ON FARM FEEDING INTERVENTIONS FOR HIGHER PERFORMANCE AND PROFITABILITY OF LOCAL CHICKENS IN BABATI DISTRICT, TANZANIA.

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EXTENDED ABSTRACT

Local chickens contribute about 56% of products from chickens produced in Tanzania. As the poultry industry grows, it is important to focus on improving their productivity to meet the increasing market demand of meat and eggs. This study was conducted aiming at developing feeding strategies that would help to increase the overall productivity of local chickens and their financial returns to farmers. The study was conducted in four villages of Matufa, Seloto, Galapo and Sabilo in four wards of Magugu, Dareda, Galapo, and Dabil respectively. The villages are located within the elevations of 1004-1803 meters above sea level. Majority of the households within the four villages practice mixed farming. The major crops grown are maize, sorghum, paddy, lablab, soybean, pigeon pea, sesame, sunflower and vegetables, while livestock kept are cattle, goats, sheep, pigs and poultry. A cross-sectional study was conducted aiming at assessing the productivity and management of local chickens in the four villages. The study involved 140 households for the individual interviews and four focused group discussions (one in each village) with an average of 18 farmers per group. The questionnaire and checklist were designed to collect information on rural chicken production status, chicken population structure, breeds/strains, feeding, housing, health management, mortality and labour distribution on chicken management within the households. The collected data were analysed using SPSS Statistics 21.0 program. The findings showed that 96.5% of the respondents in the study area kept local chickens with an average of 17 chickens per household. Most of the village households (53%) kept their chickens under a scavenging system with irregular supplementation. Other systems were semi-scavenging (44%) and full confinement (3%). The mean eggs per clutch and number of clutches/hen/year in the study area were 12.9 eggs and 3.5 respectively with an average of 45 eggs per hen per year. Only 17.1% of the

respondents kept their chickens in the chicken-shelters at night while 60.8% and 22.1% of respondents kept their chickens in family houses and kitchen respectively. Labour for chicken management was provided by the family members, either by men, women or children depending on the nature of the activity. However, most of the routine management activities were done by women and girls while men and boys played a major role in poultry house construction and marketing of chickens at distant markets. Following the survey, an on-farm experiment to evaluate the effect of feeding system was carried out in the three villages of Matufa, Seloto and Galapo in Magugu, Dareda and Galapo wards, respectively. A total of 45 farmers were purposively selected from the above villages for feeding system evaluation. The feeding systems evaluated were compounded feed with full time confinement (T1), compounded feed, with semi-scavenging (T2) and scavenging only (T3). The treatments were replicated 15 times, each village having five replications and each replication being held by an individual farmer. Thus, the experimental unit was a farmer with an average of 34 chickens. A total of 1550 chickens (520 males and 1030 females) were used to assess production and profitability parameters during the growth to maturity while 607 hens were used for egg production assessments. Data on growth and mortality rates were collected from the 6^{th} to 20^{th} week of age while laying intensity was recorded for 24 consecutive weeks commencing at the 22^{nd} week. The Lsmeans on body weight gains were 938.79 ± 18.79g, 815.70 ± 17.20g and 738.98 ± 13.50g for T1, T2 and T3 respectively.

Chickens under T1 had significantly ($P<0.05$) higher body weight gains and final body weights than those under T2 and T3. Male chickens expressed significantly ($P<0.05$) higher growth rate (4.71 ± 0.07g/d/h) and final body weight (1146.95 ± 16.05g) than female chickens (3.77±0.06g and 963.05 ±11.33g respectively) The mean egg production

intensity per flock was 30.75 ± 0.50%, 30.25 ± 0.55% and 24.16 ± 0.66% for chickens under T1, T2 and T3 respectively. Overall, T1 led to significantly ($P<0.05$) higher growth rate and survival rates. However, both growth and egg production were affected by locations whereas, T1 led to significantly ($P<0.05$) higher performance in egg production at low and medium altitudes than at high altitude when compared to T2. T2 led to significantly ($P<0.05$) higher performance in growth at low altitude than it did at high altitude when compared to T3.

Assuming that all birds were sold for meat, the results for the profitability was 0.74 for the chickens under T3 being significantly ($P<0.05$) higher by 0.19 and 0.49 for T2 and T1 respectively. As the confinement intensity increased, the feed costs increased as well, resulting in a higher cost per unit gain of meat. Overall, the chickens in T2 gave significantly ($P<0.05$) higher profitability (0.50) and gross margin of 1621.33 TZS while T1 resulted in the lowest profitability (0.25) and gross margin of 705.47 TZS in egg production. This study concludes that the free-ranging with supplementation of compounded feeds has the potential to increase both growth and egg production of local chickens in rural areas. Moreover, full-time confinement with compounded feeds improved the growth rate and survival rate and is therefore, more appropriate intervention for chicks up to the 10^{th} week of age. The profitability of 0.74 in T3 implies that local chickens are highly profitable if innovative adoptions, such as regular watering, vaccination, medication, and proper feeding at the early stage of their growth are taken into account. Thus, the study recommends T1 for the first 10 weeks of growth as it supports high survival rate, and there after, followed by either T3 for the chickens raised for selling as live birds for meat or T2 for both eggs and meat purposes.

DECLARATION

I, LEONARD JOSEPH MARWA, do hereby declare to the Senate of the Sokoine University of Agriculture that this thesis is my original work, done within the period of registration and that it has neither been submitted nor been concurrently submitted for a higher degree award in any other Institution.

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DEDICATIONS

This thesis is dedicated to my beloved wife (Flora), my sons Isaya, Ian and Ivan and my wonderful parent the late mother Yossina Mugesi Marwa. I thank you for your love, support and encouragement which helped to make this study a little bit easier for me. God bless you all.

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LIST OF ABBREVIATIONS, ACRONYMS AND SYMBOLS

ANOVA	Analysis of variance
AVG	Average daily gain
DAARS	Department of Animal, Aquaculture and Range Sciences
FAO	Food and Agriculture Organization of the United Nations
GM	Gross Margin
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
LSD	Least Significant Difference
MLDF	Ministry of Livestock Development and Fisheries
NBS	National Bureau of statistics
PI	Profitability index
PRA	Participatory Rural Appraisal
SAS	Statistical Analysis Systems
SPSS	Statistical Package for Social Sciences
TR	Total Revenue
TZS	Tanzanian shillings
TVC	Total variable costs
URT	United Republic of Tanzania
US	United States
USAID	United States Agency for International Development

ORGANIZATION OF THE THESIS

This thesis was prepared according to the “Publishable manuscript” format of the Sokoine University of Agriculture. It is organized into seven chapters. Chapter one covers the general introduction which includes the background, problem statement and justification as well as the objectives of the study. Chapter two consists of the general methodology used to carry out the studies reported in this thesis. Chapter three, four and five presents the published paper (Papers I) and two manuscripts submitted to the peer-reviewed journals. Chapter six presents the general discussion, general conclusion, recommendations and contribution of the study, followed by general references and appendices

CHAPTER ONE

1.0 GENERAL INTRODUCTION

1.1 Background of the Study

The majority of rural households (78.7%) in Tanzania like in other African countries keep local chickens as a source of protein and income (FAO 2019). The current population of chickens is estimated at 72 million of which 40 million are indigenous chicken and the remaining 32 million are exotic, which include 24 million broilers and 8 million layers (NBS, 2018). The sector is regarded as one of the easiest agricultural investments that can be used for poverty alleviation as it requires small space and low investment capital. The economic value and demand for chickens and their products are rising mainly due to increasing urbanization, demand for quality meat and eggs from the expanding tourism industry as well as increased purchasing power of the population (MLDF, 2010). Moreover, projections have shown that the human population in Tanzania will rise to 138 million in 2050 (United Nations, 2017). The increase in the human population will go concurrently with increased food consumption, including chickens and their products. This consequently will create more opportunities for poultry keepers to expand their entrepreneurial endeavors through improved production strategies.

The free-range system is predominant in the local chicken production systems, whilst a few households have adopted a semi-intensive system or an intensive system. Under the free-range system, chickens are rarely fed supplementary feeds. They mainly depend on kitchen leftovers and seasonally available grains such as maize or other farm products and by-products like maize bran and sunflower seed-cake. In rural areas, chickens are hardly confined in the daytime except in areas where field crops are near the homesteads and at

some stages of their growth, particularly for the chicks. The low number of chickens kept by farmers makes it uneconomical to construct separate chicken houses, and, therefore, in most cases, chickens spend the night time in human dwellings (Mwalusanya *et al.,* 2002; Marwa *et al.*, 2018).

There is an increasing demand for meat and eggs from local types of chickens than the exotic strains (Emuron *et al*., 2010). Despite the high demands, productivity and income generated from them are still low due to poor management and low genetic potential which consequently leads to a low growth rate, low egg production and high mortality rate (Magala *et al*., 2012). The low productivity is also contributed by the fact that the birds are given low commercial interest compared to other animals such as cattle, sheep and goats. Management of chicken has been relegated to women and children (Guèye, 2005; Dinka *et al*., 2010; Olwande *et al*., 2010; Tsadik *et al*., 2015; Marwa *et al*., 2018). Likewise, developed feed technologies in the poultry sector are geared towards improved strains of chickens in large commercial productions (Okitoi, *et al.,* 2006). This study was therefore conducted aiming at developing feeding strategies that would help to increase the overall productivity of local chickens in rural areas.

1.2 Problem Statement and Justification

Most households in Tanzania keep local chickens, which in turn provide income and contribute to food security and nutrition. However, their production is characterized by high mortality of chicks and growers caused by poor nutrition, predation and diseases (Mwalusanya *et al*., 2002; Goromela *et al*., 2008). Consequently, this low productivity translates into a low supply of local chickens to the markets (Magala *et al*., 2012). The increasing human population has also driven competition for land used for crop and

animal production. This phenomenon influences some degree of restriction of chickens' freedom to scavenging, especially during the cropping seasons. Some authors have suggested various strategies to improve the productivity of local chickens in rural areas. These include, among others better feeding, housing, health and general management practices (Mwalusanya *et al.,* 2002; Goromela *et al.,* 2008; Kugonza *et al.,* 2008; Lwelamira *et al.,* 2008; Mutayoba *et al.,* 2012). Nonetheless, there is limited information on the success and shortfalls of various interventions to improve local chicken production at farm level and their associated costs so that farmers can derive economic benefits from them (Mutayoba *et al.,* 2012). This information is crucial to farmers and policy makers. Hence, there is a need for studies to provide clear information on the best economically viable feeding strategies for local chickens. This study, therefore, intended to evaluate on-farm feed interventions and their cost implications, using local chickens subjected to improved feeding strategies at full or partial-confinement with an outcome of improved growth performance, egg production, survival rate and profitability of the sector.

1.3 Study Objectives

1.3.1 Overall objective

To develop feeding strategies that would help to increase the overall productivity of rural poultry production.

1.3.2 Specific objectives

i. To characterize poultry production systems in Babati district

ii. To determine the effects of different feeding strategies on the growth and egg production performance of local chickens.

iii. To determine the economic benefits of different feeding strategies on meat and egg production.

1.4 Research Hypothesis

Ho: There is no significant difference among feeding systems on growth performance, egg production, survival rate and profitability of local chickens.

1.5 The Conceptual Framework

As the conceptual framework illustrates in Figure 1, poultry farming in rural areas is influenced by social and economic variables describing a given area, which include the type of farming, crops grown, age of farmers, education and other income-generating activities. In rural areas, poultry are not kept as an economic venture thus, accorded little investment and hence sub-optimal performance.

There are various interventions that can be made to improve the productivity of the chicken sector, and these include among others feeds and feeding, housing and disease control. More so, intervention should address issues with regard to ownership of poultry and who can make the final decision. Often the case women are the ones who own chickens, but some investments such as housing may need the support of their husbands. Taking into consideration some of these key areas is likely to result in improved productivity in terms of increased flock size, fast growth, more eggs and reduction in mortality rates. However, the sustainability of intervention requires evaluation of the costs incurred against expected outcomes.

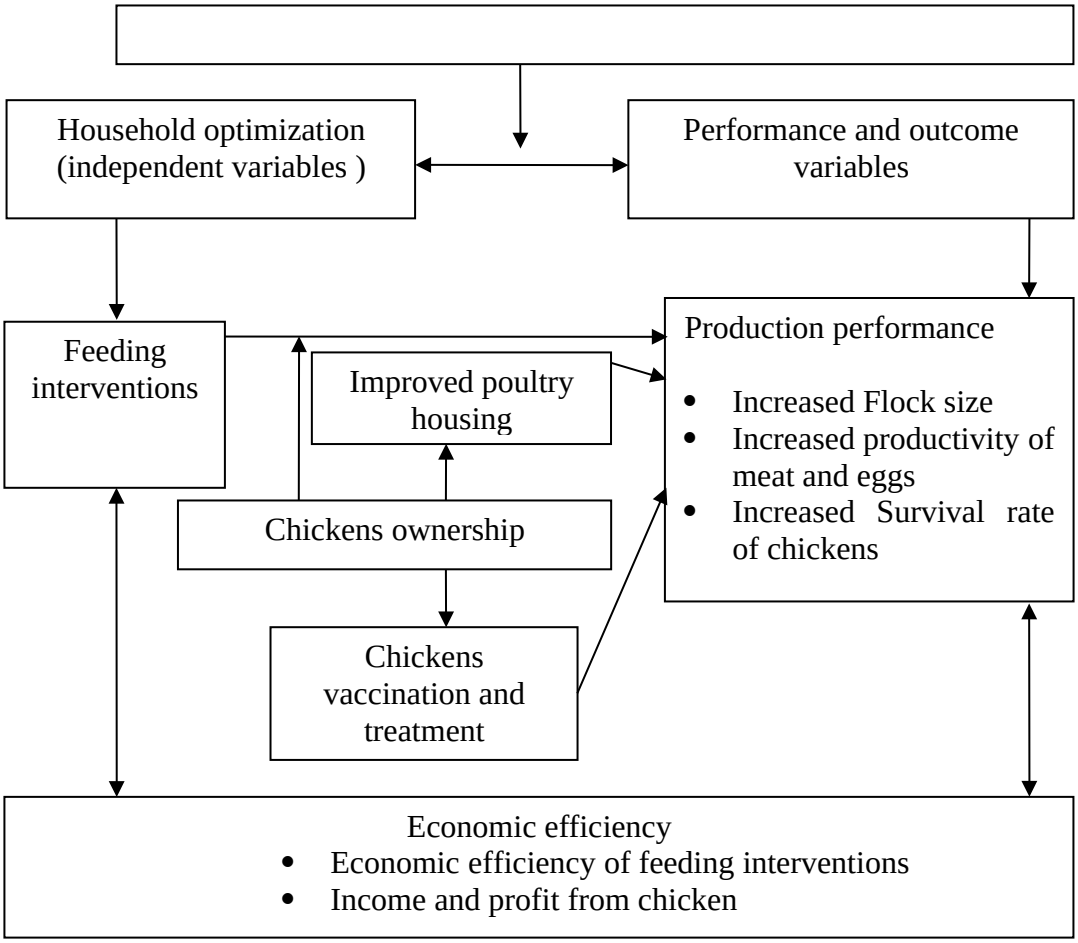

Figure 1: Conceptual framework for analysing local chicken production in rural areas

Source: Adopted and modified from Tan D.H.Q. (2013)

CHAPTER TWO

2.0 GENERAL METHODOLOGY

2.1 Study Location and Farming System

To achieve the objectives, the on-farm study was undertaken on smallholder farmers who participated in the Africa RISING project in the Babati district, Manyara region, Tanzania. The district is located south of the equator between latitude 3° and 4°South and Longitude 35° and 36° East with a total area of 6069 km^2 with a population of 405 500 people (URT 2018). The rainfall pattern in Babati district is bimodal having long rains from March to May and short rains from November to December with an average annual temperature and rainfall of 20.2°C and 831mm respectively. The dry season is experienced from June to October and January to February. The district is ranked third in keeping chickens in Manyara Region as presented in Fig. 2.

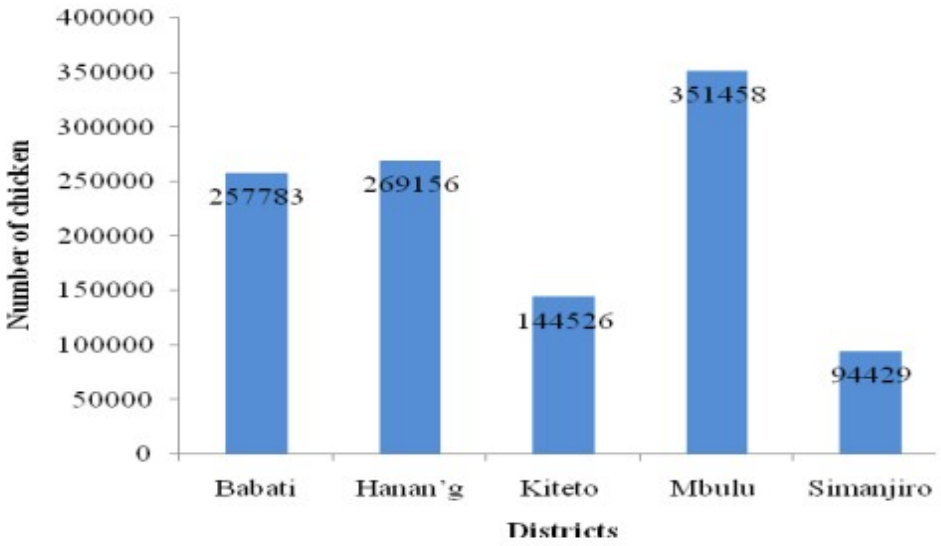

Figure 2: Number of chickens by districts in Manyara Region, Tanzania

Source: Manyara regional investment guide (2019)

The survey for objective one covered four villages namely: Matufa, Seloto, Galapo and Sabilo within Magugu, Dareda, Galapo, and Dabil wards respectively, while objectives 2 and 3 were done at Matufa, Seloto and Galapo villages, within elevations of 1004-1803 meters above the sea level. Matufa being at low altitude, Galapo at medium altitude and Seloto at high altitude with 1004, 1394 and 1803 meters above sea level, respectively. Mixed farming was dominant in the study area. Types of livestock kept by farmers are cattle, goats, sheep, pigs, poultry and rabbits while crops grown in the villages are maize, sorghum, lablab, sesame, paddy, pigeon pea, sunflower and vegetables. However, vegetables, paddy and sesame are mostly grown in Matufa village.

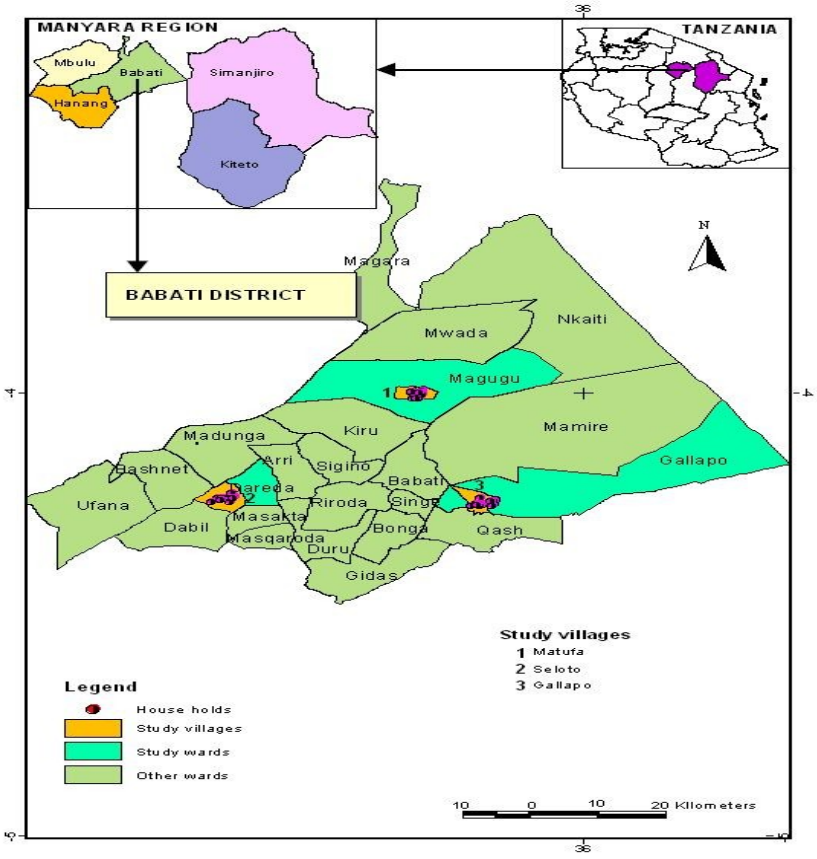

Figure 3: Map of Babati district in Manyara region, Tanzania, showing the

location of households of each village involved in on-farm experiments

2.2 Study Design

2.2.1 Cross-sectional survey

A cross-sectional study was conducted through individual interviews and participatory rural appraisal (PRA) to address objective 1. The participants involved were selected from different gender and age groups in the four villages of Matufa, Seloto, Galapo and Sabilo. The villages were purposively selected based on the population of chickens and easy access during the data collection period. Households were purposively sampled, targeting farmers under the Africa RISING project, who had been keeping chickens. Secondary data were obtained from the district office while primary data were obtained from farmers and key informants, including livestock extension officers and leaders at the village and district levels. A sample size of 140 households was drawn for this survey, according to Kothari (2004) using the following formula:

$n = ¿(z^2\ pqN)/(e^2(N-1)+z^2pq)$

Where n = size of sample, z =standard variate at a given confidence level (1.96 at 95%)

p = sample proportion (0.8), q = 1 – p (0.2); N = size of population 312 392 people (URT 2013).

e = acceptable error/the precision (0.05).

Four focused group discussions each with an average of 18 farmers were conducted in each village.

2.2.2 On-farm studies

A stratified purposive sampling experimental design (Suri, 2011) was employed in selecting farmers, for on-farm studies following objectives 2 and 3. The farmers were first grouped (stratified) based on their adoption to feeding systems (free-ranging, semi-confinement with supplementation or full-time confinement with improved feeding) and available poultry infrastructures in particular chicken houses. A random sampling within the group (strata) was employed in selecting the farmers to hold the trials. An incomplete factorial experimental design was used in these studies as described by Collins *et al.* (2009). Forty-five farmers were purposively selected for the trials. Each feeding practice was replicated 15 times, each village having five replications and each feeding practice being allotted to an individual farmer. Thus, the experimental unit was a farmer with 34 chickens of mixed sexes.

2.2.3 Management of experimental birds

A total of 1550, six-week-old local chickens were secured from hatchery at Kwaraa Farm in Babati district after being brooded and reared under intensive management. Chicks were vaccinated against Newcastle disease at 1st and 3rd weeks of age, Infectious bursal disease (at the 2nd week of age) and fowl pox at the age of 6 weeks as per the veterinarian's recommendations. Any other incidences of disease condition were immediately attended by the village extension officers after the birds have been distributed to farmers. The chickens were wing tagged and measured for their initial body weight on the day of distribution. All chickens in the treatments were in a simple shelter at night (Appendix 5) and feeding was done in groups (group feeding).

2.3 Experimental treatments

Experimental feeds were processed using a simple livestock feed processing machine provided to farmers by the Africa RISING project (Appendix 6). The feeds were formulated with crude protein (CP) ranged between 15-16% as recommended by Gakige *et al*. (2015) and Kingori *et al*. (2003) for indigenous chickens. Three treatments were designed as presented below;

In treatment 1 (T1) the chickens were full-time confined, fed with compounded feeds. The quantity of feed for chicks and growers was adjusted weekly as birds grew while the daily feed ration for adult chickens was about 120g per bird per day as presented in Table 1. The chickens were provided with feeds at 0630 hours. In treatment 2 (T2), **t**he chickens were partially confined from 0630 to 1230 hours, supplemented with compounded feeds and released to scavenge up to 1830 hours. Chicks (6-10th week) and growers (11-18th week) under T2 were supplemented with 50% of the amount fed in T1 while each adult chicken (19th week and above) was supplemented with 60g of compounded feed as shown in Table 1. In treatment 3 (T3), the chickens were full-time scavenging during the day from 0630 hours to 1830 hours relying on locally available scavenging feeds.

Table 1: Feed offered per bird per day from 7th week of age to 19th week and above

Age in weeks	Class of chickens	Amount of feed (g) for T1	Amount of supplemented feeds (g) for T2
7-10	Chicks	70	35
11-12	Grower	80	40
13-14	Growers	90	45
15-16	Growers	100	50
17-18	Growers	110	55

19 and above	Adult/layers	120	60

2.4 Data Collection Methods

2.4.1 Qualitative and quantitative survey

An exploratory study covering the indigenous chicken production systems, locally available feed resources and their availability was undertaken. A focus group discussion in each of the four villages was used to assess the chickens' production systems. The groups had an average of 18 people. Tools and techniques such as pair-wise matrix ranking, direct observations and checklist were applied during the PRA. The checklist and structured questionnaire (Appendices 2 and 3) were developed and pretested before administering. Enumerators were trained on how to use the tools for data collection in order to establish common understanding. The checklist covered seasonal variation of locally available feed resources, crop harvesting periods, poultry marketing opportunities and poultry disease incidences.

The study also examined the constraints concerning the utilization of these feed resources for rural poultry in the existing management system. Other information gathered includes rural chicken production, marketing status, breed and breeding, diseases, poultry shelters and labour mapping (gender participation in poultry activities). The locally available feed resources were identified, quantified and ranked for their availability and accessibility for poultry use. The collection of this information enhanced the proper choice of the locally available feed resources to be used in chicken feed formulation at the cheapest cost affordable to farmers.

2.4.2 Quantitative data collection

Data collection was done by a researcher with assistance from a data clerk who was recruited for each village. Initial body weight was measured on the day of distribution of chicks to farmers. Data on growth, mortality and running costs during the growing phase were collected at intervals of two weeks from the chicks' delivery date to the age of 20th week. A Silvano kitchen scale (Appendix 4) was used in weighing the birds. The subsequent body weight gains were computed as a difference between the body weights between two subsequent weighing periods. Egg production and their related costs were collected for 24 consecutive weeks, commencing at the age of 22nd week. At this age, male chickens were culled for sales while females were retained for egg production. Each farmer was given a sheet to record the daily egg production and the respective number of available hens. The monetary value of feed offered was quantified from which the profitability was analysed. The average egg production intensity was then calculated as a ratio of the number of eggs laid to the total number of laying hens and expressed as a percent. The average number of eggs per bird for 24 weeks of laying was computed as the ratio of the total number of eggs laid in the whole period to the average number of laying hens.

2.4.3 Gross margin analysis

The gross margin analysis was done according to Ayieko *et al* (2014) as a difference between total revenue (TR) and total variable cost (TVC)

Gross Margin (GM) = TR ─ TVC

2.4.4 Profitability analysis

The return on the variable cost was calculated according to Aboki *et al*., (2013) and Siyaya and Masuku (2013a) as a ratio of profit to total variable costs.

2.5 Statistical Analysis

The survey data were coded and analysed using the Statistical Package for the Social Sciences (SPSS) 21.0 program. Descriptive statistics such as mean, range, frequency and percentage were used. Analysis-of-variance (ANOVA) procedures of the General Linear Model of Statistical Analysis System (SAS, 2000) was used to evaluate the effect of the feeding system on the average body weight gain, egg number and egg production intensity. A covariate of initial body weight at the age of six weeks was employed on growth data analysis for adjusting the average body weight gain. A test of difference of means on the data was performed using the Least Significant Difference (LSD). The Chi-square with FREQ procedure was used for the analysis of mortality rate. The difference was accepted as significant when $P < 0.05$. For evaluation of feeding system, sex and location were fitted as fixed effects. For egg production, GM and profitability, feeding system and location were the fixed effect. For both models, interaction between feeding system and location were also evaluated.

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CHAPTER THREE

PAPER I

The productivity and management systems of free range local chickens in rural areas of Babati District, Tanzania

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The productivity and management systems of free-range local chickens in rural areas of Babati District, Tanzania

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Abstract

A study was conducted to assess productivity and management systems of local chickens in rural areas of Babati District, Tanzania. Four villages from four different wards were involved in the study. Cross-sectional study was employed in gathering information whereby 140 households were interviewed. In addition, four focused group discussions each with an average of 18 farmers were held. The questionnaire and check list were designed to collect information on rural chicken production status, population structure, breeds/strains, feeding, housing, health management, mortality and labour distribution in chicken management within the family members. Data were analysed using SPSS Statistics 21.0 program. The findings showed that 96.5% of the respondents in the study

area kept local chickens, at an average of 17 birds per household. Most of the village households (53%) kept their chickens under scavenging mode of production with occasional supplementations. Other systems used included semi-scavenging (44%) and full – time confinement (3%). Labour in chicken management was provided either by men, women or children depending on the nature of activity. However, majority of routine managements were done by women and children. Moreover, men and boys played major role in poultry house construction and marketing of chickens to distant markets. The results suggest a need for innovative approaches that integrate improved nutrition, housing and health management for the farmers to realize economic gains in raising local chickens while taking into consideration gender responsibilities within the family.

Key words: constraints, flock structure, labour, production performance, survey

Introduction

Majority of rural households in Tanzania like in other African countries, keep local chickens as the source of protein and income. Chickens are regarded as one of the enterprises that can be used for poverty alleviation (Mwalusanya *et al.,* 2002). They are sold for cash that is used to purchase family food, medicine, agricultural inputs, clothing and other petty needs (Guéye 2003).

Local chickens in rural areas are mostly kept under minimal input of resources though they contribute significantly to food security, poverty alleviation and ecologically sound management of natural resources (Guéye 2003 and FAO 2010). Free range system is predominant, whilst a few households have adopted semi-intensive system or intensive system. Under scavenging and semi-intensive systems, chickens are rarely fed

supplementary feeds. They mainly depend on kitchen left overs and occasionally on grains or their by-products. On the other hand, low number of chickens kept by farmers make it uneconomical for them to construct a separate house for their chickens and therefore in most cases chickens spend night time in human dwelling (Mwalusanya *et al.*, 2002).

Despite the contribution of local chickens to household economy and food security, they are constrained by periodic disease outbreaks resulting from inadequate biosecurity measures and poor feeding, which consequently leads to low growth rate and low egg production with high mortality rates. Losses are mostly observed in young chicks and growers. Alfred *et al.* (2012) reported 53% chick losses in the first six weeks of age mainly due to malnutrition, diseases and exposure to predators. Furthermore, the low productivity of local chicken is also contributed by the fact that, the birds are accorded low commercial interest and farmers do not consider it as a potential investment. Consequently, women and children take the lead in managing chickens with less input from men as reported by other studies (Guèye 2005; Dinka *et al.,* 2010; Olwande *et al.,* 2010 and Tsadik *et al.,* 2015).

Understanding the constraints of rural local chickens' production is crucial in designing of strategic interventions to enhance rural poverty alleviation. This study intended to document information on the productivity and management systems of local chickens in villages of Babati district in Tanzania as a step towards designing innovative strategies to enhance productivity.

Research Methodology

Study area

This survey was carried out in Babati district. The district is located below the equator between latitude 3° and 4° south and longitude 35° and 36°E with a total area of 6069 km^2. The study covered four villages namely, Matufa, Seloto, Galapo and Sabilo within Matufa, Dareda, Galapo, and Dabil wards respectively. The villages are within elevations of 1004-1803 meters above the sea level. Mixed farming is dominant in the study area. Types of livestock kept by farmers are cattle, goats, sheep, pigs, poultry and rabbits while crops grown are maize, sorghum, soybean, paddy, lablab, pigeon pea, sesame and sunflower.

Research design

Cross-sectional study was conducted involving different gender and age groups in selected villages. The villages were purposively sampled basing on the population of chickens and easy access for data collection. Households were randomly selected from those that had been keeping chickens for the last three years. The study involved collection of both primary and secondary data. Secondary data were obtained from the district offices while primary data were obtained from farmers and key informants including livestock extension officers at village and district levels as well as village leaders.

Sampling procedures and data collection

A sample of 140 households was drawn for the survey and was computed according to Kothari (2004). Four focused group discussions each with an average of 18 farmers comprising of males and females were held in each village. Different tools and techniques

including check list, pair-wise matrix ranking, and direct observations were applied. The general information on rural chickens' production and existing constraints were explored. The collected information included chicken production status, population structure, breeds/strains, mortality, labour distribution in chicken management and other management activities or systems particularly housing, feeding, and health.

Data analysis

The surveyed data were coded and analysed using SPSS Statistics 21.0 program. Descriptive statistics such as mean, range, frequency and percentage were used.

Results and discussion

Distribution and Flock structure of local chickens

The results in the current study showed that most of respondents (96.5%) in the study area kept local chickens while the rest kept the exotic and cross-bred chickens. The average number of chickens per household was 17.6 birds. Mortality was reported to reduce a large number of chickens (60%) particularly the chicks before attaining maturity (Table 1).

The number of chickens per household in this study conforms to observations by Mwalusanya *et al.* (2002) in Tanzania, Olwande *et al.* (2010) in Kenya and Tsadik *et al.* (2015) in Ethiopia. However, the reported number of chickens per house hold was higher than the value reported by Swai *et al.(*2007) and Guni *et al.* (2013) in Tanzania. Moreover, Muchadeyi *et al.* (2004) reported higher number of up to 30 chickens per household in Zimbabwe. The variations in flock sizes within and between the countries is

attributable to factors like differences in seasons in which the survey was carried out, ecological zones, occurrence of diseases and other culling influences.

The number of cocks, hens and chicks differed in the population structure of chickens of the study area whereby the cocks were fewer (14.9%) compared to hens (41.3%) and chicks (43.8%) as presented in Table 1. The observed number of cocks was expected since farmers need only a few males for breeding purpose and maintain a reasonable cock:hen ratio. Fewer cocks also prevent cock fighting among themselves. The culling of cocks was mainly for home consumption and sale. More sells were reported to happen during festivals, such as Christmas and New Year due to high demands. The hens and pullets were also culled but at a lower rate compared to cocks. The female chickens were mostly culled for slaughter and given to friends and relative for breeding. On average, nine chickens were culled per year. The scenario in this study correspond to the findings reported from other countries including Botswana (Mushi *et al.*, 2005), Nigeria (Fayeye *et al.*, 2006) and India (Kumaresan *et al.*, 2008).

Table 2: Population, productivity and flock structure of local chickens per household (N=140)

Parameter	**Statistics**				
	Minimum	**Maximum**	**Mean**	**Std deviation**	**Percentage**
Number of chickens	5	55	17.6	9.82	
Number of cocks	0	8	2.62	2.07	14.9
Number of hens	2	28	7.25	5.59	41.3
Number of chicks	0	30	7.69	4.92	43.8
Average eggs per clutch	10	17	12.9	2.25	
Clutch per year	2.00	6.00	3.45	1.07	
Hatchability (%)	50.0	100.0	81.5	12.3	

Survival of chicks (%)	40	100	60.9	13.5
Disposed birds per year	0	20	9	4.31

Productivity of local chickens

Uncontrolled breeding with random mating dominated in the study area and the hens were used for natural incubation and brooding of young chicks. The mean clutch size and clutches/hen/year in the study area were 12.9 eggs and 3.5 respectively (Table 1). This implies that the annual total egg production for the local chickens could be around 45 eggs which is consistent with Guni *et al.* (2013) for local chickens in Mbeya, Tanzania. Mean egg hatchability in this study was 81.5%, which was comparable to the value of 81% reported by Olwande *et al.* (2010) in Kenya, and closer to the value of 83.6% and 83.2 - 92.6% reported by Mwalusanya *et al.* (2002) and Guni *et al.* (2013) respectively for indigenous chickens in Tanzania. The values were however, much lower than those of 90% reported by Kugonza *et al.* (2008) in Uganda. The variations in hatchability within and between the countries is probably contributed by environmental factors such as differences in temperature and humidity (King'ori, 2011).

Like in many rural situations hatching and brooding of chicks were entirely done by the brooding hens, and this practice consequently reduced the number of days for laying. The broody hens spent a lot of production time either lying on eggs or taking care of young chicks (Mwalusanya *et al*., 2002, Kugonza *et al.,* 2008 and Olwande *et al.*, 2010). Though hatchability was higher, the practice of the hen to incubate her own eggs is inefficient means of reproduction and consequently contributes to low off take rate for local chickens.

Nutritional management

The results of this study as summarized in Table 2, shows that majority of respondents (86.4%) were practicing partial supplementation. The supplements used were locally available feedstuffs which included maize grain, maize bran, sorghum, sunflower seedcake and kitchen left overs. No effort was done to nutritionally balance the supplemented feeds and in most cases feeds were provided on an irregular basis depending on their availability. Among the feed supplements, kitchen left-overs were mostly available throughout the year in all households. Maize bran ranked the first among the cereal by-products being utilized by most farmers as feed supplement while whole grains particularly maize and sorghum ranked the second. With regard to protein sources, fish meal, blood meal, and sunflower seedcake were occasionally used. Nonetheless, the feeding system was still dominated by scavenging (52.9%) and in case of supplementation, farmers were mainly relaying on one or two ingredients. This observation is consistent with what was reported by Halima (2007) and Dinka *et al.* (2010) in Ethiopia as well as Mlambo (2011) in Malawi. Lack of technical know-how on feed formulations and higher cost of formulated feeds are among the reasons which caused farmers to feed chickens uncompounded feeds (Tsadiket *et al.*, 2015). However, the study by Rashid *et al.* (2004) and Goromela *et al.* (2007) for local chickens in Bangladesh and Tanzania respectively showed that the nutrient concentrations of scavengeable feed resources consumed by scavenging chickens are below the recommended levels for optimum productivity. This ultimately reduces the productivity in terms of growth rate and egg production. The situation becomes even worse during the dry season. Poor nutrition especially to chicks is likely to increase susceptibility to diseases and hence contribute to higher mortalities observed in this age class.

Table 3: Nutritional management systems of local chickens and supplementation routine (N=140)

	Frequency	Percent
Nutritional management		
Full-confinement	4	2.86
Semi-scavenging	52	44.3
Full-scavenging	84	52.9
Total	140	100.0
Supplementation routine		
Daily	85	60.7
Frequently	24	17.2
Occasionally	12	8.6
None	19	13.6
Total	140	100.0

Housing and health management systems

The results indicate that only 17.2% of the respondents kept their chickens in purposively built shelter while the majority (82.8%) provided an alternative means of shelter at night in human dwellings (60.7%) or in the kitchen (22.1%) as summarized in Table 3. This gives a picture of indigenous chicken production under extensive management system and

it comply with the findings by Swai *et al.* (2007), Dinka *et al.* (2010), Olwande *et al.*, (2010) and Mlambo *et al.*, 2011 for local chickens in Tanzania, Ethiopia, Kenya and Malawi, respectively.

Table 4: Housing management systems (N=140)

Housing pattern	**Frequency**	**Percent**
Kitchen	31	22.1
Share with owner's house	85	60.7
Chicken shelter	24	17.1
Total	140	100.0

The reasons for keeping chickens at night in the same house with owners was one of the strategies to prevent theft and predators. However, absence of specialized shelter for chickens exposes the birds to bad weather condition, diseases and predations, consequently leading to high mortality rates whereby chicks tend to be mostly affected. Similar contention was given by Dinka *et al.* (2010), Olwande *et al*. (2010) and Mlambo *et al.* (2011).

With regard to disease management, the result showed that most of the farmers (82.1%) were not vaccinating their chickens against common viral diseases such as Newcastle diseases, Gumboro (Infectious bursa disease) and Fowl pox (Table 4). Among the reasons is poor knowledge on disease prevention, high cost of veterinary inputs and poor

accessibility to extension services. It is also likely that farmers are reluctant to invest on chicken as they put less value in chicken compared to large animals such as cattle and goats. The findings of this study conform to other studies addressing the local chickens in rural areas including Mushi *et al.* (2005) in Botswana, Swai *et al.* (2007) in Tanzania and Olwande *et al.* (2010) in Kenya.

Table 5: Health management systems (N=140)

Vaccination options	**Frequency**	**Percent**
Vaccination practice	25	17.9
Absence of vaccination	115	82.1
Total	140	100.0
Access to veterinary services	21	15.0
Inaccessibility to veterinary services	119	85.0
Total	140	100.0

Roles of household members in chicken management

Labour in local chicken management in the study area was provided either by men, women or children depending on the nature of activity. Less time was used in chicken related activities due to small flock which implies less competition with other production activities. However, majority of routine management were done by women and children (Table 5). Moreover, men and children (boys) played major role in poultry house construction and marketing of chickens to distant markets.

Table 6: Role of household members in local chicken rearing

Activity	**Household involvement**		
	Men	**Women**	**Children**
Provision of kitchen waste	-	***	**
Provision of other supplemental feeds	*	***	**

Provision of water	*	***	**
Chicken house construction	**	*	***
Chicken selling	*	***	**
Chicken owning	*	***	*

**** = Higher level of involvement in the activity; ** = Medium level of involvement in the activity; * = Lower level of involvement in the activity; - = non-involvement in the activity.*

It is also very common that buyers visit the homestead and this lessens the additional cost of transporting chicken to far markets. Many studies have also reported that in rural areas, women play major role in the management of chickens (Guèye, 2005, Dinka *et al.,* 2010, Olwande *et al.,* 2010; Mlambo, 2011; and Tsadiket *et al.,* 2015). This gender responsibility implies that support and delivery of local chicken technologies should be directed to mainly women for sustainable improvement of the local chicken sector.

Conclusions

i. Majority of the households in the study areas practiced the extensive production system relying on one or two ingredients for supplementation, with poor housing and poor disease control measures.

ii. Women and children play major role in the management of chickens.

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CHAPTER FOUR

MANUSCRIPT I

The eeffect of improved feeding systems on the performance of local chickens in rural areas of Babati District, Tanzania

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The effect of improved feeding systems on the performance of local chickens in rural areas of Babati District, Tanzania.

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Abstract

An on-farm study to evaluate the effect of an improved feeding systems was carried out in Babati district, Tanzania. The feeding systems were compounded feed with full-time confinement (T1), compounded feed with partial scavenging (T2) and scavenging only (T3). A total of 45 farmers and 1550 local chickens were involved from three villages namely: Matufa, Galapo and Seloto. Data on growth and mortality rate were collected from the 6th to 20th week of age while egg laying intensity was recorded for 24 consecutive weeks commencing the 22nd week of age until 45 weeks. A GLM procedure of SAS (2000) was used to analyze the data. The mean body weight gains at the 20th week were 938.79 ± 18.79 g, 815.70 ± 17.20 g and 738.98 ± 13.50 g for chickens under T1, T2 and T3 respectively. Birds on T1 resulted in significantly ($P<0.05$) higher body weight gains and final body weights (938.79 ± 18.79 g) than those in T2 (815.70 ± 17.20 g) and T3 (738.98 ± 13.50 g). Male chickens expressed significantly ($P<0.05$) higher growth rate (4.71 ± 0.08 g/h/d) and final body weight (1146.95 ± 16.05 g/h/d) than females (3.77 ± 0.06 g and 963.05 ±11.33 g/h/d respectively). The mean egg production intensity (%) per

flock was 30.75 ± 0.50, 30.25 ± 0.55 and 24.16 ± 0.66 for chickens under T1, T2 and T3 respectively. The mortality rate for chickens under T1 was 20.97% less than what was expressed in T3, and 12.29% less than those in T2. T1 led to significantly ($P<0.05$) higher egg production at low and medium altitudes than at high altitude when compared to T2. T2 led to significantly ($P<0.05$) higher growth performance at low altitude than it did at high altitude when compared to T3. It is concluded that T1 led to higher growth and survival rates and therefore recommended for chicks and growers while T2 led to higher eggs and therefore recommended for egg production.

Keywords: Feed supplementation, body weight, egg-laying intensity, rural chickens.

Introduction

Local chicken production systems in rural areas of Tanzania are predominant free-range in which the birds are kept at subsistence level and are found in almost all households. The birds are raised with minimum resource inputs, left to scavenge for their feeds mainly from grains, forages, insects, worms and kitchen leftovers. However, most studies on local chickens show that scavenging chickens cannot fully meet the nutrient requirements for growth and production (Mwalusanya *et al*., 2002; Rashid *et al*., 2004; Goromela *et al*., 2007; Goromela *et al*., 2008; and Mutayoba *et al*., 2011). This is because the quantity and quality of available feeds under the scavenging system depend upon the nature of the land, human activities and the available foraging materials (Goromela *et al*., 2008).

Additionally, chickens are rarely confined except for areas where field crops are nearby homesteads and at a certain growth stage, in most cases, the chicks. Supplementation is also done, but more often using single (non-mixed) ingredients such as maize grains,

maize bran, kitchen leftovers or other farm products and by-products (Marwa *et al*., 2018). This practice is more frequent just around crop harvesting time and declines thereafter, thus affecting significantly the overall productivity of birds in rural areas. Most of the developed technologies for the improvement of poultry are geared towards chickens raised under confinement and mostly for commercial productions (Okitoi *et al.,* 2006). There is little information on the strategic feeding management of rural chickens to optimize their production potential. Therefore, the present study was carried out to assess the effect of feeding system using locally available feed resources on the productivity of local chickens in the rural areas of the Babati District in Tanzania.

Methodology

Study area and sampling

This study was carried out in Babati district, Tanzania. The district is located below the Equator between Latitude 3° and 4° South and Longitude 35° and 36° East, with an average annual temperature of 20.2°C and 831 mm of rainfall. The study covered three villages of Matufa, Seloto and Galapo within Magugu, Dareda and Galapo wards respectively. The villages were purposively selected based on the altitude, population of chickens and easy access during the data collection period. Stratified purposive sampling was employed in selecting farmers targeting the Africa RISING project farmers who had been keeping chickens. Altitude-wise Seloto was at high altitude (1803 masl), Galapo at medium-altitude (1394 masl) and Matufa at the low altitude, (1004 masl). Farmers were firstly grouped (stratified) basing on their adoption feeding systems (full-time free-ranging, partial free-ranging and intensive feeding) thereafter, random sampling was done within the groups. Most of the households in the selected villages practice mixed farming.

The major crops grown are maize, sorghum, paddy, lablab, pigeon pea, sesame, sunflower and different varieties of vegetables, while the livestock kept include cattle, goats, sheep, pigs and poultry. The Harvesting months differ among crops and villages as summarized in Table 1.

Table 1: Potential crops available for use in poultry feeds and their months of harvest

Village	Crop	Rank order of crops within the village	Months of their harvest											
			[illegible]	[illegible]	[illegible]	[illegible]	May	June	[illegible]	[illegible]	September	[illegible]	[illegible]	December
Galapo	Maize	1						√	√	√				
	Sorghum	3						√	√					
	Sunflower	2					√	√	√					
	Lablab	4								√	√			
Matufa	Maize	1						√	√					
	Sorghum	2							√	√				
	Sunflower	3				√	√							
	Lablab	7								√	√	√		
	Paddy	5			√	√	√	√	√					
	Vegetable	6	√	√	√	√	√	√	√	√	√	√	√	√
	Sesame	4						√	√					
Seloto	Maize	1							√	√				
	Sorghum	3							√	√				
	Sunflower	2			√	√	√	√						
	Lablab	5								√	√			
	Vegetable	4								√	√	√	√	√

Source: Field survey data 2017

Experimental design

An incomplete factorial experimental design was employed for the study as described by Collins *et al*. (2009) whereby two factors (feeding regime and/or confinement) were

combined to represent the feeding system. A total of 45 farmers were purposively selected based on their adoption level in local chicken management and their readiness to adhere to research requirements. Amongst the requirements were building a chicken shelter to accommodate the experimental chickens, readiness to dispose of the pre-existing chickens before receiving the research chickens, readiness to participate in training and data collection. Each feeding system was replicated 15 times, each village having five replications and each replication being allocated to one household. On average, each household received 34 local chickens of mixed sexes at the age of six weeks.

Management of experimental birds

A total of 1550 local chicks (the same to those of farmers) were secured from the Kwaraa farm in Babati district after being brooded under intensive management, fed with commercial starter feed to six weeks of age. The chicks were vaccinated against Newcastle disease at 1st and 3rd weeks and repeated after every three months. Infectious bursal disease (Gumboro) vaccination was done in the 2nd week while the fowl pox vaccine was administered at the age of 6 weeks. Any other incidence of disease condition was treated instantly by the village extension officer. All chicks were wing-banded and weighed for their initial weight on the day of distribution to farmers. All chickens in all treatments were supplied with clean water and at least a simple shelter at night. Feeding of chickens in T1 and T2 were done in groups (group feeding). During the egg production period, hens were not allowed to brood, hence eggs were removed from the nests. A total of 520 cocks and 1030 pullets at the age of six weeks were used for the study in assessing growth, mortality and profitability during the growth phase while 607 hens were used for

the assessment of egg production and its profitability, commenced at the age of 22nd weeks of age.

Three treatments that embraced feeding and management combination were assessed and these were as follows:

Compounded feed with full-time confinement (T1)

The chickens were full-time confined and fed with compounded feeds as shown in Table 2.

Table 2: Experimental feeds (compounded feeds) for T1 and T2

Ingredients	**Chick Mash (kg)** *(7^{th}-10^{th} week)*	**Grower Mash (kg)** *(11^{th}–18^{th} week)*	**Adult Mash (kg)** *(19^{th} week and above)*
Maize grains	46	46	40
Maize bran	22	22	27
Sunflower seed cake	15	17	17
Fish meal	5	5	5
Blood meal	6	2.5	3.5
Limestone	2	2.5	2.5
Vegetable meal	2	3	3
Bone meal	1.5	1.5	1.5
Table salt	0.5	0.5	0.5
Total	100	100	100
Calculated nutrient composition			
Metabolizable energy (kcal/kg)	2780	2816	2753
Crude protein (%)	16.53	15.16	15.82

The feed quantity for chicks and growers was adjusted weekly as birds grew. Feed and water were offered timely at 0630 hours based on the ration specification in Table 3. Beginning the 7th week, chicks were initially provided with 70g feed per chicken daily,

followed by 5g weekly increments. The daily feed ration for adult chickens was 120g per bird (Table 3).

Table 3: Amount of feed fed per bird per day from 7th week of age

Age in weeks	Class of chickens	Amount of feed (g) for T1	Amount of supplemented feeds (g) for T2
7-10	Chicks	70	35
11-12	Grower	80	40
13-14	Growers	90	45
15-16	Growers	100	50
17-18	Growers	110	55
19 and above	Adult/layers	120	60

Compounded feed with partial scavenging (T2)

The chickens were partially confined during the day-time and supplemented with compounded feed (Table 2). The chickens were confined for six hours from morning (0630 hours) to afternoon (1230 hours), then released to scavenge for six hours to evening (1230 to 1830 hours). Chicks and growers were supplemented with 50% of the amount fed to birds on T1 up to 18th week of their age, while adult chicken (19th week and above) were supplemented with 60g of compounded feed each with crude protein (CP) ranged between 15-16% as recommended by Gakige *et al*. (2015) and Kingori *et al*. (2003) for indigenous chickens.

Scavenging only (T3)

The chickens were full-time scavenging on locally available scavenge feed resources, being released in the morning at 0630 hours and confined in the evening at around 1830 hours.

Data collection

Data on growth and mortality were collected at an interval of two weeks commencing on the date of chicks' delivery to farmers (the 6th week of age) up to the age of the 20th week. Body weights were measured using a Silvano kitchen scale. The subsequent body weight gains were calculated as a difference between the body weights of two subsequent weeks while the aggregate body weight gains were calculated by subtracting initial body weights in the 6th week from final body weights in the 20th week.

Average daily gains were calculated as ADG $= \frac{\text{Final weights – Initial weights}}{\text{Age (days)}}$

Data on mortality were recorded by farmers as they occurred. Daily egg production data in each flock was collected for 24 consecutive weeks after the chickens started laying, commencing at the age of the 22nd week. At this age, male chickens were culled for sales and a total of 607 hens were retained for egg production. Each farmer was given a sheet to record the daily egg production and the respective number of available laying hens. These data were monitored at an interval of two weeks. Egg production intensity was computed as the ratio of daily eggs laid to the corresponding number of hens.

The egg production intensity (%) = (Total eggs laid/Available laying hens) x 100

The average number of eggs per bird for 24 weeks of laying was calculated as the ratio of the total number of eggs laid in the whole period to the average number of hens available.

$$\text{Number of eggs per bird} = \frac{\text{Total number of eggs laid}}{\text{Average number of laying hens}}$$

Statistical analysis

A General Linear Model procedure of Statistical Analysis Systems (SAS 2000) was used to evaluate the effect of feeding and confinement levels on the average body weight gain, egg number and egg production intensity. Initial body weight at the 6th week of age was included in the model as a covariate for growth data analysis. Test of difference between the means was performed using the Least Significant Difference (LSD). The Chi-square with FREQ procedure was used for mortality rate analysis. The difference was accepted as significant when $P<0.05$.

The following model was employed on growth data during the analysis

$$Y_{ijkl} = \mu + F_i + S_j + L_k + (FL)_{ik} + \beta(X_{ijk} - \bar{X}) + e_{ijkl} \quad \text{.....(i)}$$

Y_{ijkl} = Record of lth bird from ith feeding system, jth sex of the birds and kth location.

μ = Overall mean

F_i= Effect of the ith feeding system (1, 2, 3)

S_j = Effect of jth sex (1, 2)

L_k = Effect of kth location (1, 2, 3)

$\beta(X_{ij} - \bar{X})$ = Covariate effect of initial body weight on the lth bird from ith feeding system jth sex of the bird and kth location (1, 2, 3)

$(FL)_{ij}$ = Interaction effect between feeding system and location (1, 2)

e_{ijkl} = Random error

The following model was employed on egg production.

$Y_{ijkl} = \mu + F_i + L_j + (FL)_{ij} + e_{ijk}$ ……..……(ii)

Y_{ijkl} = Record of k^{th} flock of birds from i^{th} feeding system and j^{th} location

μ = Overall mean

F_i= Effect of the i^{th} feeding system

L_j = Effect of j^{th} location

FL_{ij} = Interaction effect feeding system and location

e_{ijk} = Random error

RESULTS

Growth performance

The effect of the feeding system and sex of the bird on body weight gains is presented in Table 4 and Fig. 1. The results show that the final body weight, cumulative body weight and daily body weight gains for chickens under T1 were significantly ($P<0.05$) higher than the chickens in T2 and T3. Moreover, males were significantly ($P<0.05$) heavier than females in the final body weight, cumulative body weight and daily body weight gains across all treatments.

Table 4: Lsmean (± SE) on the effects of the feeding system and sex on growth performance

	Feeding system				**Sex**		
Parameters	**T1**	**T2**	**T3**	**P Value**	**Male**	**Female**	**P**

							Value
Final body weight (g)	1162.63 ±18.79[a]	1039.55 ±17.20[b]	962.82 ±13.50[c]	<.0001	1146.95 ±16.05[a]	963.05 ±11.33[b]	<.0001
Cumulative body weight gain (g)	938.79 ±18.79[a]	815.70 ±17.20[b]	738.98 ±13.50[c]	<.0001	923.10 ±16.05[a]	739.21 ±11.33[b]	<.0001
Daily body weight gain (g/h/d)	4.79 ± 0.10[a]	4.16 ± 0.09[b]	3.77 ± 0.07[c]	<.0001	4.71 ± 0.08[a]	3.77 ±0.06[b]	<.0001

[abc]*Means with different superscripts in a row are significantly different (P<0.05)*

As the age increased, there was also an increase in body weight gain between treatments. At the 20th week of age, final body weight and daily gain were significant (P<0.05) higher in T1 followed by T2 and T3 (Figure 1).

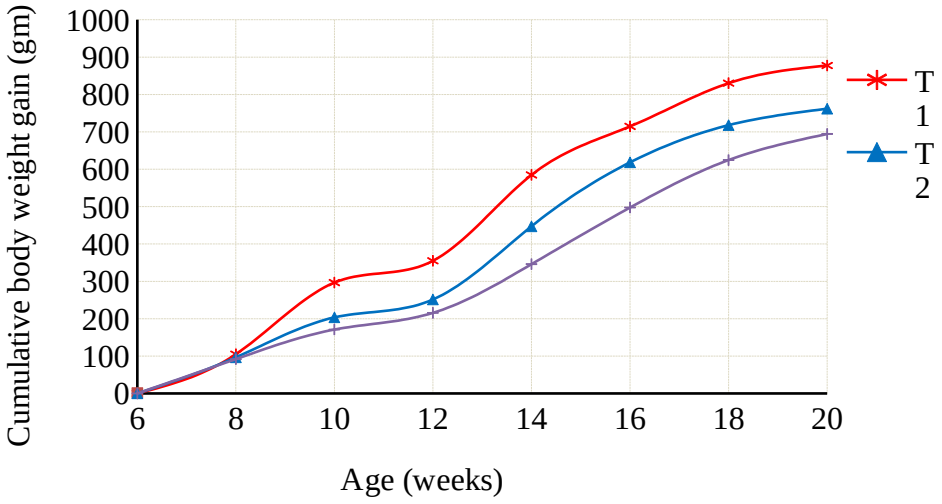

Figure 1: Effect feeding system on body weight gains of local chickens from 6th week to 20th week

There was significant interaction effect between feeding system and location on growth performance as presented in Table 5. The results show that T3 had better performance in

high altitude than T2 for cumulative body weight gains, final body weight and daily body weight. Meanwhile T2 excelled in low and medium altitude.

Table 5: Lsmean (± SE) on the interaction effects of location and feeding system on growth performance

Parameters	**Locations (altitude)**	**Treatments**			
		T1	**T2**	**T3**	
Cumulative body weight gain (g)	Low	1070.89 ± 35.08[a]	784.63 ± 29.11[b]	736.69 ± 21.05[c]	<.0001
	Medium	993.14 ± 33.95[a]	773.09 ± 25.16[b]	620.93 ± 27.14[c]	<.0001
	High	1041.56 ± 31.96[a]	707.15 ± 21.69[b]	752.33 ± 27.48[b]	<.0001
Final body weight (g)	Low	1281.50 ±37.27[a]	996.93 ± 25.16[b]	844.78 ± 27.14[c]	<.0001
	Medium	1216.99 ± 33.95[a]	996.93 ± 25.16[b]	968.21 ± 25.45[c]	<.0001
	High	1265.40 ± 31.96[a]	931.00 ± 21.69[b]	976.18 ±27.48[b]	<.0001
Daily body weight gain (g/d/h)	Low	5.31 ± 0.16[a]	3.84 ± 0.14[b]	3.61 ± 0.11[b]	<.0001
	Medium	5.07 ± 0.17[a]	3.94 ± 0.13[b]	3.17 ± 0.12[b]	<.0001
	High	5.31± 0.16[a]	3.61 ± 0.11[b]	3.84 ± 0.14[b]	<.0001

[abc]*Means with different superscript letters in a row and factor are significant different at P<0.05*

Egg production

The results for egg production are summarized in Table 6 which shows that both egg production intensity and egg number were significantly lower (P<0.05) for birds under T3 though T1 did not differ significantly (P>0.05) with T2. However, the chickens in T1 and T2 expressed significantly higher (P<0.05) egg production (%) and egg number per bird than those in T3.

Table 6: Lsmean (±SE) on the effect of feeding system and location on egg production performance over 24 weeks

Parameters	Feeding system			P Value	Location			P Value
	T1	**T2**	**T3**		**Low altitude**	**Medium altitude**	**High altitude**	
Egg Production (%)	30.75 ± 0.50[a]	30.25 ± 0.55[a]	24.16 ± 0.66[b]	<.000 1	20.08 ±0.59[a]	28.93 ±0.58[b]	36.16 ±0.55[c]	<.000 1
Egg number per bird	51.65 ± 0.84 [a]	50.83 ± 0.92[a]	40.59 ± 1.10[b]	<.000 1	33.73 ± 0.98[a]	33.73 ± 0.98[a]	60.74 ± 0.92[c]	<.000 1

[abc]*Means with different superscripts in a row are significantly different (P<0.05)*

Egg production intensity and egg numbers were not significantly (P>0.05) affected by location (Table 7). T2 outperformed T1 and T2 under high altitude for egg production percent and average egg number per bird, while in the low and medium altitude T1 was the best.

Table 7: Lsmean (± SE) on the interaction effects of the feeding system x location on egg production

Parameters	Treatments	Locations (altitude)			
		T1	**T2**	**T3**	
Egg production (%)	Low	30.21 ± 0.53[a]	29.9 ± 1.28[a]	22.7 ± 0.88[b]	<.0001
	Medium	30.90 ±0.34[a]	29.21 ± 0.90[a]	23.9 ± 1.31[b]	<.0001
	High	30.3 ±0.67[a]	31.60 ± 0.99[a]	25.9 ±0.98[b]	<.0001
Egg number per bird	Low	50.91 ± 0.72[a]	50.2 ± 0.56[a]	39.2 ± 1.34[b]	<.0001
	Medium	52.2 ± 1.21[a]	50.± 0.98[a]	40.9 ± 1.98[b]	<.0001
	High	51.1 ± 0.72[a]	52.1 ± 0.65[a]	41.3 ± 0.87[b]	<.0001

[abc]*Means with different superscript letters in a row and factor are significant different at P<0.05*

Mortality rate

The effect of the feeding system on mortality is shown in Fig. 2. The chicks in T1 experienced a significantly (P<0.05) lower mortality rate than in all other treatments for the first four weeks after their delivery to farmers. However, beginning on the 11th week, there was no significant difference (P>0.05) in mortality in all treatments. At the end of the experiment, (the 6th to 20th week of age) the cumulative mortality was significant (P<0.05) different being higher in T3, followed by T2 and lower in T1.

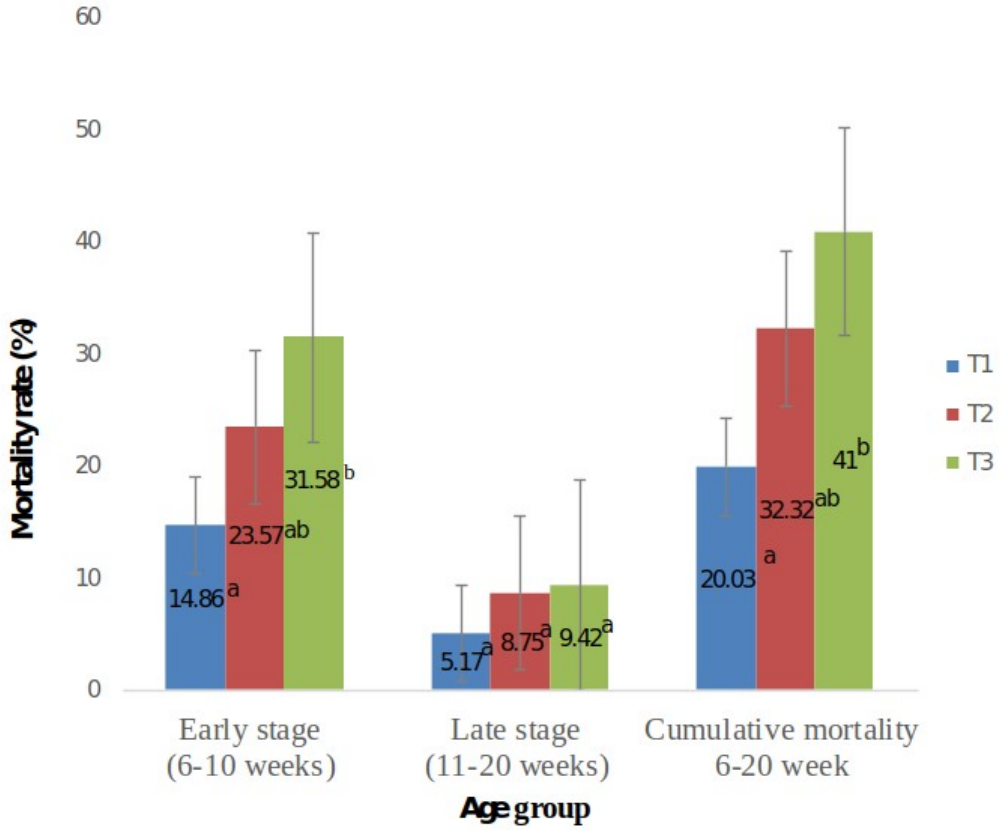

Figure 2: Effect of feeding system on mortality rate

[ab]Means with different superscripts within the age group are significantly different (P<0.05)

DISCUSSION

The results clearly show that improved feeding of local chickens improves their productivity especially if they are fed with balanced feeds. The low body weight and growth rate of chickens in T3 was attributed to the low concentration of nutrients from scavenging feed resources. According to the harvest calendar for the study area, the majority of the harvest occurred between May and July, whereas the study was conducted from December to March. At that period there were little scavenging feed resources in the

field. Thus, the chickens strive to meet their body maintenance requirements while experiencing a deficiency in other nutrients needed for growth (Mwalusanya *et al*., 2002; Rashid *et al*., 2004; Okitoi *et al*., 2006; Goromela *et al*., 2008). Growth rate, egg production intensity and survival rate were positively affected as the feeding system improved from scavenging to intensive feeding. Moreover, locations influenced differently the performance of chickens. At the low attitude, the increase in feed quantity influenced positively the growth performance.

However, at high altitude, the partial supplementation (T2) did not give a significant difference ($P>0.05$) in performance when compared to scavenging (T3). On the other hand, at high altitude, egg production performance was not significantly influenced by full-time confinement when compared to partial scavenging contrary to low and medium altitude. This was mainly due to variations in availability of scavengiable feed resources between locations, being higher at high altitude and lower at low altitude. This resulted to differences in nutrients availability in different locations as reported by Mutayoba *et al*. (2012). Therefore, T1 performance better in egg production at low and medium altitude than it did at high altitude when compared to T2. On the other hand, T2 performance better in growth at low altitude than it did at high altitude when compared to T3.

Additionally, the, confinement provided a controlled environment with less risk of diseases and predators with the ultimate of increased survival rate. The confined chickens were supplied with the recommended feed quantity and quality to meet their growth and egg production. As Gakige *et al.* (2015) recommended, the feed with CP ranging between 15-16% could influence positively the growth rate of the indigenous chickens. On the other hand, the free-range chickens were exposed to increased kinetic activity during feed

searching with an ultimate of increasing their energy requirement as they can scavenge across large areas which might affect their performance (Magala *et al.,* 2012). Therefore, apart from nutrients, the increased growth rate for the confined chickens was likely due to the reduced energy waste that ultimately was diverted to muscle-building (Okitoi *et al*., 2009; Wang *et al*., 2009).

The higher growth rate for the confined chickens supplied with compounded feeds as observed in this study concur with the findings by Okitoi *et al.* (2009) who reported the daily body weight gain of 4.48g/h/d for local chickens under confinement. However, the growth rate for the free-ranging chickens in this study was higher than the 1.40g/h/d reported by Okitoi *et al.* (2009) for scavenging local chickens in Kenya. Other researchers (Sanka and Mbaga, 2014; Magala *et al.,* 2012; Mutayoba *et al.,* 2011; Mutayoba *et al.,* 2012; Wang *et al.,* 2009) also found the same result that growth rates with confined chickens under intensive feeding were higher than those under scavenging mode of production.

Contrary to the findings in this study, the study by Chen *et al*. (2013) and Li *et al*. (2017) found no significant difference in body weight gain for medium-growing chickens raised under the free-ranging and intensive system. Chen *et al.* (2013) demonstrated that the pasture was removed from the outdoor system and hence digestibility was not much impaired. Moreover, Magala *et al.* (2012) demonstrated that the total confinement did not affect the growth when compared to the partially-confined rearing systems. The result by Santos *et al.* (2005) and Magala *et al.* (2008) cited by Magala *et al.* (2012) was also contrary to the result of this study. They argued that the body weight gain in the partially-

confined system was higher than that in the full-time confined system, due to improved bird comfort and welfare. According to Goromela *et al*. *(*2008), variations in performance could be due to the differences in scavenging feed resources accessible to chickens in the areas where the studies were conducted as the feed resources differ with locations, human activities and seasons.

The high performance in egg production observed for chickens under T1 and T2 could be explained by the effect of supplementation combined with better access to scavenging feed resources (Goromela *et al*., 2008). Egg production intensity was assessed during the wet season (April, May and June) cutting across the harvesting period and post-harvesting period (July, August and September). Thus, the birds raised in a partial-confinement system (T2) had access to the various scavenging feed resources such as grains, forages, worms and insects (Li *et al.*, 2017; Goromela *et al*., 2008) of which they complement what was fed before being released to scavenge. The egg production intensity for chickens under intensive feeding (T1) in this study was lower than the 67.3, 46.2 and 42.6% reported by Hussen *et al*. (2019) in Ethiopia, Kingori *et al.* (2014) in Kenya and Momoh *et al.* (2008) for indigenous chickens of Nigeria respectively. However, the result of this study was comparable to the value of 32% and 35% reported by Mutayoba *et al.* (2012) and Munisi *et al.* (2016) respectively for Tanzania indigenous chickens under intensive feeding system.

The results further demonstrated that better feeds combined with confinement significantly improved the survival rate of chickens. The results showed that chickens under T3 experienced a higher percentage of mortality (41%) while the chickens under T1 experienced low mortality (20.03%). Confinement reduced the vulnerability of chicks to

diseases, adverse environmental conditions (such as cold and rains) and predations. The immune system was also likely favoured with balanced feeds offered under T1 and T2 as poor feeding has always been associated with higher incidences of mortalities resulting from infectious diseases (Swai *et al*., 2007). However, all treatments experienced high mortality rates during the first four weeks after their delivery to farmers. This could have been due to stress after their transfer to farmers, thus inducing disease occurrence as reported by Swai *et al.* (2007). It is also likely that the lower experience of farmers on chicks handling could have contributed to the observed high mortality rate. Munisi *et al.*, (2015) and Hassen *et al.* (2006) contended that local chickens are more adapted to a free-range environment and confinement might create stress, which could make them susceptible to diseases hence high mortality and morbidity.

However, the mortality rate for chickens under intensive feeding (T1) in the current study was lower than the value of 54.85% and 68% reported by Regassa *et al*. (2013) and Munis *et al*. (2015) respectively under intensive management system of indigenous chickens in Ethiopia and Tanzania respectively. Higher values ranging from 52.8 - 82.4% were reported by Hassen *et al.* (2006) for different indigenous chicken lines. Diseases were the main cause of mortalities, the commonest ones being coccidiosis and fowl typhoid while, predation was at the minimum level because the chickens were mostly scavenging nearby dwellings.

Conclusions

- Compounded feeds with full-time confinement led to a higher growth rate and survival rate, but with the lower laying intensity, therefore, recommended for the

chicks and growers during the early stages (up to the 10th week) to support their higher growth and survival rate.

- Compounded feed with partial scavenging led to higher egg production, therefore, recommended for adult local chickens in rural areas if the objective is to improve egg production.

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Conflict of interest

The authors declare that they have no conflict of interest.

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CHAPTER FIVE

MANUSCRIPT II

On-farm evaluation of improved management systems on the profitability of local chickens in rural areas of Babati District, Tanzania

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On-farm evaluation of improved management systems on the profitability of local chickens in rural areas of Babati District, Tanzania

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ABSTRACT

The study was carried out to evaluate the effect of improved feeding systems on the profitability of local chickens in Babati district, Tanzania. A total of 45 farmers was purposively selected from three villages of Babati, in three different wards. A total of 1550 chickens (520 males and 1030 females at the age of six weeks) and 607 hens were used in three different feeding systems during the growth phase and in the egg production phase respectively. The feeding systems were the compounded feed with confinement (T1), compounded feed with partial scavenging (T2) and scavenging only (T3). The systems were replicated 15 times, each village having five replications and each replication being held by an individual farmer. Profit analysis shows a higher mean of 3631.86 TZS and profitability of 0.74 per chicken for birds raised on T3 in terms of market selling value of live birds. Increased in confinement intensity increased the variable costs in production and resulted in a higher cost per unit weight gain. The highest profitability of 0.74 in egg production was obtained in T2 followed by T3 while, T1 gave the lowest profitability (0.56). There was no significant difference among locations in live bird profitability. The study concludes that T1 resulted to low profitability in both meat

and egg production. T2 resulted to high profitability for egg production intended birds while, T3 expressed high profitability for meat intended birds.

Key words: Rural chickens, profitability, poultry production.

INTRODUCTION

Poultry is one of the fastest-growing sectors of the agricultural economy, particularly in developing countries. The sector plays a major role in poverty alleviation through providing off-farm income and food security and is becoming a common feature in most developing countries including Tanzania. It plays an important means for rural women and youth economic empowerment in terms of income and employment as it requires small space, low investment capital, but with quick returns and well-distributed turnover throughout the year (Guèye 2000 and Guèye 2005). Thus, the importance of poultry to the national economy cannot be overemphasized, as it is a popular industry for small-scale farmers that have a great contribution to the economy of the country.

Despite the importance of the local chickens, productivity in terms of meat and egg is low thus, affecting income. Among the hindering factors that have led to the low supply of local chickens in local markets are poor feeding and rearing management systems (Magala *et al*., 2012). Despite the availability of feed ingredients in most rural and peri-urban areas of Africa, chickens are mostly kept under the free-ranging system, relying on scavenging feed resources. Feed formulation is not a common practice to farmers due to low knowledge on feed mix and seasonal availability for most of the ingredients (Goromela *et al*., 2008; Kugonza *et al*., 2008; Lwelamira *et al*., 2008; Mutayoba *et al*., 2011 and Marwa *et al*., 2018). However, the economic value of local chicken meat and eggs is increasing as there is a higher demand for them due to their taste. Besides, their

natural management has a positive implication on consumers preference (Emuron *et al*., 2010 and Kyarisiima *et al*., 2011). Moreover, an expansion of land under crop production has resulted in competition for the land for both crops and livestock including chickens. Human population growth has also to some degree posed restrictions by the scavenging birds, especially during the cropping seasons. The prevailing situation draws attention to understand the viability of interventions to maximize the profitability of the sector. Most of interventions trials have been done mostly on-station, which does not simulate the real village/rural situation. Thus, this study aimed at establishing if confinement and supplementation levels can give a good margin of profit compared to scavenging only.

Methodology

Study area

This study was carried out in Babati district, Tanzania, being located below the Equator between Latitude 3° and 4° South and Longitude 35° and 36° East. The study involved three villages of Matufa, Seloto and Galapo within Matufa, Dareda and Galapo wards respectively. The villages are located in high, medium and low altitudes, Seloto being at high altitude, followed by Galapo and Matufa at the low altitude with an elevation 1803, 1394 and 1004 meters above sea level respectively. The farmers practice mixed farming, growing a variety of crops including maize, sorghum, paddy, lablab, soybean, pigeon pea, sesame, sunflower and varieties of vegetables.

Treatments

The economic variability of three management packages was assessed. The packages were as described below.

Treatment 1 (T1), in which the chickens were full-time confined, fed with compounded feeds. The group feeding was done with an average of 120g per bird per day. In treatment 2 (T2), the chickens were partial confined during day time from 0630 to 1230 hours, being supplied with an average of 60g of compounded feed per bird as a supplementary feed. The feed contained 16% CP and 2753 kcal/kg. For treatment 3(T3), the chickens relied on available scavenging feed resources around the homesteads.

Experimental design and treatment allocations

A stratified purposive sampling experimental design was employed in selecting farmers. Farmers were stratified basing on their adoption in chicken management systems (free-ranging, semi-scavenging or full-time confinement). Sampling was then done within the strata. Moreover, the willingness of farmers to adhere to research requirements was considered for the farmers to be selected. Amongst the requirements were building a simple chicken house for experimental chickens, readiness to dispose of the pre-existing chickens before receiving the experimental chickens and their readiness to participate in the training sessions and data collection. Forty-five farmers (fifteen from each village) were purposively selected. Each farmer was treated as a replicate, hosting one treatment. The treatments were replicated 15 times, each village having five replications. A total of 1550 chickens (an average of 34 chickens per farmer) were used in assessing profitability during the growth period while 607 (an average of 13 hens per farmer) were used in egg production assessment. The market price for the ingredients used in formulating T1 and T2 are presented in Table 1.

Table 1: Experimental feeds, their sources and prices

Ingredients	Source	Price per kg Tsh
Maize	Farmers	400
Maize bran	Open market and farmers	200
Sunflower seed cake	Open market and farmers	1000
Fish meal	Open market	700
Blood meal	Abattoir (locally processed)	500
Limestone	Open market	500
Bone meal	Abattoir (locally processed)	700
Table salt	Open market	800

Source: Field survey data 2017

Management of experimental birds

A total of 1550 brooded chicks were distributed to farmers at the age of six weeks after being vaccinated against Newcastle disease, Infectious bursal disease (Gumboro) and fowlpox at the recommended time. All the chickens were supplied with water and at least a simple shelter at night. The birds were randomly allocated to the three treatments (T1, T2 and T3).

Data collection

Data on variable costs during the growing phase were collected at intervals of two weeks commencing from the delivery date of chicks to farmers (six weeks of age) up to the age of 20 weeks. The variable costs during the early laying phase (22 to 46 weeks of age) were also collected. The monetary value for feed offered, treatment and labour were quantified and used in calculating the total variable costs. The market value for bodyweight gained and eggs produced were used in calculating the revenue, from which the profitability was analysed.

Gross Margin Analysis

The gross margin as one of the profitability indicators (Oladeebo *et al*., 2007) was calculated using the variable costs during the growth and in egg production phases with the assumption that all the birds were sold at the 20th week and all the eggs produced were sold. The gross margin analysis was done according to Ayieko *et al*., (2014) as follows;

Gross Margin (GM) = Total revenue (TR) ─ Total variable costs (TVC)

Where:

i. Total variable costs (TVC). This was calculated as the sum of all running costs involved in the production of local chickens and eggs for sale.

ii. Total revenue (TR). This was calculated as the sum monetary value for mature chickens at the 20th week of age and eggs produced for 24 weeks.

In calculating the TVC, the following were taken into account:

iii. Labour cost was calculated basing on time used in chicken management assuming the local man-day charges.

iv. Feed cost for formulated feeds was calculated basing on the market price of the ingredients used in feed formulation

v. Feed costs for scavenging chickens were quantified basing on the type and quantity of local feeds occasionally supplemented by individual farmers, from which, its cost was estimated.

vi. Treatment and medication cost were quantified basing on the market price of the purchased medicine/vaccine.

Profitability

The profitability index or return on the scale was calculated according to Aboki *et al*., (2013) and Siyaya and Masuku (2013a) as a ratio of profit to total variable cost.

Profitability = Profit/Input

Thus:

Profitability of variable costs = (Total revenue -Total variable cost)/Total variable cost

Statistical analysis

Microsoft Office Excel software package was used for data entry. Analysis-of-variance (ANOVA) procedures of the General Linear Models of Statistical Analysis Systems (SAS 2000) were used to evaluate the effect of feeding systems on total revenue, total variable costs, gross margin and profitability ratio. The test of the difference of means was performed using the Least Significant Difference (LSD).

The following model was employed during data analysis.

$Y_{ij} = \mu + F_i + L_j + (FL)_{ij} + e_{ijk}$

Y_{ijkl} = Record of k^{th} flock of birds from i^{th} feeding system and j^{th} location/village

μ = Overall mean

F_i= Effect of the i^{th} feeding system

L_j = Effect of j^{th} location/village

FL_{ij} = Interaction effect feeding system and location/village

e_{ijk} = Random error

RESULTS

Revenue

The results of this study show that at the 20th week of age, T3 resulted in significantly (P<0.05) higher gross margin, followed by T2 and the least was T1 (Table 2). On the contrary, the profitability in egg production was higher in T2 with the higher (P<0.05).

Table 2: Lsmean (± SE) on the effect of feeding systems on cost and gross margin for the first 20 weeks of growth and 24 weeks of egg production

Feeding system	Gross Margin (Tsh) per live bird	Gross margin (Tsh) per dozen eggs
T1	1770.58 ± 18.35[c]	705.47 ± 87.92[c]
T2	2646.52 ± 18.85[b]	1621.33 ±96.88[a]
T3	3631.86 ± 12.87[a]	818.97 ± 115.60[b]
P-value	<.0001	<.0001

[abc]*Means with different superscripts in a column are significantly different (p<0.05)*

Profitability ratio

The results on profitability ratio as summarized in Table 3 show that T3 was significantly (P<0.05) higher in economic efficiency in meat production.

Table 3: Lsmean (± SE) for the effect of feeding system on profitability ratio for live bird and eggs

Feeding system	Live bird profitability at 20th week of growth	Egg profitability over 24 weeks of production
T1	0.25± .01[c]	0.28±0.02[b]
T2	0.55± 0.01[b]	0.50±0.02[a]
T3	0.74± 0.01[a]	0.25± 0.0.3[b]
P Value	<.0001	<.0001

[abc]*Means with different superscripts in a column are significantly different (p<0.05)*

Likewise, high altitude demonstrated significantly (P<0.05) higher in economic efficiency. The profitability ratio on body weight gain for T3 was as twice as much when compared to T2. However, the chickens in T1 expressed significantly (P<0.05) lower economic efficiency in egg production when compared to chickens in T2 and T3.

DISCUSSION

An increase in both improved feeds and confinement of local chickens influenced positively the cost per dozen eggs produced. Free-ranging with supplementation of compounded feeds (T2) gave a significantly higher gross margin in egg production at a fixed time compared to the full-time confined chickens fed with compounded feeds (T1) and the free-ranging chickens relying on scavenging feeds only (T3). The higher gross margin in eggs was obtained for the chickens in T2 and can be explained by the fact that birds in this treatment were partially supplemented and assumed to get the rest of the nutrients from scavengiable feed resources.. The chickens under T1 gave a lower gross margin than those in T2 and T3 despite the highest level of feed quality and quantity offered. Among the reasons is the production limit of the local chickens as they cannot give economic returns beyond their genetic potential (Rodríguez *et al*., 2011 and Udo *et al*., 2006). However, if the minimum nutrient requirement for egg production is not met it results in a decline in production, which leads to a less gross margin as it was found in chickens under T3. The low egg production performance for chickens under T3 indicates that scavengiable feed resources were limited in terms of quantity and quality consequently affecting productivity (Goromela *et al*., 2008 and Mutayoba *et al*., 2011).

Assuming that all birds were sold, T3 generated a positive mean of 3631.86 TZS per bird with profitability of 0.74. This means that for every 1.00 TZS spent there is a 0.74 TZS return earned by the farmers, which indicates that scavenging despite constraints associated with the system could be as well be profitable. Moreover,high mortality particular at young age as was observed in T3. Therefore, taking into account mortalities, T1 is recommended to be used at an early stage of chickens (up to 10 weeks of age. It is further observed that when the confinement intensity increased, the feed costs increased as well. An increase in confinement intensity implies that feed has to be supplied either complete or partial, which is reflected in additional cost per unit gain. The obtained profitability of 0.25 for T1 implies that local chickens do not give promising economic returns when subjected to higher feed costs due to their low genetic potential. Similar observations were reported by Siyaya and Masuku (2013a) and Munisi *et al*., (2015). However, the chickens under T2 gave significantly higher profitability in producing a dozen eggs than the rest of the treatments. The chickens under T3 produced the same dozen eggs in more days (more than twice as much) than the days used in T2, thus inflating their production costs as the extra time is related to other variable costs. The time to produce a dozen eggs was in the ratio of 1:2:1 for T1, T2 and T3 respectively implying that by supplementing chickens with compounded feeds, the time to produce the same number of eggs is reduced by 50%.

CONCLUSIONS

- Return on investment of 0.74 in T3 and 0.50 in T2 for selling live chickens and their eggs respectively, implies that raising local chickens is profitable if supplementation of compounded feeds is done.

- Full-time confinement of chickens, fed with compounded feeds led to the lowest gross margin per bird, while partial confinement, supplemented with compounded feeds gave the highest gross margin in egg production implying that full confinement is suitable for chicks and growers while partial confinement can be recommended for laying chickens.

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Conflict of interest

The authors declare that they have no conflict of interest.

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CHAPTER SIX

6.0 GENERAL DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

6.1 General Discussion

The present study focused on improving the feeding system for local chickens under the traditional scavenging system of rural areas in the Babati district. The study aimed at characterizing the existing poultry production systems and thereafter determining the production and economic effectiveness of different feeding interventions under the rural conditions.

The study indicated that the feeding systems available to local chickens in the Babati district can be distinguished into three types: Scavenging, semi-scavenging and intensive feeding being dominated by the scavenging system whereas farmers mainly relied on one or two ingredients as a source of supplementary feeds. Lack of technical know-how of feed formulations, the seasonal availability of local feed ingredients and the higher cost of commercial feeds are among the factors limiting farmers to incorporate the balanced feeds within the system. This ultimately reduced the productivity of local chickens in terms of growth rate, survival rate and egg production as the nutrient concentrations of scavenging feed resources are below the recommended levels for optimum production. It was also noted that men were reluctant to invest in local chicken production as they put less value on them compared to large ruminant animals such as cattle and goats. This phenomenon does not encourage investment as a result chickens are exposed to common diseases which in-turn reduces the survival rate ultimately increasing the economic loss to farmers. The study also revealed that amongst other factors, the small number of chickens per household hinders the motivation of farmers to invest in feed formulation and

permanent chicken shelter construction. However, it was revealed that improved feeding management in local chickens improves their growth performance, survival rate and egg production. The observed poor growth of birds under T3 was an indicator of low nutrient availability from the scavenge feeds. There was also less risk of diseases and predation when birds are fully confined. The feeding intervention then improved the survival rate from 60.9% (pre-surveyed information of this study) to 80.0% after the feeding and applying basic managerial interventions, especially water provision, vaccination and disease treatments.

Egg production intensity was assessed during the wet season (April, May and June) cutting across the harvesting period and post-harvesting period (July, August and September). This period is characterized by plenty of scavenging feed resources in particular grains that supply energy while the protein in terms of amino acid profile could be limiting which eventually affects egg production. Egg production under T1 was still modest, and obviously, even at higher feeding, birds will be limited by their genetic potential. Both growth and egg production were affected not only by the feeding system, but differed with altitudes whereas, T1 performance better in egg production at low and medium altitudes than it did at high altitude when compared to T2. On the other hand, T2 performed better in growth at low altitude than it did at high altitude when compared to T3. This is an indication that there were some differences in nutrient availability being contributed by differences in natural vegetation and the crops grown. Thus, scavenging birds (T3) or those under partial supplementation (T2) took advantage of available scavengable nutrients which explain the difference in pattern observed between growth phase and egg production phase which can only be explained by seasonality in feed availability. Economic-wise, the chickens under T3 gave a significantly higher gross

margin at the 20th week of age when compared to other treatments when chickens' meat was the main target in production. T3 expressed three times higher returns for meat production when compared to T1. The higher gross margin was attained at a significantly lower cost per unit body weight gain compared to the rest of the treatments. This is because the chickens in T3 were mostly relying on free scavenging feed resources. Thus, the higher gross margin for selling live birds expressed in T3 reflected that scavenging feed resources have a great contribution to local chicken profitability when meat production is the target. Moreover, the higher gross margin for scavenging chicken come at the expense of low growth and egg production rate. However, semi-scavenging (T2) or total confinement (T1) increased feed cost resulting in a higher cost per unit body weight gain. Thus, the profitability of 0.25 for the chickens under T1 implies that local chickens may not give promising economic returns when subjected to higher feed costs due to their low genetic potential for growth or egg production. On the other hand, the chickens in T1 gave the low gross margin and profitability ratio in egg production, despite the intensive feeding offered. The lower net gain income in T1 was mainly due to the high feed cost imposed and partly contributed by the genetic potential limit of the local chickens, particularly, low growth rate and low egg production potential as compared to the improves strains of chickens.

The study informs that each of the evaluated feeding system have its advantage in supporting the local chicken sector despite their limitations (nutrient density, amount and cost). This suggests the need for the integrated feeding systems along the production period of chickens for improving performance of rural chickens. The results further inform that the input-output ratio should be taken into account when improving the productivity of local chickens so that farmers can generate the possible highest net

economic benefits. Thus, this study suggests that innovation adoption such as regular watering, vaccination, medication and supplementary feeding should be taken into account to improve the productivity and economic efficiency of local chickens under free ranging. Moreover, the integrated feeding systems should be adopted and adjusted according to the chicken age group rather than intensifying to full confinement.

6.2 Conclusions

The following conclusions can be drawn from the study:

i. Majority of the households in the study areas practiced the extensive production system relying on one or two ingredients for supplementation, with poor housing and poor disease control measures.

ii. Women and children play a major role in the management of chickens. This gender responsibility implies that in supporting and delivering of local chicken technologies, more emphasis should be directed to women and youth for sustainable improvement of the sub-sector.

iii. Confinement of chickens fed with compounded feed led to a higher growth rate and survival rates, but with lower gross margin and profitability. Therefore, this strategy is recommended for the chicks and growers (up to the 10^{th} week) to support their higher growth and survival.

iv. Partial scavenging supplemented with compounded feed led to higher egg production and the corresponding higher gross margin and profitability, therefore, recommended for adult local chickens in rural areas if targeting egg production.

v. Return on investment of 0.74 and 0.50 for selling live chickens and their eggs respectively, implies that local chickens are highly profitable if innovation

adoptions such as regular watering, vaccination, medication and improved feeding are taken into account.

vi. A combination of confinement of chickens fed with compounded feed (up to the 10th week) followed by partial scavenging supplemented with compounded feed or scavenging only for local chickens intended in eggs or meat (live bird) respectively led to a viable economic return.

6.3 Recommendations

These recommendations are based on the major findings of this study as a way forward in intervention dissemination.

i. There is a need to educate farmers on proper utilization of available feed ingredients for productivity improvement of chickens raised under extensive system of production. This should go along with improved housing and disease control measures.

ii. Confining chicks in a house, supplied with nutritionally balanced feeds up to the age of 10th week should be promoted to farmers, as it reduces the mortality rate caused by malnutrition due to competition pressure with the adult chickens for feeds, bad weather conditions, predations and diseases.

iii. There is a need for further studies on how to improve the genetics of local chicken strains to take advantage of the suggested improved innovations.

6.4 Contribution of the Study

This study revealed that confining chickens while fed with well-balanced feeds is only economically viable when different age groups of chickens are treated differently. The young chickens should be either fully or partial confined while, growers and laying birds

should be left to scavenge with adequate feed supplementations so as to optimize the profitability of this sub-sector in rural areas.

APPENDICES

Appendix 1: ***Guidelines on discussion with key livestock officers in Babati District council***

Core issues	Required information	Results of discussions
Status of indigenous chicken sector	production trends in the last five years	
	estimated value of the indigenous chicken sector based on current annual report	
	production per household	
Services from the Department	Extension support – nature	
	Market development – status	
	Cockerel exchange and other related services from the department	
	Role of the department in poultry sector development	
Support to chicken sector	As per different actors known to the office	
Constraints To chicken sector	Including chicken management, feeding, breeding, breed selection, trade issues, etc	
Opportunities for intervention in to enhance productivity in chicken sector ;	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 2: The Semi-structured questionnaire for poultry farmers' PRA Assessing the current status of indigenous chickens production systems in Babati district

Name of site/village:..... Name of ward..... Number of households in survey area (*to be considered a household, the dwelling must have a kitchen*):.....GPS co-ordinate of PRA location:..... Number of participants present: males..... females..... Date.....July 2014 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 indigenous poultry 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 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			**March**	**April**		**June**			**September**			
Rainfall pattern (score 0-5)												

1.3 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			**March**	**Anril**	**Mav**							
1.												
2.												
3.												

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

Name of crop		**February**	**March**	**Anril**								
1.												
2.												
3.												
4												
5												
6												
7												

2.0 Significance of livestock, gender roles, and priority

Objective: Understand how and who benefit from livestock species

Livestock species	**Use**	**% of HH that own the species.**	**Average number of animals per HH**	**Order of importance**	**Gender role**
1					
2					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					

2.1 What livestock are raised within the area? What are the animals mainly used for (eg. production of milk for sale, production of milk for household consumption, production of eggs for home consumption, production of eggs for sale, meat production, draught, manure production etc.) What percentage (%) of households in the area own 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).

3.0 Indigenous chicken management practices

Objective: *Understand how indigenous chickens are managed within the area*

4.0 What are the Motivating factors for raising indigenous chickens?

5.0 What are the Indigenous chicken production/management systems: types, seasonal variability?

Name of production system			**March**	**Anril**		**June**					
1.											
2.											
3.											
4											

6.0 What are the Indigenous chicken production/management systems preference, factors influencing farmers to adopt certain production system, and proportion of farmers practicing the preferred system (Tick the appropriate system in each month).

Name of production system			**March**									
1.												
2.												
3.												
4												
reason for preference												
Farmers' proportion												

7.0 Are the poultry provided with houses? What types of poultry houses? (if used), What characteristic of each type, preference? What is the proportion of farmers using poultry houses? What are the reasons for using poultry houses? What is the reason for not using?

Types of poultry houses commonly used-

Proportion of farmers using poultry houses-

Characteristic of each type, preference-

Reasons for using poultry houses-

Reason for not using poultry houses-

8.0 Are the poultry provided with feed supplements? What types of poultry feed supplements and their proportions? (if used), What proportion of farmers using poultry feed supplements? What are the reasons for using poultry feed supplements? What is the reason for not using feed supplements? If feed rationing is common, how is it done?

types of poultry feed supplements and their proportions of the total supplementation (These includes Concentrate feeds (commercial), Waste grains, Forage based supplements, Insects, Kitchen waste Etc.

Supplement feed	Its proportion	Supplement feed	Its proportion	Supplement feed	Its proportion
1		4		7	
2		5		8	
3		6		9	

Proportion of farmers using poultry feed supplements-

Reasons for using poultry feed supplements -

Reason for not using

Style of feeding (scavenging only, scavenging with supplementation, intensive only) –

Feed processing (grinding, mixing etc.)

Feed rationing-

9.0 What strains /breeds of chicken are commonly found in your area? Is your area equipped with any breeding knowledge? (whether IT or formal knowledge). What techniques are used to enhance breeding of better chicken in your area?

Chicken stains/breeds commonly available- Breeding techniques-

10.0 What poultry diseases and parasites are commonly affecting poultry in your area? In which season do they occur? (if seasonal). What class of chicken are affected? What mitigation mechanism do you adopt for the diseases?

Poultry diseases	Their seasons (months)	Class of chickens affected	Mitigation mechanism

11.0 What veterinary (or animal health) services are available to farmers (including price of treatments and accessibility)?

12.0 Market and marketing

Objective: *Obtain a general picture of the marketing status of the indigenous chicken and feed ingredients*

12.1 Are the birds/eggs/manure sold? Is there a formal market for indigenous chickens and eggs? What is the average price per hen/cock and egg? What are the criteria for pricing of both birds and eggs? What are the common criteria for birds for sale? Problems facing marketing and their solutions.

Market for chickens-
Market for eggs-
Distance to the market-
Pricing criteria-
criteria for birds for sale
Problems facing marketing and their solutions

12.2 How does the chicken price and their product fluctuate within a year?

Month									**September**	**October**	**November**	**December**
Price for hen												
Price for cock												
Price for												

growers												
Eggs												

12.3 What are the prices of various feed ingredients over a year (fill the average price and unit of measurement in each month)

Feed ingredients		**February**	**March**	**April**								
1.												
2.												
3.												
4												
5												
6												
7												
8												
9												
10												

Labour distribution analysis

Objective: To understand who does each activity. This can be a proportional assessment of involvement intensity on each task (allocating 10 beans by gender).

0= non-involvement in the activity

1-3= Lower level of involvement in the activity

4-6 = Medium level of involvement in the activity

7-10= Higher level of involvement in the activity

Thank the participants for their time

Appendix 3: Baseline questionnaire for individual poultry keepers

Assessment of the current status of poultry production systems in Babati district

General information

i. Date of Interview……ii.

ii. Enumerators name…….

iii. Village…….

iv. Ward……

B. Household characteristic

v. Name of respondent……vi. Sex; [1 = male 2 = female]

iv. Age of respondent……

v. Level of education [1=informal education 2=Adult education 3 = primary 4=Secondary

vi. What is your main economic activities (In chronological order)

1……. 2.……..…….

3.……4……. 5.

…… 6……

viii. Among the family, who is a decision maker for poultry issues?

1=Woman 2=man 3=children 4=man and woman

Commencement and trend of indigenous chicken production

When did you start rearing chickens?

1=Within 5 years 2=within 10 years 3=over 10 years

a. How many birds do you have?.....

b. And how many of them are (a) adult …… (b) chicks ….....

What strain of chicken do you keep now

1=indigenous chicken 2=crossbred 3=exotic

If crossbred, where did you get them?

1=Introduced by researchers 2=Introduced by extension officers

3=Introduced by NGOs 4=Bought from hatcheries 5=From neighbours

Which is the main source of your chicks?

1=Natural hatching 2=Purchasing from neighbors 3=Purchasing from hatcheries

Local chicken production and management practices.

Which system of management do you practice over different seasons of the year?

Period of the year	**Chicken production system (Tick)**		
	1=Total confinement	2=Semi confinement	3=Extensive
Planting season			
Growing season			
Harvesting season			
Off season (dry period)			

.(a) If extensive, do you have a shelter for your birds? 1=Yes 2=No [ ]

(b). If no, where do the birds rest at night?

1=Kitchen 2=share house with the owner =Roost over trees

a. If extensive, do you give any feed supplement to your birds? Yes ( ) No ( )

b. If yes, how often?

1=Daily 2=Once a week 3=Two or more days per week 4=occasionally

c. If yes in (a) above, what feed supplements do you offer

1=Chicken left over 2=commercial formulated feeds 3=Home made formulated 4=feeds grains 5=Any others [specify……]

d. Which category of your chicken do normally get the feed supplement

1=chicks 2=growers 3=adult birds 4=All

a How much of feed supplement do you supply at a time? [1=ad libitum 2=a hand full]

b. At what time do you normally supplement your chickens

1= Morning 2= Afternoon 3=Evening 4= Any time

c. Why do you prefer the time in (b) above……

a. Do you vaccinate your birds? 1=Yes 2=No

b. If yes, what kind of disease do you vaccinate against?

1=New castle [ ], 2=Gumbolo [ ] 3=Fowl pox [ ]

Do you search for veterinary officer when your chickens fall sick? Yes ( ) No ( ).

Do you buy any veterinary drugs for the birds when they are sick? Yes ( ) No ( )

If No, how do you treat your birds when they are sick?

1=Not treated at all 2=use of indigenous herbs

13. What is the average number of eggs per clutch of your hens?.....

14. What is the average number of clutch of your hens per year?.....

15. What percentage of eggs set for hatching is normally hatched?

Number of egg set for hatching……. eggs normally hatched…….....

. What percentage of chicks hatched normally survives to adulthood?

Number of chicks hatched……..... Number of chicks survive to adulthood…….

What is the average mortality of your chicken per year? (Refer the year 2014)

Total chickens (2014) ……Total died chickens (2014) ……..

a).Which category of chickens have high mortality rate? [1=Cocks 2=hens 3=chicks]

b).Which month(s) have high mortality?.....

Aside diseases, what are the other causes of mortalities

……..

. On the average, how many birds do you sell per year? .....

How much do you sell per bird (a) one hen? Tsh..... (b) one cock Tsh……

To whom do you sell your chickens

1=Rural consumers 2= local market consumers 3= small local traders (retailer)

4=traders from towns 5=any other [specify]……..

Do you sell some of the layed eggs? Yes [ ] No [ ]

If yes, how many per month?.....

To whom do you sell your eggs?

1=Rural consumers 2= local market consumers 3= small local traders (retailer)

4=traders from towns 5=any other (specify)……..How many birds do you consume per year…….

What are some of the problems that hinder you from getting the maximum benefit (in descending order)? ……

……

Thank the participant for his/her time

Appendix 4: Bodyweight measurement of experimental chickens using a Silvano kitchen scale

Silvano kitchen scale

Appendix 5: Experimental chickens in the modified poultry shelter

Seloto village

Matufa village

Appendix 6: Processing and compounding the locally available feed ingredients at Seloto village

Appendix 7: ANOVA Table for final body weight and total body weight gain at 20th week of age

Source of variation	DF	SS	MS	F value	Pr>F
Village	2	584884.73	292442.36	4.25	0.0145*
Feeding system	2	5365520.05	2682760.03	39.00	<.0001*
Sex of chicken	1	6220660.44	6220660.44	90.42	<.0001*
Village*system interaction	4	10961908.17	2740477.04	39.83	<.0001*

* Statistically significant (P < 0.05)

DF - Degree of freedom, SS – Sum of squares, MS – Mean square

Appendix 8: ANOVA for average egg production intensity per day for the first 24 weeks of production

Source of variation	DF	Type III SS	MS	F value	Pr>F
Village	2	44287.9667	22143.9833	200.39	<.0001*
Feeding system	2	7952.8760	3976.4380	35.98	<.0001*
Village*system interaction	4	119528.1985	29882.0496	270.42	<.0001*

* Statistically significant (P < 0.05)

DF - Degree of freedom, SS – Sum of squares, MS – Mean square

Appendix 9: ANOVA for total egg production per hen for the first 24 weeks of production

Source of variation	DF	Type III SS	MS	F value	Pr>F
Village	2	125011.34	62505.67	200.40	<.0001*
Feeding system	2	22451.87	11225.93	35.99	<.0001*
Village*system interaction	4	337346.36	84336.59	270.40	<.0001*

* Statistically significant (P < 0.05)

DF - Degree of freedom, SS – Sum of squares, MS – Mean square

Appendix 10: ANOVA for average gross margin per dozen eggs for the first 24 weeks of production

Source of variation	DF	Type III SS	MS	F value	Pr>F
Village	2	105594813.5	52797406.7	15.35	<.0001*
Feeding system	2	186169840.9	93084920.4	27.06	<.0001*
Village*system interaction	4	608299937.3	152074984.3	44.21	<.0001*

* Statistically significant (P < 0.05)

DF - Degree of freedom, SS – Sum of squares, MS – Mean square

Appendix 11: ANOVA for profitability ration in egg production for the first 24 weeks of production

Source of variation	DF	Type II SS	MS	F value	Pr>F
Village	2	7.68	3.84	18.50	<.0001*
Feeding system	2	12.99	6.49	31.28	<.0001*
Village*system interaction	4	14.84	3.71	17.87	<.0001*

* Statistically significant (P < 0.05)

DF - Degree of freedom, SS – Sum of squares, MS – Mean squar