditional values. However, their order of importance depends on the society keeping the livestock.

**Table 15: The order of importance of different livestock species kept in the study area**

| Livestock Species | Main use | Order of importance | | |
|---|---|---|---|---|
| | | Sabilo | Seloto | Long |
| Local cows | Meat (Beef), Milk, Manure, Traditional values and Bank (reserve) | 1 | 2 | 2 |
| Improved dairy cattle | Milk, Meat (beef), Manure and Bank (reserve) | 2 | 1 | 1 |
| Fattening and drought cattle | Drought power, beef and Bank (income) | 4 | 3 | 4 |
| Goats | Meat, Milk, Manure Traditional values and Bank | 3 | 4 | 5 |
| Sheep | Meat, Manure Traditional values and Bank | 6 | 7 | 6 |
| Piggery | Meat and Bank | 7 | 5 | 3 |
| Poultry | Meat, Eggs and Bank | 5 | 6 | 7 |

*Numbers 1, 2, 3 …7 indicate the order of importance of the livestock species where one shows more importance and seven the least

### iii. Number of livestock units per household

The average number of livestock units (TLU) per household is presented in Table 16. The results reveals that the households keep more local cows (42.5%) while improved dairy cattle contribute only 16.9% of the total livestock kept by the household.

**Table 16: Average livestock holdings (TLU) per household - dominant species**

| Livestock species | Village Sabilo | Seloto | Long | Average number of animals | Percentage |
|---|---|---|---|---|---|
| Local cows | 4.09 | 4.43 | 7.19 | 5.24 | 42.5 |
| Fattening and drought cattle | 2.43 | 3.25 | 4.51 | 3.40 | 27.6 |
| Improved dairy cattle | 2.05 | 2.24 | 1.95 | 2.08 | 16.9 |
| Goats | 1.26 | 1.09 | 1.56 | 1.30 | 10.5 |
| Sheep | 0.25 | 0.14 | 0.55 | 0.31 | 2.51 |
| **Total** | **11.2** | **15.8** | **36.9** | **12.3** | **100** |

### iv. Feeding systems

The responses on the percentages of practiced feeding system during the wet and dry season are presented in Table 17 and 18. Few farmers (28% of the respondents) practiced zero grazing. Few farmers who kept improved cattle practiced zero grazing during cropping (wet) season, when there is enough pasture for the animals, but during the dry season animals are grazed and sometime tethered in nearby farms with some stall feeding.

**Table 17: Percentage of respondents on the feeding system practiced for different categories of animals during the dry seasons**

| | Feeding system | Villages | | |
|---|---|---|---|---|
| | | Sabilo | Seloto | Long |
| Local lactating cows | A | 90 | 75 | 85 |
| | B | 10 | 25 | 15 |
| | C | - | - | - |
| | D | - | - | - |
| Improved lactating cows | A | - | - | - |
| | B | 5 | - | - |
| | C | 80 | 90 | 65 |
| | D | 15 | 10 | 35 |
| Local females – dry and in-calf/expectant | A | 95 | 90 | 85 |
| | B | 5 | 10 | 15 |
| | C | - | - | - |
| | D | - | - | - |
| Improved females – dry and in-calf/expectant | A | 25 | 20 | 15 |
| | B | 35 | 40 | 45 |
| | C | 15 | 15 | 13 |
| | D | 25 | 25 | 27 |
| Local females – dry/open, non- productive heifers | A | 90 | 85 | 80 |
| | B | 10 | 15 | 20 |
| | C | - | - | - |
| | D | - | - | - |
| Improved female – dry/open, non-productive heifers | A | 30 | 25 | 20 |
| | B | 40 | 30 | 15 |
| | C | 30 | 54 | 60 |
| | D | - | 1 | 5 |
| Males (castrated or breeding) | A | 95 | 90 | 85 |
| | B | 5 | 10 | 15 |
| | C | - | - | - |
| | D | - | - | - |
| Local calves | A | 95 | 90 | 90 |
| | B | 5 | 10 | 10 |
| | C | - | - | - |
| | D | - | - | - |
| Improved dairy calves | A | 25 | 10 | 5 |
| | B | 30 | 15 | 5 |
| | C | 45 | 65 | 75 |
| | D | - | 10 | 15 |

Feeding systems: A – Only grazing (free range or tethered), B – Mainly grazing with some stall feeding, C – Mainly stall feeding with some grazing,
D – Only stall feeding (zero grazing)

**Table 18: Percentage of respondents on the feeding system practiced for different categories of animals during the wet seasons**

| Category of animals | Feeding system | Villages | | |
|---|---|---|---|---|
| | | Sabilo | Seloto | Long |
| Local lactating cows | A | 95 | 90 | 95 |
| | B | 5 | 10 | 5 |
| | C | - | - | - |
| | D | - | - | - |
| Improved lactating cows | A | - | - | - |
| | B | 15 | - | - |
| | C | 75 | 98 | 45 |
| | D | 10 | 2 | 55 |
| Local females – dry and in-calf/expectant | A | 100 | 95 | 95 |
| | B | - | 5 | 5 |
| | C | - | - | - |
| | D | - | - | - |
| Improved females – dry and in-calf/expectant | A | 30 | 25 | 15 |
| | B | 35 | 35 | 50 |
| | C | 15 | 10 | 10 |
| | D | 20 | 30 | 25 |
| Local females – dry/open, non-productive heifers | A | 100 | 95 | 90 |
| | B | - | 5 | 10 |
| | C | - | - | - |
| | D | - | - | - |
| Improved female – dry/open, non-productive heifers | A | 45 | 30 | 15 |
| | B | 25 | 15 | 10 |
| | C | 30 | 45 | 50 |
| | D | - | 10 | 25 |
| Males (castrated or breeding) | A | 99 | 95 | 85 |
| | B | 1 | 5 | 10 |
| | C | - | - | - |
| | D | - | - | 5 |
| Local dairy calves | A | 100 | 95 | 95 |
| | B | - | 5 | 5 |
| | C | - | - | - |
| | D | - | - | - |
| Improved dairy calves | A | 15 | 5 | 2 |
| | B | 25 | 10 | 5 |
| | C | 55 | 75 | 80 |
| | D | 5 | 10 | 13 |

Feeding systems: A – Only grazing (free range or tethered), B – Mainly grazing with some stall feeding, C – Mainly stall feeding with some grazing,
D – Only stall feeding (zero grazing)

### 4.1.3 Seasonal availability of feed resources

#### 4.1.3.1 Natural forage

The results showed that feed resource base in Babati district consists of indigenous forages (naturally occurring), crop residues and to a limited extent planted forages. Farmers were aware of locally existing fodders (grasses, shrubs, bushes, weeds and trees species) which are useful to different species of livestock. The naturally occurring forages as were identified and described by farmers are presented in Appendix 10.

#### 4.1.3.2 Planted pastures

Figure 3 presents average area and dominated pasture species planted in the study area. Planted pastures were found in small patches in the study villages, with farmers managing plots of less than 0.1 ha. The dominated planted fodder was the Napier grasses (*Pennisetum spp*) which were planted along the contour bands. The grasses were poorly managed though farmers perceived that they provide sizable amount of fodder during scarcity. Some fodder trees, such as *Sesbania spp, Calliandra calothyrsus, Morus spp and Leucaena leucocephala* were also identified and they also served as the homestead farm boundaries. The trees are known to be good source of plant protein to livestock, but they were few as they ranged between 5 – 18 trees per surveyed farms. However, the study revealed that since dairy production was dominated by the indigenous livestock, then growing of fodder for livestock feed was not given priority.

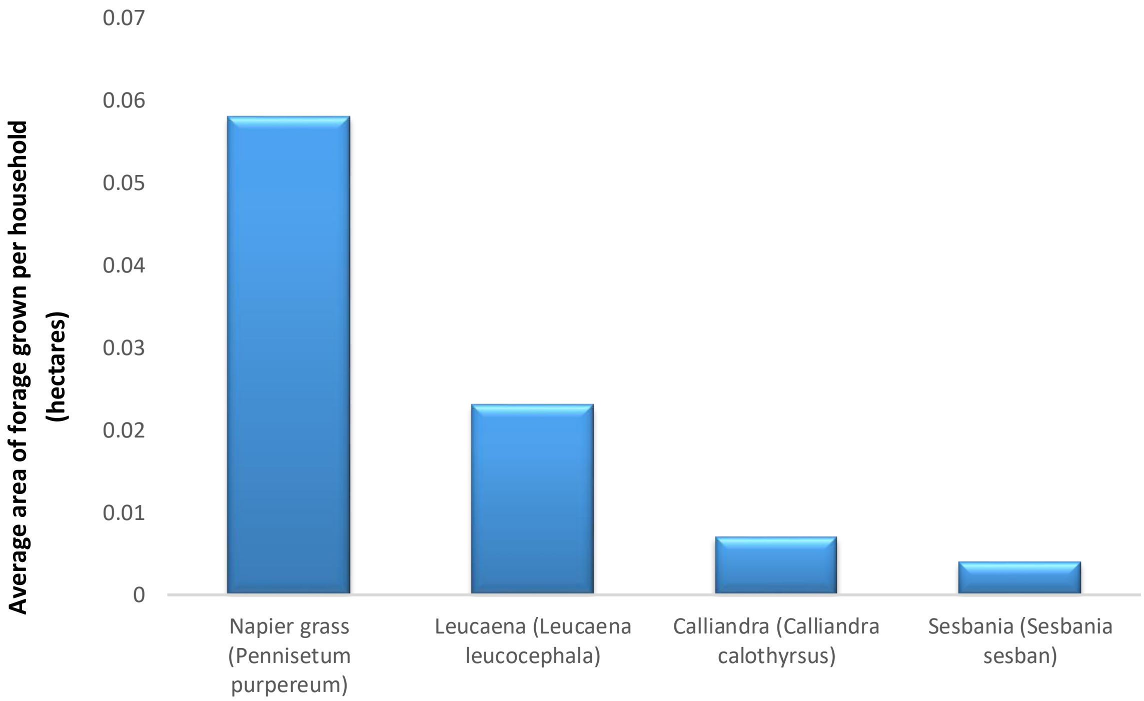


**Figure 3: Average area planted fodder crops in the study villages**

#### 4.1.3.3 Crop residues and crop by products

**i. Quantity of crop residues and other feeds**

Table 19 shows the average crop harvest and produced crop residues in a 9 year period from 2005/06 to 2013/14 in Babati district. The district produced about 153 473 metric tons of different crops ranging from 0.44 to 8.25 metric tons/Ha depending on crop types. The crop residues were consumed by different species of livestock kept in the district. It was estimated that about 141 413 metric tons of maize stover, 14 665 tons of pigeon pea chaffs and 6741 metric tons of common beans haulms were produced in a period between 2005/06 to 2013/14. These were the main crop residues commonly used as ruminant feed in almost every village within the district.

**Table 19: Average crop residues production (Mt.) for 9 years (2005 – 2014) in Babati district**

| Crop | Cultivated area (Ha) | Harvested crops (Mt.)* Dry weight | Harvest Index (HI) | Crop residues (Mt.)/year | Crop residues production/area (Mt./Ha) |
|---|---|---|---|---|---|
| ***A: Cereals*** | | | | | |
| Maize | 40 361 | 94 275 | 0.40 | 141 413.2 | 6.50 |
| Paddy | 2 337 | 9509 | 0.40 | 14 263.5 | 6.10 |
| Sorghum | 7 299 | 7514 | 0.40 | 11 271.2 | 1.54 |
| Wheat | 695 | 4801 | 0.40 | 7202.2 | 0.89 |
| Finger millet | 2 427 | 412 | 0.40 | 617.3 | 2.97 |
| ***B: Legumes*** | | | | | |
| Pigeon pea | 15 452 | 14 090 | 0.49 | 14 664.9 | 0.44 |
| Common beans | 17 590 | 6477 | 0.49 | 6 741.4 | 0.83 |
| Lablab beans | 856 | 1 132 | 0.49 | 1 178.6 | 1.38 |
| Chick pea | 343 | 299 | 0.49 | 311.6 | 0.52 |
| Cow pea | 313 | 172 | 0.49 | 179.2 | 1.00 |
| ***C: Oil crops*** | | | | | |
| Sunflower | 4 942 | 5005 | 0.52 | 4 619.9 | 0.93 |
| Groundnuts | 488 | 364 | 0.52 | 335.7 | 0.69 |
| ***D: Roots and tubers*** | | | | | |
| Sweet potatoes | 819 | 3959 | 0.40 | 5 938.9 | 7.25 |
| Cassava | 543 | 2868 | 0.40 | 4 302.7 | 7.93 |
| ***E: Vegetables*** | | | | | |
| Vegetables residues | 394 | 1093 | 0.38 | 1 782.5 | 4.52 |
| ***F: Sugar crops*** | | | | | |
| Sugar cane | 143 | 1502 | 0.56 | 1 180.2 | 8.25 |
| **Grand Total** | | | | **216 002.8** | |

* Crop residue yield = Crop yield * [(1 – HI)/HI]

### ii. Crop residues utilization and management

The utilization of different crop residues as animal feed in the study area is shown in Figure 4. The study revealed that all respondents (100%) in the study area fed maize stovers, while 81.5%, 59.3% and 12.9%, respectively fed common bean haulms, pigeon pea chaffs and groundnuts foliage. However, the level of crop residues contribution in the total animal diet within the study area was observed to be low.

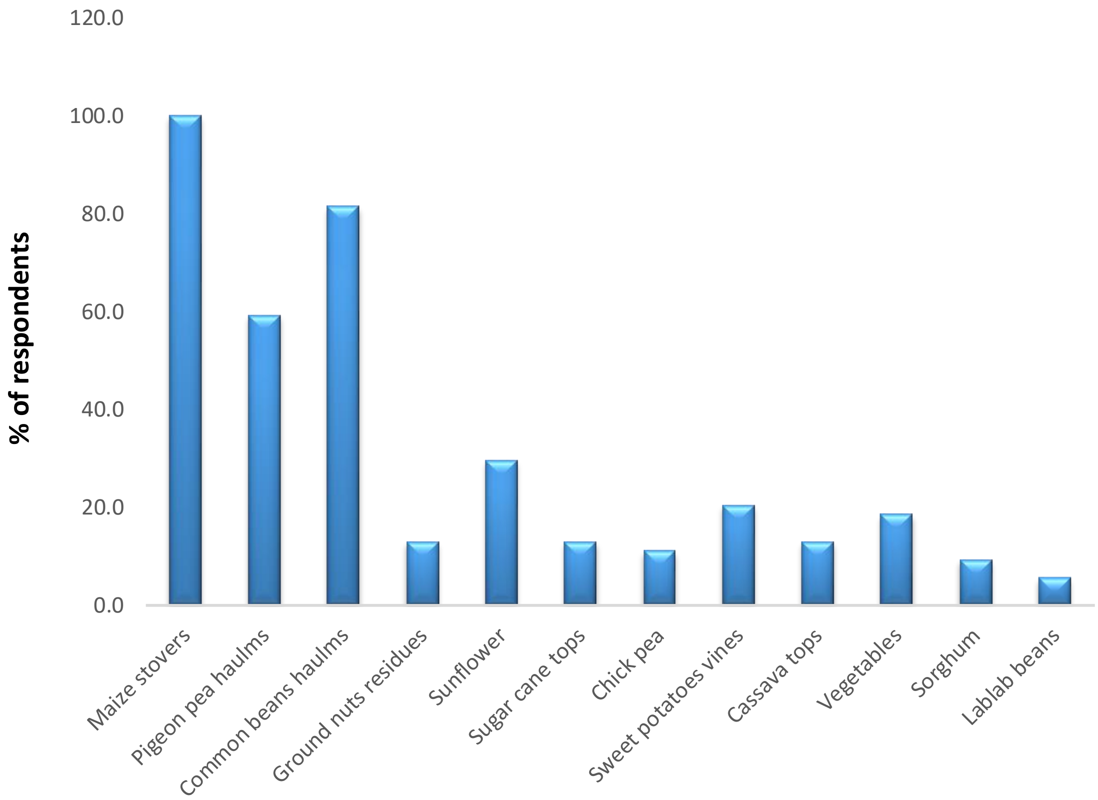


**Figure 4: Response on utilization of crop residues in Long, Sabilo and Seloto villages**

Different crop residues management practices such as harvesting methods, storage methods and processing before feeding (chopping, mixing with salts and urea treatment) gathered during the FGD meetings are shown in Table 20, 21 and 22. It was observed that managerial practices were more or less similar in all the study villages. Despite of been aware of stovers treatment with chemicals to improve intake and palatability through extension services, farmers admitted that they did not treat crop residues, but they used salted water and sometimes molasses sprinkling to improve appetite during feeding. The reason for not treating crop residues with chemicals revealed to be limited knowledge on how to treat crop residues with chemicals.

It was therefore observed that 76% of the respondents harvest maize stover by uprooting the whole remained plant after cobs have been removed. About 44 percent do store the harvested stover in a roofed ban and 33% practice chopping of the stover before feeding to the animals while 28% feed the stover as bulky as they were harvested and 30% of the respondents do not store maize stovers at all. Either the study revealed that 93% of the respondents harvest sorghum stovers by uprooting the whole plant, 56% do not store the stovers for future use but they fed soon after harvesting. Also it was found that 70% do not practice any processing of sorghum stovers and feed as harvested.

**Table 20: Management of the commonly used crop residues as livestock feed; harvesting methods**

| Crop residues | Harvesting methods (% of respondents N = 54) | | |
|---|---|---|---|
| | Uprooting | Stripping | Cutting |
| Maize stovers | 75.9 | 24.1 | 0 |
| Sorghum stovers | 92.6 | 7.40 | 0 |
| Pigeon pea chaffs | 0 | 100 | 0 |
| Beans haulms | 94.4 | 0 | 5.56 |
| Groundnuts foliage | 100 | 0 | 0 |
| Sugar cane tops | 0 | 42.6 | 57.4 |
| Vegetables | 48.2 | 25.9 | 25.9 |

It was observed further that pigeon pea is harvested by striping all over the study area while beans are uprooted by 94% of the respondents. About 63% of the respondents stored pigeon pea chaffs in bags and only 14.8% store beans haulms in bags. The results also showed that 78% of respondents fed bean haulms without storing while 82% and 98% of the respondents did not process the pigeon pea chaffs and beans haulms respectively either by chopping or mixing with any other feed ingredients.

**Table 21: Management of the commonly used crop residues as livestock feed; storage methods**

| Crop residue | Storage methods (% of respondents N = 54) | | | | |
|---|---|---|---|---|---|
| | Pilling under tree | Pilling in roofed store | Bailing | Store in Bags | Not stored |
| Maize stovers | 22.2 | 43.6 | 5.56 | 0 | 29.6 |
| Sorghum stovers | 5.56 | 38.9 | 0 | 0 | 55.6 |
| Pigeon pea chaffs | 0 | 35.2 | 0 | 63.0 | 1.85 |
| Beans haulms | 0 | 7.41 | 0 | 14.8 | 77.8 |
| Groundnuts foliage | 0 | 92.6 | 0 | 0 | 7.41 |
| Sugar cane tops | 0 | 14.8 | 1.85 | 0 | 83.3 |
| Vegetables | 0 | 0 | 0 | 0 | 100 |

**Table 22: Management of the commonly used crop residues as livestock feed; processing before feeding**

| Crop residues | Method of processing before feeding (% of respondents N = 54) | | | |
|---|---|---|---|---|
| | Chopping | Sprinkling with salt water | Mixing with molasses | No processing |
| Maize stovers | 33.3 | 27.8 | 11.1 | 27.8 |
| Sorghum stovers | 20.4 | 7.41 | 1.85 | 70.4 |
| Pigeon pea chaffs | 0 | 13 | 5.56 | 81.5 |
| Beans haulms | 0 | 1.85 | 0 | 98.1 |
| Groundnuts foliage | 0 | 3.70 | 0 | 96.3 |
| Sugar cane tops | 24.1 | 0 | 0 | 75.9 |
| Vegetables | 5.56 | 0 | 0 | 94.4 |

Table 23 shows the costs charged for managing maize stover in the production year 2013/14. Management costs for maize stover ranged from Tshs. 13 000/= to 77 500/= per one acre of maize field.

**Table 23: Costs incurred in maize stover management for 1 acre of maize field in different villages**

| Activity | Amount (Tshs.) | | |
|---|---|---|---|
| | Sabilo | Seloto | Long |
| Transport | 15 000/= - 20 000/= | 10 000/= - 20 000/= | 10 000/= - 20 000/= |
| Labour (Harvesting)/acre | 3 500/= - 5 000/= | 5000/= | 2000/= - 4000/= |
| Storage costs (6 months) | N/A | 30 000/= - 50 000/= | N/A |
| Processing (chopping/salting)/day | 1 500/= 2 000/= | 2000/= - 2500/= | 1000/= - 1500/= |
| Others | N/A | N/A | N/A |
| **TOTAL** | **20 000/= - 27 000/=** | **47 000/= - 77 500/=** | **13 000/= - 25 500/=** |

This costs depended on the geographical location of the farm, the village involved, facilities hiring (example store hiring) and method used for transportation of the residues from the main field (either by use of a tractor or ox cart).

### iii. Contribution of crop residues in animals' diet

Table 24 summarizes the annual contribution of different feed resources to the livestock diet in the study area. It was found that crop residues contributed 1.44% of the total diet DM, 1.36% of the ME and about 1.63% of the total CP.

**Table 24: Contribution of different feed resources to the DM, ME and CP of the animals diet**

| Feed resource | Total contribution (%) to the diet | | |
|---|---|---|---|
| | DM | ME | CP |
| Crop residues | 1.44 | 1.36 | 1.63 |
| Cultivated fodder (grasses and fodder trees) | 0.33 | 0.33 | 0.64 |
| Grazing * | 62.4 | 60.1 | 55.4 |
| Natural occurring and collected ** | 35.8 | 38.2 | 42.3 |
| Purchased (maize brans, sunflower seed cakes, brewers' wet grains etc.) | 0.03 | 0.05 | 0.10 |
| Total | 100 | 100 | 100 |

* Everything eaten by livestock such as crop residues, roadside grasses cut and brought back to animal, grown fodder materials or purchased feed

** Thinning, weeds from crop areas, roadside weeds, naturally occurring grasses, or any other green materials that is naturally occurring and collected for livestock feeding

### iv. Seasonal availability of feed resources

Crop residues were found to be abundant during the dry season especially the months of July to October and are frequently utilized due to scarcity of pastures. In the month of November to Mid-March there was scarcity of crop residues since storage was not done, hence crop residues are normally less available during the wet season. Figure 5, shows availability of crop residues in months where there is crop harvesting; Mid-March – May where irrigated maize is harvested and from July to October which is the main crop harvesting season.

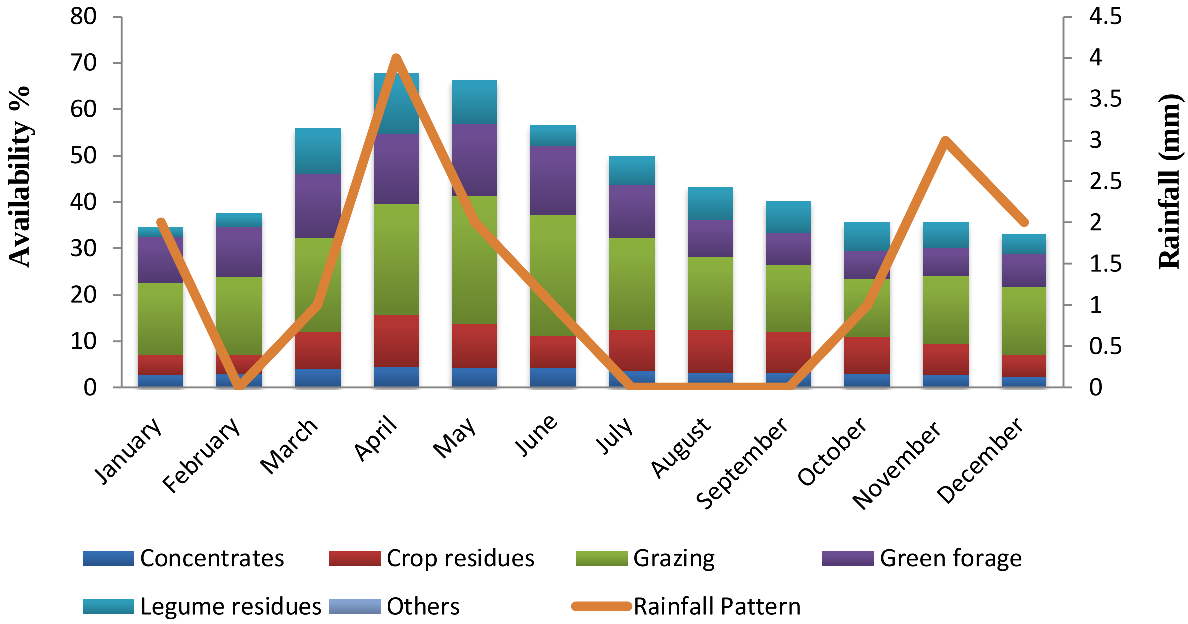


**Figure 5: Seasonal availability of different feed resources**

#### 4.1.3.4 Crop by products

Crop by products such as maize bran with glutens, sunflower seedcakes and brewers' wet grain are available in the study area, however, they are normally bought from agro – dealers shops and at the grain processing plants (machines) at the average price of 2 500 – 3500 T.sh per 8 - 10kg tin, hence referred to as purchased feed resources. The quantity of the crop by products purchased ranged from 3.56% to 66.8% of total purchased feed resources as detailed in Table 25.

Rice polishing was available in areas where rice is grown in large quantities in the district. Broken grains from farmers' farms are also commonly used as livestock feed. Crop by products contributed only 0.03% of the total DM in animal's diet.

**Table 25: The quantity of DM feed purchased per household over a 12 months period**

| Feeds purchased | Quantity of purchased crop by products | |
|---|---|---|
| | Total (Bags)* | % of purchased crop by products |
| Rice (*Oryza sativa)* – polishing | 4.27 | 3.56 |
| Maize *(Zea mays)*- bran/hominy | 80 | 66.8 |
| Sunflower *(Helianthus annuus)* – seed cake | 31.1 | 26 |
| Brewer's grain – wet | 4.39 | 3.67 |
| **Total** | **119.8** | **100** |

*1 bag estimated to weigh 75kg

### 4.1.4 Farmers' perspectives on feed quality

It was found that farmers' involvement in day to day production activities contributed to their accumulated knowledge and experience in feed resource management. Therefore farmers ranked the different feed resources according to their suitability as livestock feeds. Table 26 describes the general ranking in all the study villages. It was observed that green forages ranked the 1$^{st}$, followed by legume residues which were ranked the 2$^{nd}$ and the 3$^{rd}$ was natural grass. The rank and criteria used and score for each feed resources are shown in Appendix 11, 12 and 13 for Long, Sabilo and Seloto respectively. In all villages it was observed that feeds which leads to high milk yield were ranked the first while abundance and availability was ranked 2$^{nd}$ in Long and Seloto but 4$^{th}$ in importance at Sabilo village. On the other side, in all villages legume crop residues were ranked as the best feed resource scoring more points in almost all the set criteria. Natural grasses were ranked 2$^{nd}$ in Long and Sabilo and 3$^{rd}$ in Seloto. Planted pastures were ranked 2$^{nd}$ in Seloto while

Sabilo ranked them 4th in importance. Concentrates were ranked at 2nd position at Sabilo village while both Long and Seloto villages ranked it 4th position.

**Table 26: Ranking of different feed resources according to quality in the study villages**

| Feed resource | Village scores | | | Average score | Rank |
|---|---|---|---|---|---|
| | Long | Sabilo | Seloto | | |
| Natural grasses (tropical grass) | 12.5 | 12.0 | 10.0 | 11.7 | **3** |
| Planted pastures (grass and fodder trees) | 12.0 | 10.0 | 12.0 | 11.3 | **4** |
| Green forage (e.g. road side weeds, cut fodder) | 12.5 | 11.0 | 12.5 | 12.0 | **1** |
| Crop residues (e.g. maize stover, rice straws) | 8.50 | 10.0 | 9.50 | 9.32 | **6** |
| Legume crop residues (e.g. Canadian wonder beans, pigeon pea, chick pea) | 13.0 | 12.5 | 10.0 | 11.8 | **2** |
| Concentrates (e.g. maize bran, grains, seedcakes | 9.00 | 12.0 | 11.0 | 10.7 | **5** |

## 4.2 Phase 2: Assessment of Crop Residue use and Performance of Lactating Cows

### 4.2.1 Form and type of forage mixture fed to the animals

It was observed that farmers collect forage from different locations such as from the cropland, along the roadsides, from the nearby valleys and from pasture gardens. The use of purchased feeds and concentrates was observed to be very low. The collected bulk feed is chopped and fed to the animals. The mixture of the feed making diet in general contained collected weeds from road sides (39.8%); Napier grass (30.9%), crop residues (14.6%) and other feed resources with minimum use of concentrates (0.66%). Figure 6 illustrates the general composition of a bunch of feed offered to the animal. Either forage which are source of protein were found in low quantities in a diet, *Leucaena Spp* averages at 1.07% while other grass legumes were only 8.01%.

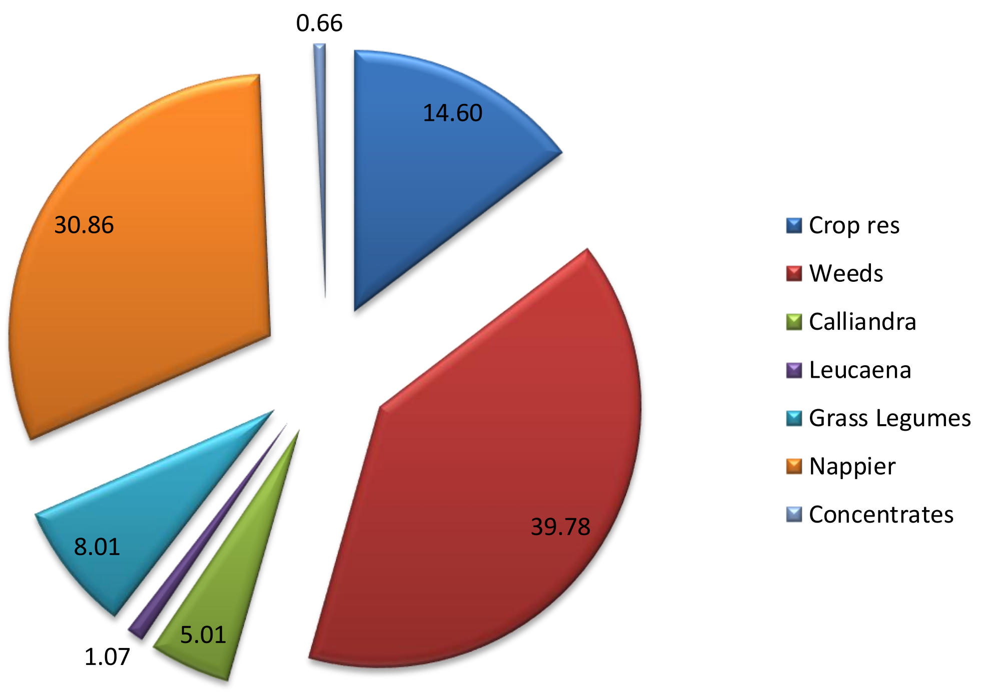


**Figure 6: General diet mixture in the study villages (%)**

### 4.2.2 Milk production

Average daily milk yield of lactating cows recorded during monitoring study in Sabilo, Seloto and Long is presented in Table 27. Daily average total milk yield of lactating cows in Long and Seloto villages were significantly ($P < 0.05$) higher than that of Sabilo village.

**Table 27: Milk production from zero grazed dairy cattle in the study villages**

| Time | Overall mean l/day | Villages<br>Sabilo n = 80 | <br>Seloto n = 80 | <br>Long n = 80 | SE | P - Values |
|---|---|---|---|---|---|---|
| | | Milk yield (kg/day)/cow | | | | |
| AM | 5.86 | $5.84^a$ | $5.86^a$ | $5.88^a$ | 0.03 | > 0.6187 |
| PM | 5.17 | $5.09^b$ | $5.19^b$ | $5.24^a$ | 0.02 | < 0 .0001 |
| **Average Total** | 11.03 | $10.9^b$ | $11.05^a$ | $11.12^a$ | 0.04 | > 0.0098 |

### 4.2.3 Manure handling and use

About 80.4% of livestock keepers in the study area practice grazing (pastoralists) and animals are not housed; instead they stay in the night boma which are not permanently located in one area. This makes it difficult in estimation of manure production as when compared to number of animals within the district. Therefore the monitoring focused on how manure is handled and used in the farming system.

It was observed that most of the produced manure (83.4%) is used as farm yard manure to fertilize farms where a big percentage is used in homestead farms and vegetable gardens (66.7%) and less is used to fertilize major crops farms (16%); either results shows that 12.5% is used as animals' bedding especially during the rainy seasons and 4.22% is used for bio gas production as indicated in Table 28. These percentages are based on the 24 farmers selected and used in the monitoring study.

**Table 28: Manure handling and use in the study villages**

| Variable | Location | | | Total |
|---|---|---|---|---|
| | Long | Sabilo | Seloto | |
| **Manure handling/storage (N = 24)** | | | | |
| Pilling outside (under a tree) | 7* (87.5)* * | 8(100) | 5(62.5) | 20(83.3) |
| Left in the ban | 0(0) | 0(0) | 0(0) | 0(0) |
| Decomposed (Pit, trench) | 1(12.5) | 0(0) | 3(37.5) | 4(16.7) |
| **Manure use (N = 24)** | | | | |
| Spread in the main field for major crops production | 1(12.5) | 2(25) | 1(12.5) | 4(16.7) |
| Used in homestead farms and gardens | 5(62.5) | 6(75) | 5(62.5) | 16(66.7) |
| Used for biogas production | 0(0) | 0(0) | 1(12.5) | 1(4.22) |
| Used for animal beddings | 2(25) | 0(0) | 1(12.5) | 3(12.5) |

*Numbers before the brackets are number of the households

* * Numbers within the brackets are the percentage of the households

## 4.3 Nutritive Value of Available Crop Residues and Diets

### 4.3.1 Chemical composition and *in-vitro* digestibility

The values of DM, CP, NDF, ADF, CF, Ash, INVDMD, INVOMD and ME of feed materials analyzed are presented in Table 29 and 30. The DM of the residues as fed ranged from 23 to 83.4% while the CP percent content on dry matter basis ranged from 4.31% for rice straw to 13.9% for cowpea (*Vigna unguiculata)* haulms. It was therefore observed that residues from legumes crops had higher CP content than those from cereals. Either cowpea haulms were found to have higher percentage of INVDMD of 65.27 or the lowest INVDMD was found in rice straws which were 28.77. Higher level of Ca was found to be 5.21g/kg in sugar cane tops, while the lowest was 0.27g/kg in maize stovers. P levels varied from 0.87 g/kg in sugar cane tops to 6.54 g/kg in groundnuts residues. The DM content of the analyzed feed samples fed to dairy cow ranged from 28.5% to 31.2% the CP content on dry matter basis ranged from 6.99% to 10.5% while INVDMD and ME content ranged from 38.6% to 49.9% and 5.69 to 8.61MEMJ/kgDM, respectively. The mineral content ranged from 1.12 to 2.01 g/kg and 3.21 to 4.06 g/kg for Ca and P, respectively.

**Table 29: Chemical composition of some crop residues in Babati district**

| Feed material | DM % as Fed | Parameters (%) DM basis | | | | | | | | Minerals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ash | CP | CF | NDF | ADF | INVDMD | INVOMD | MEMJKg | Ca(g /Kg) | P(g/Kg) |
| Common bean haulms | 56.2 | 9.47 | 8.79 | 39.4 | 61.8 | 48.3 | 55.9 | 55.6 | 8.90 | 0.98 | 5.07 |
| Cow pea haulms | 74.2 | 12.9 | 13.9 | 29.9 | 60.1 | 44.2 | 65.3 | 64.9 | 10.4 | 1.68 | 4.21 |
| Ground nuts stovers | 69.5 | 11.9 | 12.6 | 27.1 | 51.8 | 40.0 | 62.3 | 64.0 | 10.2 | 1.98 | 6.54 |
| Maize stovers | 71.9 | 10.7 | 5.85 | 41.1 | 76.1 | 41.6 | 36.9 | 39.8 | 6.37 | 0.27 | 2.66 |
| Pigeon pea haulms | 75.9 | 8.96 | 10.1 | 29.7 | 57.6 | 33.6 | 53.8 | 56.1 | 8.98 | 0.45 | 3.98 |
| Rice straws | 43.4 | 22.8 | 4.31 | 36.8 | 78.8 | 53.1 | 28.8 | 35.1 | 5.61 | 0.64 | 2.77 |
| Sorghum straws | 83.4 | 10.0 | 8.24 | 31.1 | 69.1 | 35.9 | 51.9 | 55.4 | 8.86 | 0.59 | 3.52 |
| Sugar cane tops | 23 | 9.06 | 6.84 | 37.4 | 75.9 | 44.4 | 30.8 | 34.5 | 5.52 | 5.21 | 0.87 |
| Sweet potatoes vines | 43.8 | 12.9 | 8.70 | 31.1 | 51.7 | 38.6 | 59.7 | 62.3 | 9.97 | 1.22 | 2.67 |

**Table 30: Chemical composition of sample diets from Sabilo, Seloto and Long villages; Babati district**

| Feed material | DM % as Fed | Parameters (%) DM basis | | | | | | | | Minerals | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ash | CP | CF | NDF | ADF | INVDMD | INVOMD | MEMJ kg | Ca (g/kg) | P (g/kg) |
| Diet Sabilo | 31.2 | 10.4 | 8.18 | 33.8 | 62.9 | 42.1 | 49.9 | 53.8 | 8.61 | 1.34 | 3.21 |
| Diet Seloto | 28.5 | 14.1 | 6.99 | 35.8 | 77.9 | 45.3 | 38.6 | 35.6 | 5.69 | 1.12 | 4.06 |
| Diet Long | 29.2 | 12.3 | 10.5 | 37.9 | 75.6 | 43.9 | 42.3 | 43.1 | 6.90 | 2.01 | 3.67 |

### 4.3.2 Body weight and dry matter intake by lactating cows

The mean value of body weights and DMI of lactating cows under zero grazing in Sabilo, Seloto and Long villages are shown in Table 31. Animals in Long were significantly heavier than those from Sabilo and Seloto. The average DMI by the animals in Seloto and Long were significantly ($P < 0.0324$) higher than those of animals from Sabilo.

**Table 31: Body weight and DMI by lactating cows in study villages**

| Parameters | | Villages | | | SE | P – value |
|---|---|---|---|---|---|---|
| | Overall mean | Sabilo | Seloto | Long | | |
| Body weight (kg) | 393.5 | 383.8$^{b}$ | 390.4$^{c}$ | 406.2$^{a}$ | 1.68 | <.0001 |
| DMI (kg) | 12.6 | 12.05$^{b}$ | 12.7$^{a}$ | 12.9$^{a}$ | 0.25 | < 0.0324 |

Values bearing the same superscript are not significantly difference in Body weight and DMI between villages at $P < .0001$ and $P< 0.0324$, respectively

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 General Observation

The general objective of this study was to assess the possibility of utilizing more of the different crop residues available in Babati district as livestock feeds under the smallholders' crop-livestock production system. The study was performed in three different agro-ecological zones of Babati district which are humid highlands, semi humid uplands and semi-arid midlands representing Long, Seloto and Sabilo villages, respectively. The discussion covers the types and quantity of crop residues and other feed resources, quality of available crop residues and handling, quantity fed, milk yield and manure use within the farming system.

### 5.2 Quantity and quality of Crop Residues and other Feed Resources Found in the Study Area

#### 5.2.1 Quantity of crop residues and other feed resources

Different types of crop residues were produced in Babati district due to its diverse agro-ecological conditions. Kangalawe (2013) also reported production of different crop residues in a wide range of agro-ecological zones of semiarid regions of central Tanzania. The produced quantities of crop residues in Babati district are in the range of quantity reported elsewhere in Tanzania (De Groote *et al.*, 2013; Marandu *et al.,* 2014; Mtengeti *et al.,* 2015; Kangalawe, 2013; Ndwasinde, 2013). The observed major crop residues produced in the area (maize stover, pigeon pea chaffs, beans haulms, rice straw sorghum, cow pea haulms, cassava tops, sugar cane tops, sweet potatoes vines, groundnuts foliage and lablab beans haulms) was almost similar to crop residues reported by Mangesho *et al.* (2013).

The average of 6.5 metric tons per hectare of maize stovers produced yearly in Babati district is within the range of 5.33 to 15.4 metric tons per hectare reported by Mtengeti *et al.* (2015). However, this amount is higher compared to 1.82 and 3.71 metric tons per hectare reported by Kangalawe (2013) and De Groote (2013) in central parts of Tanzania and elsewhere in East Africa respectively. Several factors have been reported by different authors that contribute to the differences in crop residues yields, these factors include increased cultivation of food (cereals and leguminous) crops in a specific areas, high vegetative growth due to different crop varieties, field management and improvement of agronomic practices (Keftasa, 1987; Karlsson, 2008; Mtengeti *et al.*, 2015).

The high utilization of common bean haulms (81.5% of respondents) as livestock feed could be due to easiness of collection and transportation since the haulms are packed in bags, its contribution to animal performance and increased milk yield as ranked by farmers and also due to nutritive value as shown by the CP content (8.79%). About 1.00 metric tons per hectare of bean haulms are produced yearly in the district. This amount is more or less similar to the quantity of 1.07 metric tons per hectare produced in central regions of Tanzania as reported by Kangalawe (2013). Intercropping and poor spacing of the crop may lead to such low residue production in Babati district as reported that farmers often intercrop more than one crop in the same field (Mangesho *et al.*, 2013). Also poor use of FYM to improve farm productivity contribute to low biomass harvest as it was also reported that poor soil fertility is a limiting factor to high crop production in the district (Kimoro, 2003; Fredrik, 2005).

The observed quantity of pigeon pea chaffs produced is low compared to 0.65 and 1.59 metric tons per hectare reported by Marandu *et al.* (2014) in Tanga region and Kangalawe (2013) in central regions of Tanzania, respectively. Pigeon pea cultivars differ in biomass production due to height of growth, branching and number of leaves and pods produced (Marandu *et al.,* 2014). The utilization of pigeon pea chaffs as livestock feed by 59.3% of the respondent is low compared to 81.5% for common bean haulms even though pigeon pea has higher CP (10.1%). This lower use of pigeon pea could be due to its lower acceptance by the animals caused by its unpleasant smell as reported by Cheva-Isarakul (1992) and also small quantity of crop residues produced in the locality. More pigeon peas are produced in semi humid arid midland of Babati (Sabilo village) while in the humid highlands and Semi humid uplands where Long and Seloto villages are found, pigeon pea production is minimum.

Rice is produced in valleys and swamp areas of Babati with the local varieties being produced in larger areas. During the study period it was observed that rice is the third crop that produces large quantities of residues after maize and pigeon pea. It was also estimated that in a 9 year cropping season (2005 – 2014) a total of 14 263.5 metric tons of rice straws was produced per year with an average of 6.1 Mt./Ha. This amount is within the range of 3.81 to 7.41 Mt/Ha of rice straw produced elsewhere in Tanzania as reported by Mtengeti *et al.* (2015). But the produced quantity in Babati is higher as compared to quantity of rice straw of 4.09 Mt/Ha produced in some parts of Morogoro reported by Ndwasinde (2013). Local varieties have more vegetative growth and yields more dry mass of straws than most of the improved varieties (Ndwasinde, 2013). Since in rice growing areas of Babati farmers cultivate local varieties, it is possible that this could be the reason for higher production of rice a straw in Babati as compared to what is reported in Morogoro. It was also found that about 1.54 Mt/Ha of sorghum stovers is produced in Babati. The reported quantity is about the same as quantity of 1.41 Mt/Ha produced in semiarid central parts of Tanzania (Kangalawe, 2013). The quantity produced in Babati rank the fourth compared to other crop residues produced, this could be due to the fact that sorghum is cultivated in all agro-ecological zones of Babati. It performs well in a wide range of soil type and rainfall (Pande *et al.*, 2003) and also farmers normally grow sorghum as a risk coping crop (Reddy *et al.*, 2003).

Generally, there are large volumes of crop residues produced in Babati which could contribute highly to livestock feeding. Mangesho *et al.* (2013) reported that maize stovers, pigeon pea chaffs, rice straws, common beans haulms and sorghum stovers are produced in the district in large quantities during the harvesting periods.

Local/natural existing fodder included grasses, shrubs, bushes, weeds and different trees as identified by the farmers. This finding was similar to those reported by Mtui (2004) and Selemani *et al.* (2013) in Turiani and Meatu districts respectively. Concentrates and other crop by products were also available in the area. Estimation of the quantity of other feed resources found in Babati district was not on the scope of the present study. However, the concentrates contribution of 0.66% to the total daily livestock diet (Figure 5) gave an idea on the amount of this feed available for livestock feeding.

### 5.2.2 Quality of available crop residues

The observed as fed DM content of maize stovers (61.9% as fed) was generally higher than what was reported by Wambui *et al.* (2006). The variations were probably due to plant maturity, post-harvest treatment, plant part (leaf or stem) season harvested and state of hydration and due to higher temperatures within the tropics that burns the residues and hence removing the available moisture (Hindrichsen *et al.,* 2002; Ndemanisho *et al.,* 1998). The CP content of the maize stovers was relatively higher than those reported by Kilongozi (1992), Nherera *et al.* (1998) and Tolera and Sundstøl (2000) however, lower than what has been reported by Stanton and Le valley (2006) and Wambui *et al.* (2006).

Farmers in Babati leave their maize to dry in the field hence over mature and over drying of the straw may be the cause of the observed low CP content. Kimoro (2003) reported that maturity is often accompanied by the increase in cell wall concentration and decrease in digestibility as well as decrease in crude protein.

The CP content of rice straw (4.31%) is similar to that reported by Adegbola (2002), but higher than those reported by Samklong *et al*. (2010) and Kimario (2003) and lower than those reported by Cheva-Isarakul (1992) and Mtamakaya (2002). The probable reason for the variation in CP content could be varieties grown, seasons and farm management in general. Nutritional value of rice straw is dependent on factors such as climatic condition; harvesting time, farm condition and residue management (Wanapat *et al.,* 2009), but also variation between season in which rice is grown has marked effect on nutritional value of rice straws. Devendra and Thomas (2002) reported that early season rice has higher N content in the residues (1.04% of DM) while the late grown rice has lower N content of 0.96% of DM found in the straws. The observed Ca (0.64 g/kg) was higher than the one reported by Kimario (2003) while P was very low as compared to amount reported by Kimario (2003). This could probably be due to late season which most farmers in Babati harvest rice crop, difference in location as well as soil condition and farm management.

The observed CP level of the sorghum straws (8.24%) was higher than those reported by Akinfemi *et al.* (2010); Stanton and Le valley (2006); Lardy and Anderson (2009). This may be contributed by the parts which farmers in the district used to feed their animals. In Babati district, farmers feed leaf parts rather than the stems. Comparing sorghum straws with good quality hay, Lardy and Anderson (2009) reported that vegetative parts of sorghum are good protein and energy sources. Reddy *et al.* (2003) also reported that sorghum stubbles do not decrease in quality as rapidly as maize stover after physiological maturity because of new tillers emerging continuous after maturity. However, the feeding value of sorghum is limited due to high CF and lignin and lower vitamins and minerals (Akinfemi *et al.*, 2010). The observed CF in the present study was 31.1% with 0.59 g/kg Ca and 3.52 g/kg P.

The observed CP content in pigeon pea chaffs in the present study was higher than that reported by El hardalou (1980) but lower than that reported by Fatima (2003). The variation in CP was probably due to varieties differences, leaf, stem and pod ratio as well as seed separation efficiency. Whiteman and Norton (1982) reported that chemical composition of the pigeon pea vary depending on maturity and proportion of various plant components such as leaf, stem, flowers, seeds and pods, while Foster (2008), Singh and Diwakar (1993) and Cheva-Isarakul (1991, 1992) reported a high CP content in pigeon pea leaves.

### 5.2.3 Digestibility of the crop residues

In the present study, low INVDMD and INVOMD were observed in rice straws (28.8% and 35.1% respectively). These observed values were lower compared to other researchers findings and reports (Ørskov and Ryle, (1990); Mtamakaya (2002); Cherdthong *et al.* (2014). Rice straws in Babati are normally not stored in sheltered stores, they are left in the field and when needed for feeding animals, are collected from the field directly to the intended animals. The rice crops are harvested when about 80% of the grains are dry. Harvesting stage, level of lignification, CP content and residues management have notable contribution to digestibility of the straws. High fibre and lignin (NDF > 50%) in rice straws and low content of CP (2 – 5%) in DM basis, lead to low digestibility of the straws (Wanapat *et al.*, 1994). According to McDonald *et al.* (2010) and Shem (1993) forage quality (high fibre and low CP) leads to lower digestibility. Therefore, a wide variation between reported findings of the current study with findings of other authors may also be due to method used to evaluate digestibility of the straws since *in vitro* values are normally lower than *in vivo* values (McDonald *et al.*, 2010).

Dry matter digestibility of the maize stovers in the present study (55.9%) was found to be higher than the percentage reported by Ondiek *et al.* (2013) but lower than that reported by Harding *et al.* (2016). Either the Organic matter digestibility (55.6%) was more or less the same as the one reported by Ondiek *et al.* (2013) of 55.9% but lower than that reported by Harding *et al.* (2016). The difference may be due to the stage of maturity when maize stover was harvested, as maize stovers harvested immediately after grains harvest has higher CP levels and lower concentration in fibres, hence more digestible than those left in the field for long period after grain harvest (Lardy and Anderson, 2009).

For pigeon pea chaffs, in the present study was found to have DM digestibility of 53.8%. This percentage is higher than what was reported by Whiteman and Norton (1982). It has been reported that pigeon pea chaffs which contain more of the leaf and broken grains have more protein content hence higher digestibility (Foster, 2008). Also it has been reported by Ahamefule *et al.* (2006) that, height of cut of pigeon pea stems has effect on digestibility as moody parts lowers digestibility. Most pigeon pea chaffs in Babati have lower stem ratio due to prevailing harvesting method of stripping the branches and pods, rather than cutting the stems hence this could probably contribute to the observed higher DM digestibility in the present study.

## 5.3 Handling of Crop Residues and Feeding

Crop residue handling practices observed in the present study was similar to those reported by other researchers elsewhere (Owen and Jayasuriya, 1989; Bogale *et al.*, 2008;

Valbuena *et al.,* 2012). The handling practices in Babati district did not show marked different between the study villages. This may be due to sharing of the same or similar farming systems. Valbuena *et al.* (2012) reported that the marked diversity in crop residues management practices depends on farming system of locality and pressure on land which can be used for grazing. Example; Bogale *et al.* (2008) mentioned that in Ethiopia Highlands, the change in crop residue management practices was necessitated by the practice of feeding livestock with straws in the morning and evening around the homestead hence need for storing the straws. However, in the present study, it was revealed that (through FGD) 75% of the livestock keepers in the study villages do not store crop residues but they graze *in situ* after the grain have been removed. This observation is less than the 78 percentage reported by Kihara *et al.* (2015) in the same district. Farmers avoid storing crop residues due to the bulkiness of the residues when they are stored as harvested from the main fields. But this is caused by lack of proper crop residues management skills such as chopping; bailing by use of simple technologies like use of wooden bailing boxes and easy cutting/chopping machines such as pulverizes for future use (Massawe and Mruttu, 2005; Kihara *et al.* 2015). Since the dominating livestock species in the district is indigenous cattle, most of the livestock keepers graze their animals rather than keeping them in confinement; therefore it become hard for them to store crop residues.

In Kenya, it was reported that stall feeding and stubble grazing has increased demand for crop residues storage and hence decreased grazing in the field after the main crop is harvested (Valbuena *et al.,* 2012). Owen and Jayasuriya (1989) suggested that for maintaining good quality straws, it is important to consider hipping the straws under a well-constructed shed, also chopping and bailing for easy storage for future use are important. It was also revealed in the current study that 27.8 – 70.4% of the respondents do not do any processing of the straws prior to feeding to the livestock. It is known that treatments such as chopping, sprinkling with salted water or molasses minimizes selections by animals and encourage intake and hence lower nutrient digestibility. But, increasing intake and digestibility of the crop residues can also be achieved by several ways including physical methods such as chopping, grinding, soaking in water and striping, mixing with high quality feeds with high CP content and use of any other physical treatment so as to increase surface area of digestible material exposed to rumen microbes (Clark and Ipharraguerre, 2001; Salem and Smith, 2008).

In the present study, it was observed that crop residues included in the animals' diet was only 14.6% and hence contribute about 1.44%, 1.36% and 1.63% DM, ME and CP respectively of the total diet. This amount was more or less similar to the one reported by Mangesho *et al.* (2013). Poor skills and techniques on storage and processing of the residues before feeding may be the major reason for the low quantity of crop residues included because the bulk of crop residues is wasted due to damage by termites and hence used for only short period in the year.

## 5.4 Effect of Crop Residues Feeding on Performance of Cows

The daily average milk yield from the grade dairy cattle observed in all the study villages (11.2L/day) was higher than the average daily production observed in the district reports, but this can be due to the fact that the district reports include production values from grazed local cows which are dominant and these produce less milk due to their low genetic potential. The observed amount was found to be higher than quantity reported by Sarwatt and Njau (1990), Nkenwa (2009) and Nkya *et al.* (2015), but within the range of average daily yield of 10.7 to 12.4 kg/day reported by Wanapat *et al.* (2009) and lower than quantity reported by Abate (1995). The low milk yield reported by other authors could be due to poor feeding of the dairy cow especially during the late gestation period (Nkya *et al.,* 2015), while the higher milk yield which was observed in partial grazed lactating cows was due to a benefit of selection of nutritious plants (Bareeba, 2003). The possible reason for high milk yield in Babati could be due to feeding system of the expectant cows, which are more cared as compared to other category of animals in both seasons through stall feeding as was revealed by a high percentage of respondents (Table 17 and 18). Several authors have reported on sound performance of animals fed on crop residues as basal diets. Example; Bal *et al.* (2000) reported high milk yield of up to 33.4 kg/day in a lactating cow fed diets containing 67% maize stover with 33% Alfalfa hay. On other hand, Harding *et al.* (2015) reported an average daily weight gain of 263.1g/day in growing cattle fed a diet that contained 50% crop residues treated with CaO while Anandan *et al.* (2010) also reported a growth rate of 90 g/day in sheep fed basal diet contained 50% sorghum straws. However, feeding the crop residues as basal diets requires supplementation to ensure the required levels of protein and energy to maintain production levels is achieved (Fadel Elseed, 2005; Savadogo *et al.,* 2000). However, inadequate feeding and poor supplementation lowers milk yield, either supplementing dairy cows with improved forages, crop residues and milling by products was found to be a strategic technique to increase milk yield (Bal *et al.,* 2000; Wanapat *et al.,* 2009; Promkot and Wanapat, 2005; Nkya *et al.,* 2015).

## 5.5 Manure Handling and Use

From the survey, it was observed that the collected manure are stored in different ways before they are used within the farming system. It was revealed that only 16.7% of the homesteads decompose collected manure in either pit or trench. The observed percentage is relatively low compared to 21.6% reported by Jackson (2005). For the best quality manure for farm use, it has been recommended that the collected manure should be stored in a well-constructed wooden barn, or pit so as to undergo decomposition (Rufino *et al.*, 2007; Jackson, 2005; Baijukya *et al.*, 2005). In Babati district, majority of the homesteads (83.3%) collected the manure and piled it under the trees for a period of 3 – 6 months. Pilling of manure in open area where there is possibilities of sun burn and splashes of rain water, most of the important nutrients such as N is leached hence the quality of manure is reduced (Jackson, 2005; Jackson and Mtengeti, 2005; Fredrik, 2005).

From the current study it was also observed that 66.7% of produced manure in the study villages is used for fertilization of homestead farms and vegetable gardens while only 16.7% is used in the major crop fields. The amount used in major crop field is lower than those reported by several authors in other areas in Tanzania (Jackson and Mtengeti, 2005; Baijukya *et al.*, 2007). Low productivity of major crop in Babati could be due to poor nutrients recycling due to nutrient mining. Most of the removed crops and residues are rarely returned to the main fields as farm yard manure. Fredrik (2005) reported that soil fertility is one of the limiting factors for crop production following poor use of FYM. Therefore, success in long-term agriculture production in resource poor farming system relies on the efficiency on how nutrients are conserved and recycled.

# CHAPTER SIX

## 6.0 CONCLUSION AND RECOMMENDATIONS

### 6.1 Conclusions

It is concluded that although large quantities of different crop residues are produced in Babati district, only small percentage of these are used in animals' diet. This indicates that more crop residues could be used in feeding animals if proper handling of these feeds and feeding techniques are imparted to the farmers. Similarly, more of the produced manure could be used in nutrient recycling to improve crop productivity where manure management and utilization practices are imparted to the farmers.

### 6.2 Recommendations

i. Introduction of simplified techniques to farmers on Management of crop residues, processing/treatment before feeding and supplementation to improve utilization of the crop residues must be emphasized.

ii. Simple technologies that will enable cutting/chopping, bailing and simplify storage of crop residues by minimizing bulkiness should be developed and introduced on farms.

iii. Further research on performance of zero grazed cows and quality of feed offered (including crop residues) to those cows in all seasons is required for establishing supplementary ration.

## REFERENCES

Abdul, S. B., Yashim, S. M. and Jokthan, G. E. (2008). Effects of supplementing sorghum stover with poultry litter on performance of Wadara cattle. *American-Eurasian Journal of Agronomy* 1(1): 16 – 18.

Adegbola, T. A. (2002). Nutrient intake, digestibility and rumen metabolites in bulls fed rice straw with or without supplements. *Nigeria Journal of Animal Production* 29(1): 40 – 46.

Ahamefule, F. O., Ibeawuchi, J. A. and Ibe, S. N. (2006). Nutrient intake and utilization of pigeon pea-cassava peel based diets by West African Dwarf (WAD) bucks. *Pakistan Journal of Nutrition* 5(5): 419 – 424.

Akinfemi, A., Adu, O. A. and Doherty, F. (2010). Conversion of sorghum stover into animal feed with white-rot fungi: Pleurotus ostreatus and Pleurotus pulmonarius. *African Journal of Biotechnology* 9(11): 18 – 21.

Anandan, S., Khan, A. A., Ravi, D., Reddy, J. and Blümmel, M. (2010). A comparison of sorghum stover based complete feed blocks with a conventional feeding practice in a peri-urban dairy. *Animal Nutrition and Feed Technology* 10: 23 – 28.

Anandan, S., Khan, A.A., Ravi, D. and Blümmel, M. (2010). A comparison of two complete feed blocks based on sorghum stover of two different cultivars on weight gain in sheep and economy of feeding. *Animal Nutrition and Feed Technology* 1: 101 – 104.

AOAC (1990). Official Methods of Analysis, 15th ed. Association of Analytical Chemists, Washington, DC. 45pp.

AOAC (2006). Official Methods of Analysis, 18th ed. Association of Analytical Chemists, Washington, DC. 24pp.

Babati district profile (2002). [www.nbs.go.tz.pdf/babatiprofile2002] site visited on 2/10/2014.

Baijukya, F. P., de Ridder, N., Masuki, K. F. and Giller, K. E. (2005). Dynamics of banana-based farming system in Bukoba district, Tanzania: Changes in land use, cropping and cattle keeping. *Agriculture Ecosystem and Environment* 106 pp.

Bal, M. A., Shaver, R. D., Al-Jobeile, H., Coors, J. G. and Lauer, J. G. (2000). Corn silage hybrid effects on intake, digestion and milk production by dairy cows. *Journal of Dairy Science* 83(12): 2849 – 2858.

Bal, M. A., Shaver, R. D., Shinners, K. J., Coors, J. G., Lauer, J. G., Straub, R. J. and Koegel, R. G. (2000). Stage of maturity, processing, and hybrid effects on ruminal in situ disappearance of whole-plant corn silage. *Animal Feed Science and Technology* 86(1): 83 – 94.

Bareeba, F. (2003). Evaluation of forage legumes in association with *Panicum maximum* under grazing and cutting management systems. In: *Proceeding of the 30th Scientific Conference of the Tanzania Society of Animal Production.* pp. 228 – 235.

Bebe, B. O., Udo, H. M. J., Rowlands, G. J. and Thorpe, W. (2003). Smallholder dairy systems in the Kenya highlands: breed preferences and breeding practices. *Livestock Production Science* 82(2): 117 – 127.

Bee, F. K. (2007). Rural financial markets in Tanzania. *An analysis of access to financial services in Babati district, Manyara region*. *Thesis for the degree of Doctor of Literature and Phylosophy in the subjects of development studies.* University of South Africa. 299pp.

Bello, A. A. and Tsado, D. N. (2013). Feed intake and nutrient digestibility of growing Yankasa rams fed sorghum stover supplemented with graded levels of dried poultry droppings based diet. *Asian Journal of Animal Sciences* 7(2): 56 – 63.

Biwi, K. M. (1993). Development of smallholder dairying in Zanzibar. In: Future of livestock industries in Eastern and Southern Africa. *In: Proceedings of workshop held at Kadoma Ranch Hotel, Zimbabwe 20 – 23rd July 1992. (Edited by Kategile, J. A. and Mubi, S.) ILCA, Adis Ababa, Ethiopia.* pp 173 -176.

Blümmel, M., Zerbini, E., Reddy, B. V. S., Hash, C. T., Bidinger, F. and Khan, A. A. (2003). Improving the production and utilization of sorghum and pearl millet as livestock feed: progress towards dual-purpose genotypes. *Field Crops Research* 84(1): 143 – 158.

Bogale, S., Melaku, S. and Yami, A. (2008). Potential use of crop residues as livestock feed resources under smallholder farmers' conditions in Bale highlands of Ethiopia. *Tropical and Subtropical Agro-Ecosystems* 8: 107 – 114.

Boitumelo, W. S. (1993). Peri-Urban small-scale dairy research programme in Botswana. In: Future of livestock industries in Eastern and Southern Africa. *Proceedings of the workshop held at Kadama ranch hotel, Zimbabwe, 20 – 23 July 1992. (Edited by Kategile, J. A. and Mubi, S. J.) ILCA, Adis Ababa, Ethiopia.* pp. 50 – 58.

Butler, W. R. (2000). Nutritional interactions with reproductive performance in dairy cattle. *Animal Reproduction Science* 60: 449 – 457.

Cherdthong, A., Wanapat, M., Wongwungchun, W., Yeekeng, S., Niltho, T., Rakwongrit, D. and Foiklang, S. (2014). Effect of feeding feed blocks containing different levels of urea calcium sulphate mixture on feed intake, digestibility and rumen fermentation in Thai native beef cattle fed on rice straw. *Animal Feed Science and Technology* 198: 151 – 157.

Cheva-Isarakul, B. (1991). Supplementary effect of various levels of dry *Leucaena* leaves to rice straw and the precision of AIA as an indicator for digestibility determination. *Thai Journal of Agriculture Science* 24(3): 233 – 242.

Cheva-Isarakull, B. (1992). Pigeon pea as a ruminant feed. In: Ruminant feeding utilizing fibrous agriculture residues. (Ed. R. M. Dixon) IDP Canberra, Australia. pp. 133 – 138.

Clark, J. H. and Ipharraguerre, I. R. (2001). Livestock performance: Feeding biotech crops. *Journal of Dairy Science* 84: E9 - E18.

Coleman, S. W. and Moore, J. E. (2003). Feed quality and animal performance. *Field Crops Research* 84(1): 17 – 29.

Devendra, C. and Thomas, D. (2002). Crop-animal interaction in mixed farming system in Asia. In: Crop residues in sustainable mixed crop/livestock farming system (Ed. C. Renard) CAB International; Wallingford, UK. pp. 241 – 267.

De Groote, H., Dema, G., Sonda, G. B. and Gitonga, Z. M. (2013). Maize for food and feed in East Africa - The farmers' perspective. *Field Crops Research* 153: 22 – 36.

Duncan, A., York, L., Lukuyu, B., Samaddar, A. and Stür, W. (2012). Feed Assessment Tool (FEAST): A systematic method for assessing local feed resource availability and use with a view to designing intervention strategies aimed at optimizing feed utilization. Questionnaire for Facilitators (Version 5.3); updated: 15 June, 2012. ILRI, Addis Ababa, Ethiopia. [http://www.ilri.org/feast.] Site visited on 22/7/2015.

El hardalou, S. B., Eating, A. H. and Nour, A. A. (1980). Chemical characteristics of some legumes grown in Sudan. *The Sudan Journal of Food Science and Technology* 12: 35 – 42.

Fadel Elseed, A. M. A. (2005). Effect of supplement protein feeding frequency on ruminal characteristics and microbial N production in sheep fed treated rice straw. *Small Ruminant Research* 57: 11 – 17.

Fatima, M. A. (2003). The effect of dietary pigeon pea (*Cajanus cajan)* on growth and some blood parameters of Desert goats. *Animal Production University of Khartoum, Sudan*. 98 pp.

Foster, J. L. (2008). Improving the productivity of livestock with warm season legumes. *A dissertation presented to graduate school of the University of Florida in partial fulfilment of the requirements for the degree of Doctor of Philosophy: University of Florida*. 232pp.

Fredrik, L. (2005). Conservation agriculture in Babati district, Tanzania: *Impacts of conservation agriculture for small-scale farmers and methods for increasing soil fertility* - Master of Science thesis: 145: 2005 Swedish University of Agriculture Science. 140pp.

Giger-Riverdin, S. (2000). Characterisation of feed stuffs for ruminant using some physical parameters. *Animal Science and Technology* 86: 53 – 69.

Gillah, K. A., Kifaro, G. C. and Madsen, J. (2014). Effects of pre partum supplementation on milk yield, reproduction and milk quality of crossbred dairy cows raised in a peri urban farm of Morogoro town Tanzania. *Livestock Research for Rural Development* 26(9): 12 – 17.

Goering, H. K. and Van Soest, P. J. (1970). Forage fibre analysis. Agriculture handbook 379. Agriculture Research Service, USDA, Washington, DC. 20 pp.

Guo, T., Sanchez, M. D. and Guo, P. (Eds.). (2002). *Animal production based on crop residues: Chinese experiences* (No. 149). Food and Agriculture Organisation. 12pp.

Harding, J. L., Bittner, C. J., Burken, D. B., Erickson, G. E. and MacDonald, J. C. (2015). Effects of Processing Treated Corn Stover and Distillers Grains on Performance of Growing Cattle. *Animal Feed Science and Technology* 11: 24 – 29.

Harding, J. L., Jolly, M. L., Erickson, G. E. and MacDonald, J. C. (2016). Effects of Replacing a Traditional Growing Diet with a Complete Pelleted Feed on Total Tract Digestibility of Growing Diets. *University of Nebraska – Lincoln; Nebraska Beef cattle Reports Paper* 880: 33 – 35.

Hindrichsen, I. K., Osuji, P. O., Odenyo, A. A., Madsen, J. and Hvelplund, T. (2002). Effect of supplementation of a basal diet of maize stover with different amounts of *Leucaena diversifolia* on intake, digestibility, nitrogen metabolism and rumen parameters in sheep. *Animal Feed Science and Technology* 98: 131 – 142.

Hvelplund, T. (1999). Evolution of feed evaluation in developed countries. Feed Database Development for Tanzania. In: *Proceedings of SUA-MU ENRECA projects Workshop.* (Edited by Kimambo, A. E., Kurwijila, L. R. and Mgheni, D. M). 1 August 1999, Arusha, Tanzania. pp. 5 - 14.

ILCA (1990). Feeding and management System. *ILCA annual report and programme highlight. ILCA (International Livestock Centre for Africa) Adis Ababa, Ethiopia*. 144 pp.

Jackson, H. L. (2005). Assessment of livestock manure production, management and utilization in Southern Highlands of Tanzania. *A case study of Makambako division in Njombe district.* MSc. Dissertation. Sokoine university of Agriculture, Morogoro, Tanzania. 108 pp.

Jackson, H. L. and Mtengeti, E. J. (2005). Assessment of animal manure production, management and utilization in Southern Highlands of Tanzania. *Livestock Research for Rural Development* 17(10): 11 -18.

Joshi, P. K., Parithasarathy, R. P., Gowda, C. L. L., Jones, R. B., Silim, S. N., Saxena, K. B. and Jagdish, K. (2001). The world chickpea and pigeon pea economies; Facts, Trends and Outlook: *International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)* - Patancheru 502 324 Andhra Pradesh, India. 45pp.

Kangalawe, R. Y. (2014). Nutrient budget analysis under smallholder farming systems and implications on agricultural sustainability in degraded environments of semiarid central Tanzania. *Journal of Soil Science and Environmental Management* 5(3): 44 – 60.

Karlsson, I. (2008). Rural-Urban Migration in Babati District, Tanzania: *Arbetsrapporter. Kultur Geografiska Institutionen*. 22pp.

Keftasa, D. (1987). Role of crop residues as livestock feed in Ethiopian highlands. In Africa Forage Genetic Resources. Evaluation of forage germplasm and extensive livestock production systems. In: *Proceedings of a workshop held in Arusha, Tanzania*. pp. 430 – 439.

Kellems, R. O. and Church, D. C. (2002). *Livestock feeds and feeding* (No. 636.084 K4L5 2002). Upper saddle River, NJ: Prentice Hall. 21pp.

Kifaro, G. C. (1991). Genotype × Environmental interaction in livestock production systems. In: Milk production from smallholder system with emphasis on strategies in Semi-Arid areas. In: *Proceedings of seminar held at SUA, Morogoro Tanzania. 22 – 24 January, 1991. Sweedish Agency for Research Cooperation with Developing Countries (SAREC).* pp 173 – 181.

Kihara, J., Tamene, L. D., Massawe, P. and Bekunda, M. (2015). Agronomic survey to assess crop yield, controlling factors and management implications: a case-study of Babati in northern Tanzania. *Nutrient Cycling in Agro Ecosystems* 102(1): 5-16.

Kilongozi, N. B. (1992). Urea treatment of maize stover. The effectiveness and cost of the method relative to improvement in feeding value. MSc. Dissertation SUA, Morogoro, Tanzania. 182 pp.

Kimario, F. M. (2003). Effect of methods of treating rice straws using wood ash extract on dry matter intake, nutrient digestibility and performance of lambs. MSc. Dissertation. Sokoine University of Agriculture, Morogoro, Tanzania. 133 pp.

Kimbi, E. F. C. (1997). The effect of substituting *Leucaena leucocephala* forage for cotton seed cake as protein supplement for urea treated maize stover on performance of goat weaners. MSc. Dissertation. Sokoine University of Agriculture – Morogoro, Tanzania. 151pp.

Kimoro, B. N. (2003). Potential of selected tropical multipurpose trees as protein supplement for grazing goats fed maize Stover basal diet. MSc. Dissertation. Sokoine University of Agriculture – Morogoro, Tanzania. 145 pp.

Kivaisi A. K. (1997). The potential of agro-industrial residues and municipal solid waste for production of electricity in Tanzania. Paper presented at the international seminar on Bioenergy-Biogass, 22–23 Sep 1997, Dar es Salaam, Tanzania.

Kurwijila, R. L. (1991). Basic dairy husbandry and management practices under tropical environment. Lecture notes for bachelor degree of science courses at Sokoine University of Agriculture, Morogoro. 99 pp.

Kurwijila, R. L. and Kifaro, G. C. (1998). Strategies for smallholder dairy development. The Tanzania experience. *Paper presented at UZW/RVAU ENRECA workshop 13 -16 January, 1998. Harare, Zimbabwe.* pp 1 – 11.

Lanné, J. M. and Thomas, D. (2005a). Identifying options to reduce poverty and enhance the livelihood of small-scale crop-livestock producers in sub-Sahara Africa: *Output report from R8444 for the DFID crop production and livestock production programmes.* Aylesford. [www.cpp.uk.com.] Site visited on 24/5/2014.

Lanné, J. M. and Thomas, D. (2005b). Opportunities for increasing productivity and reducing poverty through crop-livestock integration in sub-Sahara Africa, *in: (Haris D., Richards, J. L., Silverside, P., Ward, A. F., and Witcombe, J. Reds. editions) Pathway out of poverty, Aspects of Applied Biology* 75: 99 - 108.

Lanné, J. M. and Thomas, D. (2005c). Addressing poverty through crop-livestock integration: the contribution of past research to future challenges. *Integrating Livestock-Crop Systems to Meet the Challenges of Globalization*. Proceedings of AHAT/BSAS. 33pp.

Lanné, J. M. and Thomas, D. (2006). Integration crop – livestock research and development in sub-Sahara Africa: *Outlook on Agriculture*. pp. 167 – 175.

Lanné, J. M., Fernandez-Rivera, S. and Blümmel, M. (2003). Approaches to improve the utilization of food–feed crops—synthesis. *Field Crops Research* 84: 213 – 222.

Lardy, G. and Anderson, V. (2009). Alternative feeds for ruminants. General concept and recommendations for using alternative feeds. NDSU Extension service. North Dakota State University. Fargo, North Dakota 58108. 24pp.

Linden, D. R., Clapp, C. E. and Dowdy, R. H. (2000). Long-term corn grain and stover yields as a function of tillage and residue removal in east central Minnesota. *Soil and Tillage Research* 56(3): 167 – 174.

Little, D. A. (1985). The dietary mineral requirements; implications for the utilization of tropical fibrous agricultural residues. In: The utilization of fibrous agriculture residues as animal feed. *Proceedings of the 4th Annual workshop (Edited by Dolye, P.T.). Australian – Asian Fibrous Agriculture Residues Research Network*. pp 34 – 43.

MAFF (1975). Energy Allowances and Feeding Systems for Ruminants. Technical Bulleting 33. Ministry of Agriculture, Fisheries and Food. HMSO, London.

Mahesh, M. S. and Mohini, M. (2013). Biological treatment of crop residues for ruminant feeding: A review. *African Journal of Biotechnology 12*(27): 4221-4231.

Malau-Aduli, B. S., Eduvie, L., Lakpini, C. and Malau-Aduli, A. E. O. (2004). Crop-residue supplementation of pregnant does influences birth weight and weight gain of kids, daily milk yield but not the progesterone profile of Red Sokoto goats. *Reproduction Nutrition Development* 44(2): 111 – 121.

MALD (1988). Ministry of Agriculture and Livestock Development annual report. 13 pp.

MALF (2014). Ministry of Livestock and Fisheries. Financial budget plan for the year 2014/15). [www.mifugouvuvi.go.tz/Hotuba-mwaka-2013-2014.pdf] site visited on 24/5/2014.

Males, J. R. (1987). Optimizing the utilization of cereal crop residues for beef cattle. *Journal of Animal Science* 65: 1124 – 1130.

Mangesho, W., Loina, R., Diyu, J., Urassa, V. and Lukuyu, B. (2013). Report on feed assessment in Babati district, Manyara region, The United Republic of Tanzania: *Africa RISING program WP* 13pp.

Mapfumo, P. and Giller, K. E. (2001). Soil fertility management strategies and practices by smallholder farmers in Semi-arid areas of Zimbabwe. ICRISAT/FAO. Patancheru, AP, India. pp. 25 – 41.

Marandu, A. E. T., Semu, E., Mrema, J. P. and Nyaki, A. S. (2014). Contribution of legume rotations to the nitrogen requirements of a subsequent maize crop on a Rhodic Ferralsol in Tanga, Tanzania. *Tanzania Journal of Agricultural Sciences* 12(1): 27 – 31.

Massawe, N. F., Owen, E., Mtenga, L. A., Ashley, S. D., Holden, S. J. and Rommey, D. L. (1997). Forage feedstuff resources and economic constraints on crop/livestock smallholding producing milk from cows and goats in three locations in Tanzania. In: *Proceedings of 24$^{th}$ Scientific Conference of Tanzania Society of Animal Production. LITI-Tengeru, 5$^{th}$ – 22$^{nd}$ August 1997.* pp. 115 – 123.

Massawe, N. F. and Mruttu, H. A. (2005). Dissemination of low-cost technology for handling crop residues and dry forages for dry-season feeding in Northern Tanzania. In: *Proceedings of a workshop on enhancing the contribution of small livestock to the livelihood of resource-poor communities*; held in Masaka, Uganda 15 – 19 November, 2004; Small Stock in Development 191 – 196pp.

McDonald, P., Edwards, R. A., Greenhalgh, J. F. D., Morgan, C. A., Sinclair, L. A. and Wilkinson, R. G. (2010). *Animal Nutrition.* Seventh edition. Prentice Hall Publishers, Harlow, England. 714 pp.

Mdoe, N. S. Y. and Nyange, D. (1993). Competitive performance of formal and informal milk marketing channels in Northern Tanzania. The case of Hai district. *In: Seminar proceedings: Dairy development policy and implementation.* Harare Zimbabwe. 12 – 16th July 1993. pp. 211 – 222.

Mele, M., Buccioni, A., Petacchi, F., Serra, A., Banni, S., Antongiovanni, M. and Secchiari, P. (2006). Effect of forage/concentrate ratio and soybean oil supplementation on milk yield and composition from Sarda ewes. *Animal Research* 55(4): 273 – 285.

Miller, W. J. (2012). Dairy cattle feeding and nutrition. *Animal feeding and Nutrition. A series of monographs.* Academic pres, Inc. A Subsidiary of Harcourt Brace Javanovich, Publishers. 403pp.

Msechu, J. K. K., Syrstad, O. and Mgheni, M. (1995). Contribution of climatic factors to variation in milk yield in Mpwapwa cattle and their crosses. *In: Proceedings of the 22nd Scientific conference of the Tanzania Society of Animal Production (TSAP) AICC, Arusha. 15th – 17th August 1995.* TSAP. Conference Series pp 242.

Mtamakaya, J. D. (2002). Evaluation of the effectiveness of ash extract in improving the feeding value of rice straws to ruminant animals. MSc. Dissertation. Sokoine University of Agriculture – Morogoro, Tanzania 107 pp.

Mtengeti, E. J., Brentrup, F., Mtengeti, E., Eik, L. O. and Chambuya, R. (2015). Sustainable Intensification of Maize and Rice in Smallholder Farming Systems

Under Climate Change in Tanzania. In *Sustainable Intensification to Advance Food Security and Enhance Climate Resilience in Africa* pp. 441 – 465.

Mtui, D. J. (2004). Available feed resources and seasonal variation under smallholder dairy production in Turiani division Morogoro, Tanzania. MSc. Dissertation. Sokoine University of Agriculture, Morogoro, Tanzania. 111 pp.

Ndemanisho, E. E., Mtenga, L. A., Kimbi, E. F. C., Kimambo, A. E. and Mtengeti, E. J. (1998). Substitution of dry *Leucaena leucocephala* (DLL) leaves for cotton seed cake (CSC) as a protein supplement to urea treated maize stovers fed to dairy weaners goats. *Animal Feed Science and Technology* 73: 365 – 375.

Ndwasinde, L. D. (2013). Response of lowland rice *(Oryza sativa L.)* varieties to moisture stress at different levels of potassium. Doctoral dissertation, Sokoine University of Agriculture, Morogoro, Tanzania. 122 pp.

Nherera, F. V., Ndlovu, L. R. and Dzowela, B. H. (1998). Utilization of *Leucaena diversifolia*, *Leucaena esculenta*, *Leucaena palida* and *Calliandra calothyrsus* as nitrogen supplement for growing goats fed maize stovers. *Animal Feed Science and Technology* 74: 15 – 28.

Nicholson, J. W. G. (1984). Digestibility, nutritive value and feed intake. In: Straw and other by-products as feed. (Edited by Sundstøl, F. and Owen, E.). Elservier-Amsterdam. pp 340 – 349.

Nkenwa, D. D. (2009). Assessment of feeding practices and performance of dairy cattle in Kibaha district, Tanzania. MSc. Dissertation. Sokoine University of Agriculture, Morogoro, Tanzania. 118 pp.

Nkya, R., Kessy, B. M. and Aboud, A. A. (2015). Blood metabolites and their relationship to dairy cattle productive and reproductive performance in Smallholder farms in Morogoro, Tanzania. *Tanzania Journal of Agricultural Sciences* 5(2): 17 – 21.

Odeny, D. A. (2007). The potential of pigeon pea (*Cajanus cajan* (L.) Millsp.) In Africa. In *Natural resources forum* (31: 4) Blackwell Publishing Ltd. pp. 297 – 305.

Ondiek, J. O., Ogore, P. B., Shakala, E. K. and Kaburu, G. M. (2013). Feed intake, digestibility and performance of growing small East African goats offered maize (Zea mays) stover supplemented with *Balanites aegyptiaca* and *Acacia tortilis* leaf forages. *Basic Research Journal of Agricultural Science and Review 2*(1): 21-26.

Owen, E. and Jayasuriya, M. C. N. (1989). Use of crop residues as animal feeds in developing countries. *Research and Development in Agriculture* 6: 129 - 138.

Pande, S., Bandyopadhyay, R., Blümmel, M., Rao, J. N., Thomas, D. and Navi, S. S. (2003). Disease management factors influencing yield and quality of sorghum and groundnut crop residues. *Field Crops Research* 84: 89 – 103.

Pretty, J. N. (1995). Participatory learning for sustainable agriculture. *World development* 23(8): 1247 - 1263.

Promkot, C. and Wanapat, M. (2005). Effect of level of crude protein and use of cottonseed meal in diets containing cassava chips and rice straw for lactating dairy cows. *Asian-Australian Journal of Animal Science* 18: 502 - 511.

Ørskov, E. R. and Ryle, M. (1990). Energy Nutrition in Ruminants. Chapter 8, pp. 102-121. Elsevier Science, Publishers LTD. London and New York 67pp.

Reddy, B. V. S., Reddy, P. S., Bidinger, F. and Blümmel, M. (2003). Crop management factors influencing yield and quality of crop residues. *Field Crops Research* 84: 57 - 77.

Rufino, M. C., Rowe, E. C., Delve, R. J. and Giller, K. E. (2006). Nitrogen cycling efficiencies through resource-poor African crop–livestock systems. *Agriculture, Ecosystems and Environment* 112: 261 – 282.

Rufino, M. C., Tittonell, P., Van Wijk, M. T., Castellanos-Navarrete, A., Delve, R. J., De Ridder, N. and Giller, K. E. (2007). Manure as a key resource within smallholder farming systems: analyzing farm-scale nutrient cycling efficiencies with the NUANCES framework. *Livestock Science* 112: 273 -287.

Salem, H. and Smith, T. (2008). Feeding strategies to increase small ruminant production in dry environments. *Small Ruminant Research* 77(2): 174 – 194.

Sarnklong, C., Cone, J. W., Pellikaan, W. and Hendriks, W. H. (2010). Utilization of rice straw and different treatments to improve its feed value for ruminants: A review. *Asian-Australasian Journal of Animal Sciences* 23(5): 680 – 686.

Sarwatt, S. V. and Njau, F. B. C. (1990). Feeding systems for smallholder dairy farmers in Morogoro Urban. *In Proceedings of the 17th Scientific conference of the Tanzania Society of Animal Production (TSAP)* 17: 98 – 104.

Saunders, M. D., Smagner, J. P. and Saunders, R. R. (2003). Improving methodological and technological analyses of adaptive switch use of individuals with profound multiple impairments. *Behavioral Interventions* 18(4): 227 - 243.

Saunders, M. N., Saunders, M., Lewis, P. and Thornhill, A. (2011). *Research methods for business students, 5/e*. Pearson Education India. 33pp.

Savadogo, M., Zemmelink, G. and Nianogo, A. J. (2000). Effect of selective consumption on voluntary intake and digestibility of sorghum (*Sorghum bicolor L. Moench*) stover, cowpea (*Vigna unguiculata L. Walp*.) and groundnut (*Arachis hypogaea L.*) haulms by sheep. *Animal Feed Science and Technology* 84(3): 265 – 277.

Selemani, I. S., Eik, L. O., Holand, Ø., Ådnøy, T., Mtengeti, E. and Mushi, D. (2013). Variation in quantity and quality of native forages and grazing behavior of cattle and goats in Tanzania. *Livestock Science* 157(1): 173 – 183.

Shekimweri, T. (1982). A comparative study of dairy cattle crosses in the humid coastal belt of Tanzania. MSc. Dissertation University of Dar es Salaam. 180pp.

Shem, M. (1993). Evaluation of the locally available feed resources on smallholder farms on the slopes on Mount Kilimanjaro. PhD. Thesis, University of Readings, UK 217 pp.

Shenkute, B., Hassen, A., Ebro, A. and Amen, N. (2013). Performance of Arsi-Bale kids supplemented with graded levels of pigeon pea in dry season in Mid Rift valley of Ethiopia. *African Journal of Agricultural Research 8*(20): 2366 – 2370.

Sibanda, S. and Abdullah, N. S. (1991). The role of crop residues and Agro-industrial by products as animal feed resources in Sub-Sahara Africa. *ILCA paper read at NLPD/ACIAR forage production and utilization workshop – Nigeria*. 15pp.

Singh, F. and Diwakar, B. (1993). Nutritive value and uses of pigeon pea and groundnut. *Human Resource Development Program, Skill Development series* (14): 45 – 57.

Smil, V. (1999). Crop Residues: Agriculture's Largest Harvest Crop residues incorporate more than half of the world's agricultural phytomass. *Bioscience* 49(4): 299 – 308.

Smith, O. B. and Akinbamijo, O. O. (2000). Micronutrient and reproduction in farm animals. *Animal Reproduction Science* 60(6): 549 – 560.

Stanton, T. L. and LeValley, S. B. (2006). *Feed composition for cattle and sheep*. Colorado State University Extension Service. *Fact Sheet, Livestock Management Series* 615(1): 1 – 6.

Sundstøl, F. and Owen, E. (1984). Straw and other fibrous by products as feed. 1st Elsevier-Amsterdam. pp 340 – 349.

Tedla, F. A. (2014). Feeding potential and nutritional value of *Erythrina burana* AND *Casimiroa edulis* (Doctoral dissertation, Haramaya University). 134pp.

Tilley, J. M. A. and Terry, R. A. (1963). A two – stage technique for the *in vitro* digestion of forage crops. *Grass and Forage Science* 18(2): 104 – 111.

Tolera, A. and Sundstøl, F. (2000). Supplementation of graded levels of *Desmodium intortum* hay to sheep feeding on maize stover harvested at three stages of maturity: 2. Rumen fermentation and nitrogen metabolism. *Animal Feed Science and Technology* 87(3): 215 – 229.

Tolera, A., Sundstøl, F. and Said, A. N. (1998). The effect of stage of maturity on yield and quality of maize grain and stover. *Animal Feed Science and Technology* 75: 157 – 168.

Urassa, J. K. (1999). A study of the factors influencing milk output of dairy cattle under smallholder farms in Tanga region. MSc. Dissertation. Sokoine university of Agriculture - Morogoro, Tanzania. 130 pp.

Urassa, V. C. (2012). Supplementation strategy for improving milk production of cross bred dairy cows under smallholder farmers in Kibaha and Arumeru districts. MSc. Dissertation. Sokoine University of Agriculture - Morogoro, Tanzania. 124 pp.

Valbuena, D., Erenstein, O., Tui, S. H. K., Abdoulaye, T., Claessens, L., Duncan, A. J. and van Wijk, M. T. (2012). Conservation Agriculture in mixed crop–livestock systems: Scoping crop residue trade-offs in Sub-Saharan Africa and South Asia. *Field Crops Research* 132: 175 – 184.

Van Soest, P. J., Robertson, J.B. and Lewis, A.B. (1991). Methods for dietary fibre, neutral detergent fibre and non starch polysacchairides in relation to animals nutrition. *Journal of Dairy Science* 74: 3583 – 3597.

Wambui, C. C., Abdulrazak, S. A. and Noordin, Q. (2006). The effect of supplementing urea treated maize stover with Tithonia, Calliandra and Sesbania to growing goats. *Livestock Research for Rural Development* 18(5): 64 – 70.

Wanapat, M., Sommart, K., Wachirapakorn, C., Uriyapongson, S. and Wattanachant, C. (1994). Recent advances in swamp buffalo nutrition and feeding. In *proceedings: 1st Asian buffalo association congress. Khon Kaen, Thailand*. pp. 155 – 187.

Wanapat, M., Polyorach, S., Boonnop, K., Mapato, C. and Cherdthong, A. (2009). Effects of treating rice straw with urea or urea and calcium hydroxide upon intake, digestibility, rumen fermentation and milk yield of dairy cows. *Livestock Science* 125(2): 238 – 243.

Wanapat, M., Kang, S., Hankla, N. and Phesatcha, K. (2013). Effect of rice straw treatment on feed intake, rumen fermentation and milk production in lactating dairy cows. *African Journal of Agricultural Research* 8(17): 1677-1687.

Whiteman, P. C. and Norton, B. W. (1982). Alternative use of pigeon pea. In *Proceedings of a meeting; ICRISAT centre,* Patancheru, India. 15 – 17, December 1980. pp 365 – 376.

Winugroho, M. (2000). Nutritive values of major feed ingredients in Tropics; *Research institute for animal production,* Bogor, Indonesia. 44pp.

Williams, T. O., Fernandez-Rivera, S., Kelley, T. G. and Renard, C. (1997). The influence of socioeconomic factors on the availability and utilization of crop residues as animal feeds. *CAB International*. 75pp.

Yousif, A. T. (2005). Silage Making from Pigeon Pea, *Cajanus* and Bagasse and their Combinations. MSc. Dissertation; University of Khartoum. 59 pp.

Yousuf, A. B., Dismuke, A., Kering, M. and Atalay, A. (2014). Effects of treatment of sorghum stover residue with ammonium hydroxide on cell wall composition and in vitro digestibility. *Journal of Agricultural Science* 6(9): 21 – 28.

# APPENDICES

## Appendix 1: PRA checklist

i. Available crop residues by crop type,

ii. Crop harvest stage; current practices, how and when (at what maturity stage) the crops for crop residues are harvested,

iii. Storage (conservation) practices, (how and for how long crop residues are stored before feeding the livestock),

iv. Feeding practices to different classes of livestock including chopping/not chopping, mixing/treating with other feed resources or not.

v. At what period of the year are crop residues often used

## Appendix 2: Discussion guidelines – consultations with key Agriculture and Livestock officers at the District

| Core issues | Required information | Results of discussions |
|---|---|---|
| Crop production in a district (Average production in a five years period) | Grain production;<br>**Maize; …………………….. (tones)**<br>**Common beans …………… (tones)**<br>**Pigeon pea ………………….. (tones)**<br>**………………………………..**<br>**……………………………….**<br>**………………………………**<br>**……………………………..** | |
| Services from the Department | Extension support – nature | |
| | Training on livestock feeding practices | |
| | Demarcated land for grazing/pasture production | |
| | Role of the department in crop-livestock farming system development | |
| Support to the livestock sector | As per different actors known to the office (including NGOs) | |
| Constraints facing livestock sector | Including livestock management, feed/pasture availability and management | |
| Opportunities for intervention in to enhance productivity of livestock in the farming system | enhanced production and management /knowledge e.g. utilization of locally available feed resources, housing status | |
| | Marketing | |
| | Access to extension services | |
| | Technology | |
| | Linkages and orders management | |

## Appendix 3: FGD tool: The Semi-structured questionnaire for Feed resource availability

Assessing the current status of crop residues availability in crop-livestock production systems in Babati district

| | |
|---|---|
| Name of site/village: ............................................<br>Name of ward...............................................<br>Number of households in survey area (*to be considered a household, the dwelling must have a kitchen*): ...........................<br>GPS co-ordinate of PRA location: ............................................<br>Number of participants present: males................... Females.........................<br>Date................July 2014<br>Enumerator's name: ....................................................................... | |
| Starting time of PRA: ...................... | Finishing time of PRA: .......................... |

*Introduction will be done starting by Providing a clear picture of who we are, what is our purpose in being here, what we would like to do and how long it will take. Introduction to both visitors and farmers will be enhanced explaining the purpose and the process of meeting including any potential long-term or short-term benefits for the participants (without raising unreasonable expectations); giving an estimate of how long it will take to complete the meeting).*

### 1. General Farming System Description.

*Objective:* *Obtain a general picture of the farming and livestock system*

1.1. What is the average farm size per household ("farm size" is considered to be cultivated land)? Also consider additional lands that may be leased or shared.

| |
|---|
| |

1.2. What is the typical (or average) **household** size? On average, how many people have been living continuously in each household for the past 6 months

| |
|---|
| |

1.3. How does the rainfall pattern vary over a year (on a scale of 0-5, where *5 = heavy rainfall levels* and *0=no rainfall*)?

| **Month** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **June** | **July** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall pattern (score 0-5) | | | | | | | | | | | | |

1.4. Name the cropping seasons that occur in this area. In which months do the various seasons occur (tick the appropriate boxes in the table below).

| **Name of season** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | | | | | | | | | | | | |
| 2. | | | | | | | | | | | | |
| 3. | | | | | | | | | | | | |

1.5. Name the food crops that are grown in this area. In which months do the various crops harvest occurs (tick the appropriate boxes in the table below).

| **Name of Crop** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1………………… | | | | | | | | | | | | |
| 2………….. | | | | | | | | | | | | |
| 3…………… | | | | | | | | | | | | |
| 4…………… | | | | | | | | | | | | |
| 5…………… | | | | | | | | | | | | |
| 6……………. | | | | | | | | | | | | |
| 7. …………… | | | | | | | | | | | | |

1.6. Name the crop residues that are available in this area. In which months do the various crops residues occur (tick the appropriate boxes in the table below).

| **Name of crop residues** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
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## 2.0 Feed availability, conservation and utilization

2.1 What livestock are raised within the area? What are the animals mainly used for (e.g. production of milk for sale, milk for household consumption, production of eggs for home consumption, production of eggs for sale, meat production, drought, manure production etc.)? What percentage (%) of household in the area owns each species? What is the average number of animals per household? What is the order of importance of species? What is the gender role of each livestock? (M = Male, F = Female, B = Both)

| **Livestock species** | **Use** | **% of HH that own the species** | **Average number of animals per HH** | **Order of importance** | **Gender role** |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |

2.2 What are the common feeding systems?

| **Seasonality** | **Feeding system** | | | |
|---|---|---|---|---|
| | Only grazing (free range or tethered) | Mainly grazing with some stall feeding | Mainly stall feeding with some grazing | Only stall feeding (zero grazing) |
| Dry season Proportion of farmers (%) | | | | |
| Wet season Proportion of farmers (%) | | | | |

*Please tick where applicable and indicate proportion in percentage

2.3 Is there differentiated feeding systems amongst different categories of animals by season?

| **Categories of animals** | **Dry season** | | | | **Wet season** | | | |
|---|---|---|---|---|---|---|---|---|
| **Feeding system (**see codes) | A | B | C | D | A | B | C | D |
| Local lactating dairy cow | | | | | | | | |
| Improved lactating dairy cows | | | | | | | | |
| Female – dry and in-calf/expectant (local) | | | | | | | | |
| Female – dry and in-calf/expectant (improved) | | | | | | | | |
| Female – dry/open, non-productive (local heifers) | | | | | | | | |
| Female – dry/open, non-productive (improved heifers) | | | | | | | | |
| Males (castrated, fattening or breeding – local) | | | | | | | | |
| Males (castrated, fattening or breeding – improved) | | | | | | | | |
| Calves – local | | | | | | | | |
| Calves – improved | | | | | | | | |

* Please tick where applicable

**Codes**

| **Codes** | **Feeding system** |
|---|---|
| A | Only grazing (free range or tethered) |
| B | Mainly grazing with some stall feeding |
| C | Mainly stall feeding with some grazing |
| D | Only stall feeding (zero grazing) |

Discussion

notes:____________________________________________________________

2.4 What are the common types of feed resources? What is the seasonal availability and proportion of these resources in the diet?

| **Feed types** | **Dry season** | | **Wet season** | |
|---|---|---|---|---|
| | Availability * | Proportion in the diet | Availability * | Proportion in the diet |
| Natural grazing | | | | |
| Planted pastures | | | | |
| Planted forages *** | | | | |
| Crop residues | | | | |
| Crop by-products e.g. brans, pollard etc. | | | | |
| Grains | | | | |
| Compounded feeds | | | | |
| Roots and tubers | | | | |
| **TOTAL (must add to 100)** | | | | |

* Availability score: High (H), Medium (M), Low (L) and None (0)

** Proportion in the diet as percentage (%) 0 = Not used, 1 = [< 25], 2 = [25 – 50], 3 = [50 – 75], 4 = [75 – 100]

***Cut and carry forages

NB: All estimates will be averages as perceived by group

Discussion

notes:____________________________________________________________

2.5 What are the main sources of these feed resources?

| Feed type | Season | **Sources** of feed resources and **proportion** coming from each source | | |
|---|---|---|---|---|
| | | Own farm (own and rented) | Community (road side, public land etc.) | Market (off farm feeds) |
| Natural grazing | Dry | | | |
| | Wet | | | |
| Planted pastures | Dry | | | |
| | Wet | | | |
| Planted forages ** | Dry | | | |
| | Wet | | | |
| Crop residues | Dry | | | |
| | Wet | | | |
| Crop by-products (bran, pollards etc.) | Dry | | | |
| | Wet | | | |
| Grains | Dry | | | |
| | Wet | | | |
| Compounded feeds | Dry | | | |
| | Wet | | | |
| Roots and tubers | Dry | | | |
| | Wet | | | |

* Please tick where applicable and indicate in each cell proportion (estimated %) coming from each source

** Cut and carry forages

Discussion

notes:_____________________________________________________________

2.6 If feed is sourced off farm,

a. Is it brought, obtained in kind (free), butter traded etc.?
b. Over what distance radius is feed sourced?
c. What type of labour participates in collecting feed? Is it family labour or hired workers and is it easily available?
d. Who is normally charged with the responsibility of collecting feeds in the household?
e. How much time is required to collect feed on daily basis?

2.7 If fodder trading occurs,

a. What are the factors that influence fodder production and selling?
b. What are the main sale and purchase channels of fodder trading?
c. What are the main important factors influences on the choice of channels?
d. What are the relative prices in the wet and dry seasons?
e. What factors are considered when negotiating prices with feed traders (buyers and sellers)?
f. How stable are feed product buying and selling prices throughout the year?
g. What are the main problems you face when producing and selling feeds?

2.8 Farmers' perception of the forage/fodder quality.

a. How do farmers know that the fodder/forage is of good quality (from their point of view)? Please list criteria and reason why.

2.9 What are the main problems/constraints you face producing forage/fodder/crop residues?

a. What could be the solution to overcome the limitation identified in fodder production?

2.10 Which type of compounded feeds, feed ingredients, agro industrial by products and feed supplements/minerals are available and fed on farms?

a. How do farmers know that compounded feed/ingredients or supplements are of good quality? Please list criteria and reasons why
b. What are the identified problems associated with feeding compounded feeds, feeds ingredients and agro industrial by products and feed supplements?
c. What are the potential solutions/interventions?

2.11 Do you practice feed conservation for critical periods of the year?

a. What feed conservation methods are used?
b. What problems are identified/observed with feed conservation?

c. What are the potential solutions/interventions?

2.12 What other coping strategies are available during times of forage scarcity?

## 3.0 Management of crop residues as livestock feed

<u>Objective:</u> *Understand how crop residues are managed within the area*

3.1 How are crop residues managed as livestock feed in the area (including how harvested, stored, processed before feeding "chopping, urea treatment, mixing etc." amount fed). Is there any seasonal variation in management methods?

| Type of crop residues | Harvesting methods | Storage methods | Processing methods before feeding |
|---|---|---|---|
| 1. | | | |
| 2. | | | |
| 3. | | | |
| 4. | | | |

a. How do you harvest crop residues?

b. Do you store crop residues?

c. How do you store crop residues on farm?

d. How long do you store crop residues?

e. Is there any spoilage associated with storing crop residues?

f. How do you deal with this problem?

g. Are crop residues processed? If so how?

h. If not why?

i. What processing methods are used to process different types of crop residues?

j. What sort of quantities do you process and feed per day or given period?

k. What are the advantages of the method that you use?

l. What are disadvantages of the methods you use?

m. What costs do you incur in processing crop residues?

n. Give other costs that are incurred when processing crop residues

| **Activities** | **Amount (Tshs.)** |
|---|---|
| Transport | |
| Labour (Harvesting)/acre | |
| Storage costs (6 months) | |
| Processing (chopping/salting)/day | |
| Others | |
| **TOTAL** | |

o. What is your opinion about quality of crop residues? How do you rate quality of various crop residues? Please rank them.

p. How do you assess quality of fodder?

   i. Stage of harvest (Leaf: Stem ratio)
   ii. Type of forage
   iii. Cultivar of forage
   iv. Leaf colour of forage
   v. Smell
   vi. Texture

q. How do you feed crop residues?

   i. How much
   ii. Do you mix with other feeds
   iii. Do you treat them in any form?

r. What problems have you experienced with feeding crop residues?

s. Is crop residues traded on the market?

t. If so, what is the price of various types of crop residues

| **Type of crop residues** | **Quantity** | **Unit** | **Price (Tshs)** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

- Does price vary according to quality?

3.2 Who participate in crop residues harvesting, processing and feeding?

3.3 Indicate the types of crop residues fed mostly to which type of livestock;

| Types of crop residues | Type of livestock fed | Method used to feed the livestock |
|---|---|---|
| | | |
| | | |
| | | |

3.4 What is the period(s) where crop residues are more used to feed livestock?

| **Name of crop residues** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |
| | | | | | | | | | | | | |

3.5 What are your future plans regarding production processing and using crop residues?

**4.0. Selection of 15 – 20 individuals to complete the final section of the questionnaire.**

The remaining section of the survey should take between 15mins – 45mins (depending on their answers). Individuals should be selected that represent the various classes of farmers (small, medium and large) within the area. Selection will be based on the amount of land utilised for farming. In previous questions (on page 1) the average farm size was determined. Use this figure as a starting point to determine:

- How much land a **small** (below average land size)**, medium** (above average land size) and **large** (above average land size) farmer would have. The cut-off points between the categories should be determined by the farmers.

Based on this information, determine the distribution of farmers in the area, i.e. percentage of farmers in the area that would be considered small, medium and large. Record this information in the table below.

| **Category of farmers** | **Range of land** | **% of households that fall in the category** |
|---|---|---|
| Small farmers | | |
| Medium farmers | | |
| Large farmers | | |

After this table has been filled, select five individuals from each category (**small, medium** and **large**). Try to select individuals that have land holdings towards the middle of each category. A total of nine individuals should be selected for further interview.

| **Category of farmer** | **Name of farmer** | **Contact number** |
|---|---|---|
| Small | | |
| Medium | | |
| Large | | |

This is the end of the group PRA section of the survey.

Thank the unselected farmers for their time and explain how this information will be used.

*Questionnaire complete*

*Thank the participants for their time*

## Appendix 4: Household Questionnaire (quick feed questionnaire)

This section of the survey should be carried out with 18 individual farmers answering questions based on their own farms. Three farmers should be selected to represent each category of land holding as described above.

| | |
|---|---|
| Respondent name | ………………………………… |
| Landholding category | • Below<br>• Average (Tick one)<br>• Above average |
| How much land do you farm (hectares) | |
| Co-operative/Organization affiliation | |
| Occupation | |
| Name of village | |
| Name of Ward | |
| Name of district | |
| Date | |

### 1. Livestock holdings

What types of livestock do you currently own? What is the approximate weight of the animals? What is the dominant breed?

| **Types of animals** | **Number of animals** | **Approximate weight per animal (Kg)** | **Dominant breed** |
|---|---|---|---|
| Local dairy cows – Lactating | | | |
| Local dairy cows – Non lactating (dry) | | | |
| Local dairy heifers (> 6 months old **-** < 1st calving) | | | |
| Local dairy calves (< 6 months old) – female | | | |
| Local dairy calves (< 6 months old) – Male | | | |
| Improved dairy cows – Lactating | | | |
| Improved dairy cows – Non lactating (dry) | | | |
| Improved dairy heifers (> 6 months old **-** < 1st calving) | | | |
| Improved dairy calves (< 6 months old) – males | | | |
| Bulls or castrated male cattle (> 2 years) | | | |
| Bulls or castrated male cattle (> 6 months old **-** < 2 years) | | | |
| Sheep | | | |
| Local goats – Female | | | |
| Local goats – Males | | | |
| Dairy goats – female | | | |
| Dairy goats – males | | | |
| Pigs | | | |
| Poultry | | | |
| Donkey | | | |

***NOTE:*** In the event that farmers do not know the weight of their animals and cannot provide an estimate, please consult secondary sources for this information.

## 2. Crops grown on farm

What crops are grown on your farm? How much would you normally expect these areas to yield (in local units)? What do you do with the residue material (as a percentage)?

*(INTERVIEWER: EXCLUDE CROPS GROWN SOLELY FOR **FODDER PRODUCTION**. DETAILS FOR THESE CROPS WILL FOLLOW)*

***NOTE:*** If the residue material produced from a crop is fed to livestock, it is important that an estimate of yield is obtained from farmers. If the farmer is unable to provide an estimate of yield the crop residue material will not be considered as contributing to the diet of the animal.

| **Crops** | **Area** | **Local unit** | **1ha = how many local units** | **Yields** | **Local units** | **1tonne = how many local units** | **Residue use %** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | *Fee ding* | *Bur nt* | *Mulc h* | *Sold* | *Others (specify)* |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
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## 3. Cultivated fodder

What plants (including deliberately planted forage trees) are deliberately grown on your farm for the sole purpose of feeding livestock? How much area is used to grow these crops?

| **Fodder crop grown** | **Area (in local units)** | **Local units** | **1ha = how many local units** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

### 4. Collected fodder

Do you collect any other naturally occurring green fodder material from surrounding areas? Naturally occurring green fodder can include: **thinning, weeds from cropping areas, roadside weeds, naturally occurring grasses, or any other green material that is naturally occurring and collected for livestock feeding.** If so, how much does this material contribute to the diet (as a percentage)?

Percentage (%) contribution to the animals diet…………………………………......

### 5. Purchased feed

What feeds do you purchase over a typical 12 month period? Feeds can include: **crop residues, green fodder, commercially available mixed concentrate feeds, industrial by-products or any other material that is purchased for the purpose of livestock feed**. What is the price of these feeds? How much do you purchase (in kilograms) each time you purchase the feed? How many times throughout the year do you purchase each feed?

| Feed purchased | Price/local unit | Local unit name | 1kg = how many local units | Quantity purchased each time (local unit) | Number of time purchased in a year |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

### 6. Grazing

Considering everything eaten by livestock (e.g. crop residues, roadside grasses cut and bought back to animal, grown fodder material, purchased feed), how much does **grazing** contribute to this over the course of a year (as a percentage)?

Percentage (%) contribution to the animal's diet........................................................

## 7. Contributors to household income

Select the **four main** sources of household income from the list? What percentage (%) of household income does each of these sources contribute?

| Income source | Contribution to the income (%) |
|---|---|
| Cash crops | |
| Charcoal making | |
| Dairying | |
| Draft animals | |
| Fattening – cattle | |
| Fattening – Sheep and goats | |
| Food crops | |
| Handcrafts | |
| Labouring/services | |
| Off-farm business | |
| Poultry (eggs) | |
| Poultry (meat) | |
| Remittances | |
| Others (specify) | |
| Total contribution | 100% |

## 8. Production per household

8.1. How many ruminants (cattle, sheep and goats) have been sold (or slaughtered for home consumption) over the past 3 years? What was the approximate weight of the animals sold?

| Type of Animal sold | Number of males sold | Approximate weight | Number of females sold | Approximate weight |
|---|---|---|---|---|
| Number of cattle sold over the past 3 years | | | | |
| Number of goats sold over the past 3 years | | | | |
| Number of sheep sold over the past 3 years | | | | |

8.2. What is the average milk yield per day of your household throughout an average year? What is the average price received for milk per litre? What is the average amount of milk retained by the household each day?

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total average milk yield (litres/day) | | | | | | | | | | | | |
| Average price received for milk (per litre) | | | | | | | | | | | | |
| Amount of milk retained for household use (litre/day) | | | | | | | | | | | | |

## 9. Sale of livestock and livestock products

What is the average price received for livestock and livestock products throughout a year?

| Month | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Market price for cattle (per head)** | | | | | | | | | | | | |
| Market price for sheep (per head)*** | | | | | | | | | | | | |
| Market price for goat (per head)*** | | | | | | | | | | | | |

**If respondents are having trouble determining an average price for cattle. Ask for them to imagine a 400kg fattened castrated male, and how much would that be worth at different periods in the year?

*** If respondents are having trouble determining an average price for sheep or goats. Ask them to imagine a 30kg fattened castrated male, and how much would that be worth at different periods in the year?

## 10. Seasonality

(*INTERVIEWER—TO MAKE THE FOLLOWING SECTIONS QUICKER AND EASIER FOR RESPONDENTS, SHOW THEM THEIR RESPONSES AS THEY ARE ANSWERING. IT WILL ALLOW THEM TO VISUALIZE TRENDS).*

10.1. How does the availability of feed vary over an average year? (on a scale of 0-10, where *10 = excess feed available*, 5= *adequate feed available and 0=no feed available*)

| **Month** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Feed availability (Score 0 – 10) | | | | | | | | | | | | |

10.2. How much do the various feeds contribute to the diet of the animal throughout a year? Proportion of nutrition derived from different sources.

The different sources **must add to 10**

| **Month** | **Jan** | **Feb** | **Mar** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Crop residues (e.g. maize stovers, rice straw etc.) | | | | | | | | | | | | |
| Legume crop residues from legume crops (e.g. Chickpea, common beans, pigeon pea etc.) | | | | | | | | | | | | |
| Green forage (e.g. road side weeds, cut fodder) | | | | | | | | | | | | |
| Grazing | | | | | | | | | | | | |
| Concentrates (e.g. wheat bran, maize bran, grains, oil seedcakes) | | | | | | | | | | | | |
| Others (Specify) | | | | | | | | | | | | |
| **Score** | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 |

**Questionnaire complete**

**Thank the participants for their time!!**

**Appendix 5: Farmers' calendar on feed resources availability at Sabilo village, Babati district**

| Feed resource | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural occurring grass | 1 | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| **Planted pastures** | | | | | | | | | | | | |
| *Pennisetum purpereum* | 2 | 3 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| *Leucaena leucocephala* | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 2 |
| *Calliandra calothyrsus* | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 |
| *Sesbania sesban* | 1 | 1 | 2 | 3 | 3 | 3 | 2 | 2 | 1 | 0 | 1 | 1 |
| Green forage (collected from road sides, weeds, cut fodder) | 1 | 1 | 3 | 3 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 1 |
| **Crop residues** | | | | | | | | | | | | |
| Common bean haulms | 0 | 0 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Common pea haulms | 0 | 0 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Groundnuts foliage | 0 | 0 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Maize stovers | 0 | 0 | 1 | 1 | 1 | 0 | 2 | 3 | 2 | 1 | 0 | 0 |
| Sorghum straws | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 1 | 0 | 0 | 0 |
| Pigeon pea haulms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 | 3 | 2 | 0 |
| Sunflower chaffs | 0 | 0 | 0 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 | 0 |
| Vegetables | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| Cassava tops | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 3 | 1 | 1 |
| Sweet potatoes vines | 0 | 0 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 0 | 0 | 0 |
| Lablab beans haulms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 0 |
| Chick pea haulms | 0 | 0 | 0 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| **Crop by products** | | | | | | | | | | | | |
| Brewers grain wastes | 1 | 1 | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 1 |
| Maize bran/pollard | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 1 | 1 |
| Sunflower seed cakes | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 | 2 | 1 |
| **Overall Feed resource availability** | **2** | **3** | **3** | **3** | **2** | **2** | **2** | **1** | **1** | **1** | **1** | **2** |

Key: 0 = Not available, 1 = Low availability, 2 = moderately available and 3 = highly available

**Appendix 6: Farmers' calendar on feed resources availability at Seloto village, Babati district**

| Feed resource | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural occurring grass | 1 | 1 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 1 | 2 |
| **Planted pastures** | | | | | | | | | | | | |
| *Pennisetum purpereum* | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 | 1 | 2 |
| *Leucaena leucocephala* | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 0 | 0 |
| *Calliandra calothyrsus* | 1 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 |
| *Sesbania sesban* | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 | 1 |
| Green forage (collected from road sides, weeds, cut fodder) | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 2 | 1 | 0 | 0 | 1 |
| **Crop residues** | | | | | | | | | | | | |
| Common bean haulms | 0 | 0 | 2 | 3 | 3 | 2 | 1 | 1 | 0 | 0 | 0 | 0 |
| Common pea haulms | 0 | 0 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sugarcane tops | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 |
| Maize stovers | 0 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | 2 | 1 | 0 | 0 |
| Green maize stovers | 0 | 1 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sorghum straws | 0 | 0 | 0 | 1 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 |
| Rice straws | 0 | 0 | 0 | 2 | 2 | 3 | 3 | 2 | 0 | 0 | 0 | 0 |
| Pigeon pea haulms | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 0 |
| Sunflower chaffs | 0 | 0 | 1 | 3 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Sweet potatoes vines | 0 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 1 | 1 | 1 | 1 |
| Cassava tops | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 2 | 1 | 1 | 1 | 1 |
| Lablab beans straws | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 3 | 2 | 1 |
| Wheat straws | 0 | 0 | 0 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 0 | 0 |
| **Crop by products** | | | | | | | | | | | | |
| Brewers grain wastes | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 2 | 1 | 1 |
| Maize bran/pollard | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 1 | 1 |
| Sunflower seed cakes | 1 | 1 | 1 | 1 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 1 |
| **Overall Feed resource availability** | **2** | **2** | **3** | **3** | **3** | **3** | **3** | **2** | **2** | **2** | **2** | **1** |

Key: 0 = Not available, 1 = Low availability, 2 = moderately available and 3 = highly available

**Appendix 7: Farmers' calendar on feed resources availability at Long village, Babati district**

| Feed resource | Jan | Feb | March | April | May | June | July | Aug | Sept | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural occurring grass | 1 | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 |
| **Planted pastures** | | | | | | | | | | | | |
| *Pennisetum purpereum* | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| *Leucaena leucocephala* | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| *Calliandra calothyrsus* | 1 | 1 | 1 | 1 | 3 | 3 | 3 | 1 | 1 | 1 | 0 | 0 |
| *Sesbania sesban* | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 |
| Green forage (collected from road sides, weeds, cut fodder) | 1 | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 1 | 1 |
| **Crop residues** | | | | | | | | | | | | |
| Common bean haulms | 0 | 0 | 2 | 2 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 |
| Common pea haulms | 0 | 0 | 1 | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sugarcane tops | 1 | 1 | 1 | 2 | 3 | 3 | 3 | 1 | 1 | 1 | 1 | 1 |
| Maize stovers | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 2 | 3 | 3 | 2 | 1 |
| Green maize stovers | 1 | 1 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sorghum straws | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 2 | 0 | 0 | 0 | 0 |
| Pigeon pea haulms | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 3 | 1 |
| Sweet potatoes vines | 1 | 1 | 1 | 1 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 |
| Vegetables | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 1 | 1 | 1 | 1 |
| **Crop by products** | | | | | | | | | | | | |
| Brewers grain wastes | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 |
| Maize bran/pollard | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 |
| Sunflower seed cakes | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 0 | 0 | 0 |
| **Overall Feed resources availability** | **2** | **3** | **3** | **3** | **3** | **3** | **3** | **3** | **2** | **2** | **2** | **2** |

Key: 0 = Not available, 1 = Low availability, 2 = moderately available and 3 = highly available

## Appendix 8: Crop production in Babati 2005/6 to 2013/14

| Year | 2005/06 | 2006/07 | 2007/08 | 2008/09 | 2009/10 | 2010/11 | 2011/12 | 2012/13 | 2013/14 |
|---|---|---|---|---|---|---|---|---|---|
| **Crop** | **Harvested grains (Metric tons)** | | | | | | | | |
| A: Cereals | | | | | | | | | |
| Maize | 192 176 | 63 439 | 98 728 | 69 089 | 120 000 | 89 813 | 55 909 | 83 200 | 139 125 |
| Paddy | 6799 | 8425.8 | 9675 | 8836 | 14 928 | 9908 | 5293 | 13 440 | 8276 |
| Sorghum | 17 272 | 11 220 | 10 876 | 2020 | 5216 | 7408 | 3224 | 3875 | 6516 |
| Finger millet | 466 | 640 | 275 | 414 | 398 | 238 | 478 | 648 | 147 |
| Wheat | 5370 | 2414 | 3300 | 3865 | 4902 | 4800 | 6525 | 8015 | 4022 |
| B: Legumes | | | | | | | | | |
| Common beans | 1264.3 | 4272 | 5417 | 2366 | 3708 | 1510 | 17 612 | 13 000 | 9144 |
| Pigeon pea | - | - | 7521.8 | 7279 | 8011 | 5013.6 | 14 740 | 37 725 | 18338 |
| Lablab beans | - | - | 244.8 | 649.8 | 374 | 952 | 1368 | 3836 | 502 |
| Common peas | 62 | 265 | 36 | 50.4 | 201.7 | 101 | 650 | 73 | 110.5 |
| Chick pea | - | - | 66 | 190 | 261 | 322 | 325 | 291.5 | 640 |
| C: Oil crops | | | | | | | | | |
| Sunflower | 4199 | 2282 | 3209 | 2961 | 3184 | 6531 | 7653 | 7050 | 7975 |
| Groundnuts | - | - | 207 | 232.5 | 546 | 408 | 432 | 217.5 | 502.5 |
| D: Root and tubers | | | | | | | | | |
| Sweet potatoes | 1945.6 | 2512 | 1716 | 4124.8 | 1128 | 2735 | 3060 | 6412 | 4081.5 |
| Cassava | 5236 | 1355 | 1728 | 1208 | 1153 | 2316 | 4928 | 6088 | 1804 |
| E: Vegetables | - | - | 1837 | 1223 | 590 | 1107 | - | - | 705 |
| F: Sugar crops | | | | | | | | | |
| Sugarcane | - | - | 5200 | - | 1304 | 1200 | 1600 | 2220 | 1995 |

Source: DAICO office, Crop reduction file no. DED/BBT/KIL.40 (yearly reports 2005/6 to 2013/14

**Appendix 9: Milk yield card**

Name of village: ………………………………………………

Name of hamlet: ………………………………………………

Farmers name: ……………………………………………..

| Animal ID/Name | Breed | Date | Milk production (lts) | | Remarks |
|---|---|---|---|---|---|
| | | | *AM* | *PM* | |
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## Appendix 10: Forage species at study villages (Long, Sabilo and Seloto)

### (a): Natural forages

Grasses

| SN | Botanical name | Site | Abundance |
|---|---|---|---|
| 1 | *Adropogon spp* | Lowlands, fallowed areas | 2 |
| 2 | *Bothriochloa spp* | Open land, valley bottom | 2 |
| 3 | *Cynodon plectostachyus* | Along roadsides, bottom valley | 3 |
| 4 | *Digitaria spp* | Crop weed, around homestead | 3 |
| 5 | *Digitaria spp* | Cultivated areas, along roadsides, homestead | 3 |
| 6 | *Eleusine indica* | Homestead, along roadsides, crop weeds | 2 |
| 7 | *Eragrotis spp* | Hilly areas | 1 |
| 8 | *Heteropogon contortus* | Fallowed areas, crop weeds | 1 |
| 9 | *Heteropogon macrostachyus* | Sloppy areas | 1 |
| 10 | *Hperrhenia filipendula* | Fallow lands, hilly areas | 1 |
| 11 | *Melinus minutflora* | Sloppy areas | 4 |
| 12 | *Panicum spp* | Cultivated land, fallowed areas | 4 |
| 13 | *Penisetum polystachion* | Sloppy areas | 3 |
| 14 | *Penisetum purpereum* | Valley bottom | 3 |
| 15 | *Pyrene canthamalvifolia* | Valley bottom, river banks | 1 |
| 16 | *Rottboelia cochinchinesis* | Valley bottom, fallow land, crop weed | 1 |
| 17 | *Typha spp* | Water logged area | 4 |

Herbs

| SN | Botanical name | Site | Abundance |
|---|---|---|---|
| 1 | *Centrocema spp* | Valley bottom, along road sides, bush edges | 2 |
| 2 | *Clitoria ternatea* | Raod sides, lowlands, bushy land, crop weed | 2 |
| 3 | *Commelina spp* | Crop weed, lowlands | 3 |
| 4 | *Ipomea spp* | Riversides areas, fallowed areas | 4 |
| 5 | *Neonotonia wightii* | Valley bottom, along road sides | 2 |

Shrubs and trees

| SN | Botanical name | Site | Abundance |
|---|---|---|---|
| 1 | *Acacia tortilis* | Bush land, retained crop lands | 3 |
| 2 | *Bahunia spp* | Valley bottom | 2 |
| 3 | *Delonix spp* | Hilly areas | 1 |
| 4 | *Sesbania spp* | Valley bottom | 3 |

### (b): Planted forages

Grasses

| SN | Botanical name | Site | Abundance |
|---|---|---|---|
| 1 | *Pennisetum spp* | Along contour strips (farm land), homestead | 2 |

Trees and Shrubs

| SN | Botanical name | Site | Abundance |
|---|---|---|---|
| 1 | *Calliandra calpthyrus* | Homestead, farm boundaries | 1 |
| 2 | *Leucaena leucocephala* | Homestead, farm boundaries | 4 |
| 3 | *Morus spp* | Homestead, farm boundaries | 3 |
| 4 | *Sesbania sesban* | Homestead, farm boundaries | 3 |

**Appendix 11: Ranking of different feeding resources according to quality in Long Village (Appendix 11)**

| Feed resource | Benefits/criteria of ranking | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Animal pref. | Improved health | Milk yield | Easy to cut | Abundance and availability | Stomach fill | **Total** | Ranking |
| Natural grasses (tropical grass) | 2 | 2 | 1.5 | 1.5 | 3 | 2.5 | **12.5** | **2nd** |
| Planted pastures (grass and fodder trees) | 1.5 | 2 | 2.5 | 2 | 1.5 | 2.5 | **12** | **3rd** |
| Green forage (e.g. road side weeds, cut fodder) | 2 | 1.5 | 1.5 | 3 | 2.5 | 2 | **12.5** | **2nd** |
| Crop residues (e.g. maize stovers, rice straws) | 1 | 1 | 1.5 | 2 | 2 | 1 | **8.5** | **5th** |
| Legume crop residues (e.g. Canadian wonder beans, pigeon pea, chick pea) | 2 | 3 | 3 | 2.5 | 1.5 | 1 | **13** | **1st** |
| Concentrates (e.g. maize bran, grains, seedcakes) | 2 | 2 | 3 | **-** | 1 | 1 | **9** | **4th** |
| **Total** | **10.5** | **11.5** | **13** | **11** | **11.5** | **10** | | |
| **Ranking** | **4th** | **2nd** | **1st** | **3rd** | **2nd** | **5th** | | |

NOTE: 0 = Not used 1 = Poor, 2 = Good, 3 = Very good

**Appendix 12: Ranking of different feeding resources according to quality in Sabilo Village (Appendix 12)**

| Feed resource | Benefits/criteria of ranking | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Animal pref. | Improved health | Milk yield | Easy to cut | Abundance and availability | Stomach fill | **Total** | **Ranking** |
| Natural grasses (tropical grass) | 2 | 2 | 3 | 1 | 3 | 1 | **12** | **2nd** |
| Planted pastures (grass and fodder trees) | 1.5 | 2.5 | 3 | 1 | 1.5 | 0.5 | **10** | **4th** |
| Green forage (e.g. road side weeds, cut fodder) | 1 | 2 | 2.5 | 2 | 2 | 1.5 | **11** | **3rd** |
| Crop residues (e.g. maize stovers, rice straws) | 1 | 2 | 2 | 2 | 1 | 2 | **10** | **4th** |
| Legume crop residues (e.g. Canadian wonder beans, pigeon pea, chick pea) | 2.5 | 3 | 3 | 1 | 2 | 1 | **12.5** | **1st** |
| Concentrates (e.g. maize bran, grains, seedcakes) | 3 | 1.5 | 3 | 1 | 1.5 | 2 | **12** | **2nd** |
| **Total** | **11** | **13** | **16.5** | **8** | **11** | **8** | | |
| **Ranking** | **4th** | **2nd** | **1st** | **4rd** | **4th** | **5th** | | |

NOTE: 0 = Not used 1 = Poor, 2 = Good, 3 = Very good.

**Appendix 13: Ranking of different feeding resources according to quality in Seloto Village (Appendix 13)**

| Feed resource | Benefits/criteria of ranking | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Animal pref. | Improved health | Milk yield | Easy to cut | Abundance and availability | Stomach fill | **Total** | **Ranking** |
| Natural grasses (tropical grass) | 2 | 2 | 3 | 0 | 2.5 | 1 | **10.5** | **3rd** |
| Planted pastures (grass and fodder trees) | 2 | 2.5 | 2.5 | 1 | 2 | 2 | **12** | **2nd** |
| Green forage (e.g. road side weeds, cut fodder) | 1.5 | 2 | 2.5 | 3 | 2.5 | 2 | **12.5** | **1st** |
| Crop residues (e.g. maize stovers, rice straws) | 1.5 | 2 | 2 | 0 | 2 | 2 | **9.5** | **6th** |
| Legume crop residues (e.g. Canadian wonder beans, pigeon pea, chick pea) | 2 | 1.5 | 2.5 | 1 | 2 | 1 | **10** | **5th** |
| Concentrates (e.g. maize bran, grains, seedcakes) | 2.5 | 2.5 | 3 | 0 | 1.5 | 1.5 | **11** | **4th** |
| **Total** | **11.5** | **12.5** | **15.5** | **5** | **12.5** | **9** | | |
| **Ranking** | **3nd** | **2nd** | **1st** | **5th** | **2nd** | **4th** | | |

NOTE: 0 = Not used 1 = Poor, 2 = Good, 3 = Very good