MANURE MANAGEMENT AND UTILIZATION PRACTICES FOR ENHANCING SMALLHOLDER DAIRY FARMING PRODUCTIVITY IN LUSHOTO AND KOROGWE DISTRICTS, TANZANIA

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A Thesis Submitted in Fulfillment of the Requirements for the Degree of Master's in Life Sciences of the Nelson Mandela African Institution of Science and Technology

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ABSTRACT

The use of cattle manure in agricultural fields improves soil quality and contributes to nutrient recycling when applied back to the soil compared with synthetic fertilizers that are associated with high cost and limited access. The Community Action Research Project was conducted at Lushoto and Korogwe Districts, exploring the practices associated with manure management and utilization in selected seven villages. Two hundred farmers were interviewed, 120 samples of manure collected and 112 soil samples taken from farm applied with (66) and farm not applied with manure (66). The soils analysis of Nitrogen (N), Phosphorus (P), Potassium (K), Organic Carbon (OC), Organic Matter (OM), soil pH, Cation Exchange Capacity (CEC) and Electro Conductivity (EC) were done. Analytical results show that in the farms applied with manure the average of NPK values were 0.21%, 0.23% and 1.63% respectively while those not applied with manure had average NPK of 0.12%, 0.11% and 0.61% respectively. Other parameters in farms applied with manure were pH 6.95, EC 0.12 dS/m, CEC 24.26 Meq $100g^{-1}$ of soil, SOC 2.43 % and SOM 4.19%. The average chemical properties of pit compost manure were 1.78%N, 1.58%P, and 1.28% K while the surface stored manure had 2.51%N, 1.78%P and 1.23%K. Farms applied with manure showed a relative increase in nutrients and the surface stored manure had increased nutrient content compared to pit composite. The study observed poor manure handling practices. This shows the need for training these farmers on proper manure management. Studies on understanding the effects of inherent manure microbial composition and environmental factors such as temperature and moisture on manure quality under the different storage practices are recommended.

AUTHOR'S DECLARATION

I, **Patrick Simburya Rukiko** do hereby declare to the Senate of Nelson Mandela African Institution of Science and Technology that this thesis is my own original work and that it has neither been submitted nor being concurrently submitted for degree award in any other institution.

Rukiko ____________________ 13/03/2019 ____________________

Mr. Patrick S. Rukiko **Date**

Name and signature of candidate

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CERTIFICATION

The undersigned certify that they have read the thesis titled **"Manure Management and Utilization Practices for Enhancing Smallholder Dairy Farming Productivity in Lushoto and Korogwe Districts, Tanzania"** and recommended for examination in fulfillment of the requirements for the degree of Master's of Life Science (Sustainable Agriculture) of the Nelson Mandela African Institution of Science and Technology

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DEDICATION

Special dedication to my beloved wife Happy Joseph Mallya, my children; Henry Patrick, Dorcas Patrick and Daniel Patrick as well as my mother, Florence Simburya for being calm throughout my entire study period. Their inspiration and the encouragement from them were highly appreciated.

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LIST OF ABBREVIATIONS AND SYMBOLS

%	Percentage
ANOVA	Analysis of Variance
AP	Available Phosphorus
asl	Above Sea Level
CARP	Community Action Research Project
CEC	Cation Exchange Capacity
EC	Electrical Conductivity
EDTA	Ethylene Diamine Tetraacetic Acid
FAM	Farm applied with Manure
FGD	Focus Group Discussion
FNAM	Farm not applied with manure
K	Potassium
LSD	Least Significant Difference
NBS	National Bureau of Statistics
NM-AIST	Nelson Mandela African Institution of Science and Technology
PC	Pit Compost
SOC	Soil Organic Carbon
SOM	Soil Organic Matter
SS	Surface Storage
TN	Total Nitrogen

CHAPTER ONE

INTRODUCTION

1.1 Background

Cattle manure is an important source of soil nutrients for many smallholder farms in East Africa who cannot afford or use only limited amounts of chemical fertilizer (Snijders *et al.,* 2009). It is an organic vital resource that can supply plant nutrients and replenish organic matter content of most agricultural soils, particularly in the tropics (Reddy *et al.*, 2000). The use of manure in agricultural fields can improve soil quality depending on good manure management and the inherent chemical properties of the soil. This reduces the use of synthetic fertilizers that are associated with high cost, limited access and technical capabilities on their use (Carmo *et al.*, 2016). Poor soil fertility has been pointed as the fundamental biophysical cause of declining per capita food production on smallholder farms in Africa (Sanchez, 2002). Low or no agricultural residues are returned to the soil (Baitilwake *et al.*, 2011) and as a result soil nutrient mining becomes a major cause of decreasing crop yields and per capita food production (Henao and Baanante, 2006).

Animal manure is an important factor in maintaining land productivity and contribution to household income and food security (Lekasi *et al.,* 2001). Manure accounts for about 14% of Nitrogen, 25% Phosphorus and 40% of Potassium (Herrero *et al.*, 2009) inputs into the soils. In Tanzania, the amount of nitrogen and phosphorus removed from the soil every year by the main crops was estimated to be 251 448 tons N and 115 112 tons P by the year 2000 and only 21% N and 14%P removed was projected to be replaced through fertilizer application (Kaihura *et al.,* 2001). When animal manure is applied to the soil, it adds nutrients and assists in preventing further deterioration of the land resources (Liu *et al.,* 2008). Maerere *et al.* (2001) reported that efficient use of animal manure could alleviate the problem of declining land productivity in most parts of Tanzania. Besides it's important for nutrient cycling in agricultural systems as manure, can be used for producing energy and reducing climate emissions from unsafe energy sources (Teenstra *et al.*, 2014). This contributes to providing affordable energy for many smallholders.

Smallholder farmers are the primary producers of agriculture products who are characterized as a smallholder business, with farm sizes ranging in size from 0.9 to 3 hectares, dedicated to subsistence with limited marketable surpluses (Kiratu *et al.*, 2011). It has been reported that about half of the population in Lushoto are living below the poverty line while farming is the primary source of food and income and there is low agricultural productivity (Mahoo *et al.*, 2015). The low agricultural productivity might be due to low soil fertility status in most parts of the Western Usambara Mountains that makes it difficult to sustain agricultural production (Ndakidemi 2015). This is also attributed to the low income levels of the majority smallholder famers who cannot afford to purchase expensive agricultural inputs (Ndakidemi, 2015) and most of them raise cows for milk production that ensures the presence of manure. The present study was designed with the overall objective of exploring the status of manure management and utilization practices that contribute to the effects of soil chemical properties on farmers' fields.

1.2 Problem statement and justification

Animal manure is a relatively plenty resource to many smallholder dairy farmers especially in Lushoto and Korogwe districts where this study was done. Despite manure being an important resource for improving soil fertility it is still given less emphasis by smallholder farmers and other key stakeholders. Limited knowledge and technical know-how to properly manage and utilize this resource for crop production has been reported in several places including the study area. Manure handling practices (bedding materials, collection, storage and application) were poorly observed and under-utilized (sites scooping visit). There is no scientific information that has been conducted to explore the details on the challenges and constraints facing smallholder farmers on the management and utilization of cattle manure in the study sites. This study assessed the current practices used by smallholder dairy farmers for management and utilization and pointed out the areas that need more intervention to increase quantity and quality of manure. Specifically, the study identified constraints facing smallholder dairy farmers in managing and utilizing manures.

1.3 Research Objectives

1.3.1 General Objective

Assessment of options for manure management and utilizations in Lushoto and Korogwe districts for improving productivities in smallholder dairy farmers

1.3.2 Specific objectives

(i) To evaluate the existing practices for manure management and utilization at selected villages.

(ii) To assess soil fertility status among non-manure users and manure users, and

(iii) To assess nutrient levels in manure stored under various practices.

1.4 Significance of the study

The findings will recommend the best practices in helping farmers to manage manure in order to increase levels of soil fertility and ultimately ensure family food security while reducing the cost of purchasing inorganic fertilizer. The recommendations will also contribute to appropriate intervention under the project that supports this study (CARP-Livestock Project). The results of the soil and manure generally will assist to improve manure storage and farming practices that will improve the productivities of the smallholder dairy farmers.

CHAPTER TWO

LITERATURE REVIEW

2.1 Role of manure in soil

Manure consists of feces, urine and materials used for bedding/left over-feeds (Tisdale and Nelson, 1958). Other study defines manure as organic matter, mostly derived from animal feces except in the case of green manure, which can be used as organic fertilizer in agriculture. Manure increase soil organic matter (Rosen and Bierman, 2005) which tend to reduce infestation of *Striga hermonthica*, a parasitic weed which causes major losses to maize yields (Waithaka *et al.,* 2007). Organic matter affects crops growth and yield either directly by supplying nutrients or indirectly by modifying soil physical properties such as stability of aggregates, porosity and available water capacity that can improve the root environment and stimulate plant growth (Bandyopadhyay *et al.*, 2010). Studies have shown that adding organic amendments such as manure results in increasing microbial biomass (soil bacteria and fungi) and higher microbial activity compared with mineral fertilizers (Liu *et al.,* 2010). Manure from well fed animals and appropriate managed contains nutrients needed for crop growth including trace elements and has the potential for improving soil fertility (Achieng *et al.,* 2010; Ngetich *et al.,* 2012). Palma (1997), cited by Bayu *et al.* (2005) found that animal manures can influence nutrient availability by the total nutrients added, by controlling net mineralization-immobilization patterns, by serving as a source of C and energy to soil microbes. Manure improves soil physical properties that can be used as indicators for soil quality assessments and for determining the sustainability of farming systems (Malik *et al.,* 2014).

2.2 Factors contributing to manure production

Cowshed made by concrete floor rather than soil floor results in not only higher quality but also quantity of manure (Faso, 2004) which provide maximum opportunity for manure collection compared with traditional kraals which have poor drainage (Lekasi *et al.,* 2001; Snijders *et al.,* 2009). Therefore, it's important to have a cattle house made from a concrete floor that will enhance drainage, urine collection mixed with bedding material for quality and quantity of manure production. The estimated dung production for cattle is 4 to 5 and 2 to 2.5 kg DM^{-1} day for crossbred and local cattle respectively according to Raussen (1997) as he was cited by Jackson and Mtengeti (2005). Manure production from cattle is influenced much by the amount of feed intake. Fodder resources depend on rainfall, which is extremely variable in amount and distribution over the season. According to the study done in West Africa, palatable crop residues are harvested at the end of the cropping season and stored for consumption by the livestock to reduce the fodder shortage as well as to maintain manure production (Harris, 2002). Weiss *et al.* (2007) pointed out that manure excretion increased on average with increasing milk production although this is not necessarily but increased milk is the result of adequate feed which may contribute to manure excreted. Total amount of dung that needs to be removed from the cow shed is affected by stocking rate, digestibility of the diet, moisture content, frequency of cleaning and techniques.

2.3 Factors influencing quality of manure

The manure nutrient management plan includes various factors; estimated nutrient excretion in manure, manure nutrients recovered and applied for fertilizer, and contingency plan to export nutrients off-farm if there is an excess of critical manure nutrients relative to on-farm crop production needs (Van, 1998). Romney *et al.* (1994) reported that the quality of manure produced by livestock varies according to their diet. The manure from roofed cowshed with concrete floor or from storage with cover or in pit composite performed considerably better than those from uncovered or unroofed in terms of cattle manure quality (Zake *et al*., 2010). Tethering system of livestock has also been reported as another factor that affects the collection of good quality manure (Waithaka *et al.*, 2007).

Animals fed on high levels of concentrates produce excreta with larger amounts of N (Lekasi *et al.*, 2003). The use of cattle concentrate feeds would be a way of improving the levels of phosphorous in manures; this is only possible in areas where there is intensive milk production (Waithaka *et al*., 2007) because of the economic aspects. According to Lekasi *et al.* (2003) roofing offered protection from the leaching effect of rain and from high temperatures. This protects the loss of phosphorus and increases the manure quality. Therefore, the qualities of animal feeds are necessary for improving the manure quality.

2.4 Practices used in manure management and utilization at farm level

Recently many farmers leaving manure uncovered in a heap is the most common storage method while others applying it directly as fresh to crops (Lupindu *et al.*, 2012; Muhereza *et al.*, 2014). In Rwanda farmers primarily used hoes (24%), and baskets (46%) to facilitate manure handling and transportation and over 60% of farmers used their hands, often with banana leaves to collect cow manure (Kim, 2013). Most cattle keepers dispose the manure either as fertilizer or waste within a radius of 10m from their residential house (Lupindu *et al.*, 2012). A study carried out by Lupindu *et al.* (2012) in Morogoro revealed that some cattle keepers use manure as fertilizer, especially those owning large piece of land while others did not use manure as fertilizer but most of the farmers spread manure directly on land as the preferred way of disposal.

The quality of materials used to make composted manure determines its quality. Faso (2004) noted that higher-quality manures are often obtained from covered-shed composting than from open-shed composting; and similarly from pit composting compared with heap or surface composting. A study done by Zake *et al.* (2010) in central Uganda reported that cattle manure managed under the improved method of composting (heap method under a tree shade) was ready for use after a period of one month (Zake *et al.*, 2005) and posed no risk of immobilization of soil nutrients. In Rwanda, underground method (pit composite) is preferred by male farmers compared with female farmers, whereas, for the over ground storage method, more female farmers adopted the practice than males (Kim *et al.*, 2013). Kuepper (2000) noted that good compost is a safe fertilizer, low insoluble salts, it doesn't burn plants, also less likely to cause nutrient imbalances and it can be applied directly to growing vegetable crops. The use of composted manure contributes more to the organic matter content of the soil (Rosen and Bierman, 2005) which is an indicator of soil fertility (Muhmood *et al*., 2014).

In most farms, animal manure used is mainly from cattle (65%) with the rest coming from diverse sources such as sheep and goats (6%) and poultry (4%) (Lekasi *et al.*, 2001) and in Kenya more than 95% of smallholder farmers growing maize use manure (Ngetich *et al.*, 2012). Utilization of manure mostly used on maize plots (Jackson and Mtengeti, 2005) decreases with an increase in steepness of the slope (Ketema *et al.*, 2011). The efficiency of manure utilization by a crop is determined by the method of application, time of incorporation and the rate of decomposition in the soil (Achieng *et al.*, 2010). If manure is spread on the ground without being mixed into the soil by a tillage operation then a large portion of the ammonia nitrogen can be lost to the atmosphere (Chastain and Camberato, 2004). Repeated applications of manure can result in their building to detrimental levels (Kuepper, 200). A study done in South Africa shows the majority (78%) of the farmers broadcast the manure and ploughs it under with a hoe or tractor before planting. The second most used method was applying manure in open fallows either as continuous line (63%) or spot application and 7%

farmers were mixing the manure with water and applied the solution to the soil around the areas where the roots were growing (Materechera, 2010). So to avoid manure-induced imbalances of soil fertility, continually monitor of soil fertility, using appropriate soil tests is the most important. Therefore, proper application rate, time and application methods should be adhered to by farmers in order to reduce any environmental effects.

2.5 Factors affecting utilization of manure by smallholder dairy farmers

Various studies have pointed a number of factors that affect smallholder dairy farmers to utilize manure in their farms and or any other uses. The common ones are; insufficient manure, labor and/or knowledge as important constraints in using manure (Snijders *et al.*, 2009) to fertilize the whole farm in a single cropping season which is also affected by small herd size on the limited land available and inadequate fodder as reported by Muhereza *et al.* (2014). Another challenge as mentioned by farmers and reported by Kim *et al.* (2013) showed that 95% of the interviewed farmers in Garinka, Rwanda, mentioned the lack of manure handling and transportation tools and cost of transportation (Rosen and Bierman, 2005) which is also reported in the Eastern Highlands of Ethiopia (Ketema and Bauer 2011; Onduru *et al.*, 1999). Another factor was reported from Eastern Highland of Ethiopia that if farmers can afford to buy fertilizers, then the probability to use the labor-intensive manure decreases and if households are endowed with sufficient labor to apply manure, then the probability to opt for expensive fertilizers decreases (Ketema and Bauer 2011). Other scholars cited reasons reported by farmers in South Africa were most farmers lack the necessary guide and knowledge on the optimum amounts, time and method of application for the different crops grown. Others pointed out that manure encourage growth of weeds and pests in the fields and most young people do not like to engage in the handling of manure and thus the task was mostly left to the elderly members of the household (Materechera, 2010). Therefore, learning of customs, norms of the society and provide training and practical skill to extension officers and farmers are the most important. It's also important to encourage farmers to raise animals nearby a farm to reduce the cost of manure transportation.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study site description

This study was conducted in Lushoto and Korogwe districts, Tanga region. Lushoto district is situated in the Western Usambara Mountain at latitude 4.7987° S, longitude38.2902° E with an altitude of 1000–2100 m.a.s.l. Korogwe district is situated in the North Eastern of Tanzania at latitude 5°9'23.46"S, longitude 38°26'53.47"E with an altitude 311.72 m.a.s.l. Rainfall seasons in Lushoto are divided into three: the short rainy season (October-December), the long rainy season (March-May) and an intermediary season (July-September). The district is covered by steep-sided, narrow valleys, which limit mechanized farming and require substantial soil erosion control. The study villages included six (6) upland villages namely Viti and Hambalawei (upland villages 1800 – 2100 m.a.s.l.), Ngulwi, Bombo, Ubiri and Mbuzii (midland villages 1100 – 1400 m.a.s.l.) located within the West Usambara Mountains. In addition, there was one lowland study village namely Hale in Korogwe district (Fig. 1). Hale village is located in the lowland (240 - 260 m.a.s.l) along the Pangani River Basin with the average temperature of 24.6^{o}C whereas during the hottest month temperatures could exceed 30^{o} C and average annual rainfall of 900mm per year. The villages located in the upland (Usambara Mountains) experience average annual rainfall and temperature of 600 -2000mm and 18 - 23^{o}C respectively.

3.2 Study design

3.2.1 The Households survey

Questionnaire administering and focus group discussion (FGD) was held in seven villages. The average response was between 6 to 12 farmers per village; whereby men were 43 (69.35%) and women were 19 (30.65%). The discussion was held to the respective government office in the village. A cross-sectional survey was conducted from September to October 2016. A combined qualitative and quantitative method was used whereby focus group meetings, observations, and household surveys were conducted. Sites were selected based on the pre-set criteria which included at least 50% of the households keeping dairy cattle and practicing crop-livestock production systems. Seven sites were selected into which farmers were pre-selected based on a number of herds (three or more dairy cattle) and land size of not less than 0.25 acre. Thirty (30) households were randomly sampled from a list of farmers in a village to be interviewed through a structured questionnaire and ten (10) households were identified for focus group discussion.

Village extension officers and village executive officers participated to provide the list of their respective farmers and were involved in the group discussion.

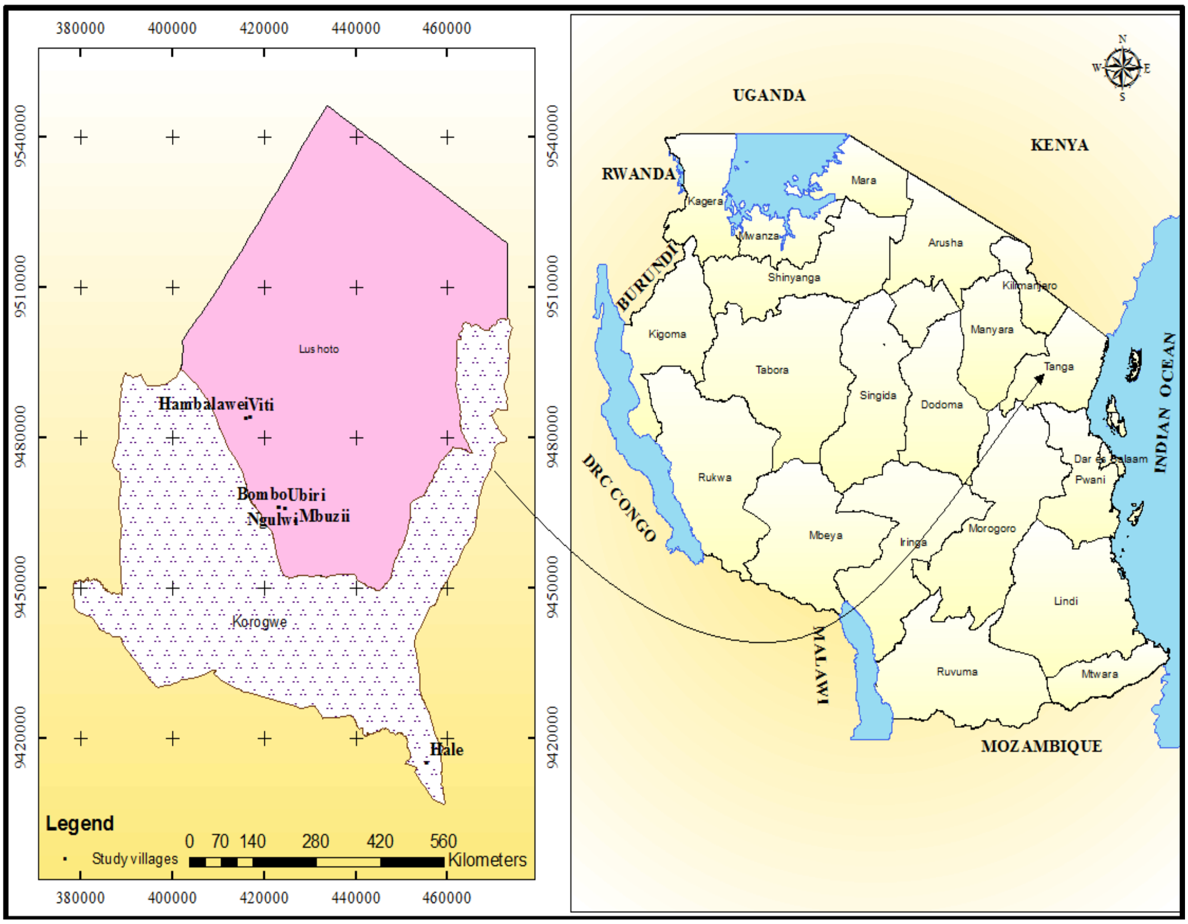

Figure 1: A map showing the location of the study sites (villages) in Lushoto and Korogwe districts, Tanga region, Tanzania.

3.2.2 Soil and Manure sampling

Cattle manure was classified according to the state it was applied in the field. Sample collections included manure stored openly "Surface Storage" (SS) and "Pit Compost" (PS). Soil samples were collected from farms which were previously applied with manure and those which were not. To enable this, fertilizer and manure application history of the farms was sourced through the household survey. Eight samples were collected from each village and composited to four for each practice and approximately 0.5 kg was taken. The soil was taken using soil auger from five points (four points from the corner and one at center) at a depth of 0-20 cm and mixed together to make one representative sample. This was followed by sub-sampling to obtain 0.5 kg sample which was carefully packed in a plastic bag and labeled for analysis. Surface storage (SS) manure was scooped from five points of the hip to make one representative sample while with the pit compost (PC) manure; an auger was immersed to take 200 gms sample. The samples were then stored in plastic bags, well labeled and transferred to Nelson Mandela African Institution of Science and Technology laboratory. The samples were air-dried, then sieved through 0.25mm and 0.5mm for the analysis of chemical properties and organic carbon respectively.

3.3 Laboratory analysis

Soil pH and EC were determined in soil to water ratio of 1:2.5 using pH meter and electrical conductivity (EC) meter respectively. The determination of organic carbon was done according to Walkley and Black, (1934) and soil organic matter concentration was computed by multiplying the organic carbon values by 1.724 (Ellert and Bettany, 1995). Total nitrogen (N) was determined by Kjeldahl method while Potassium (K) and available phosphorus (AP) were determined through atomic absorption spectrophotometry following Mehlch III procedure as described by Carter (1993). Cation exchange capacity (CEC) was analyzed by ammonium acetate method (Ross and Ketterings, 1995).

3.4 Statistical analysis

Data obtained from the survey were analyzed using Statistic Package for Social Science (IBM-SPSS version 21) Computer Software. Descriptive statistics namely means, frequencies, percentages, and cross-tabulation were used to establish relationships between variables. Laboratory data were subjected to analysis of variance (ANOVA) and the computation was performed with the software program STATISTICA 8. The fisher's least significance difference (L.S.D.) was used to compare treatment means at p = 0.05 levels of significance.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Socio-economic characteristics and manure management practices

4.1.1 Socio-economic and demographic characteristics

Hundred percent (100%) of the respondents practice mixed farming as the main means of income generation which is more efficient compared with specialized crop or livestock production systems (Lungu, 2002). Many respondents age ranged from 30 – 70 years (Fig. 2**)**. One-hundred and seventy-seven respondent (84.29%) are married, 27 (12.86%) widow, 3 (1.43%) divorced and 3 (1.43%) single (Table 1). This implies that a smallholder daily farmer provides employment to widows. Traditionally it's easy to give an animal to female and in the future, she is expected to return a female cow compared with other tangible resources. This finding is in agreement with the study done by Herrero *et al.* (2013) who reported that it's often easier for women to acquire livestock through inheritance or market than land or other physical assets.

Table 1: Gender and marital status of respondents in the study sites (%)

Sites	Viti	Hambalawei	Bombo	Ngulwi	Mbuzii	Ubiri	Hale	Average
Gender								
Male	86.7	96.7	80	96.7	73.3	73.3	66.7	81.92
Female	13.3	3.3	20	3.3	26.7	26.7	33.3	18.08
Marital Status								
Single	-	-	-	-	3.3	-	6.7	1.43
Married	90	96.7	80	100	80	73.3	70	84.28
Divorced	-	-	-	-	-	6.7	3.3	1.43
Widow	10	3.3	20	-	16.7	20	20	12.85

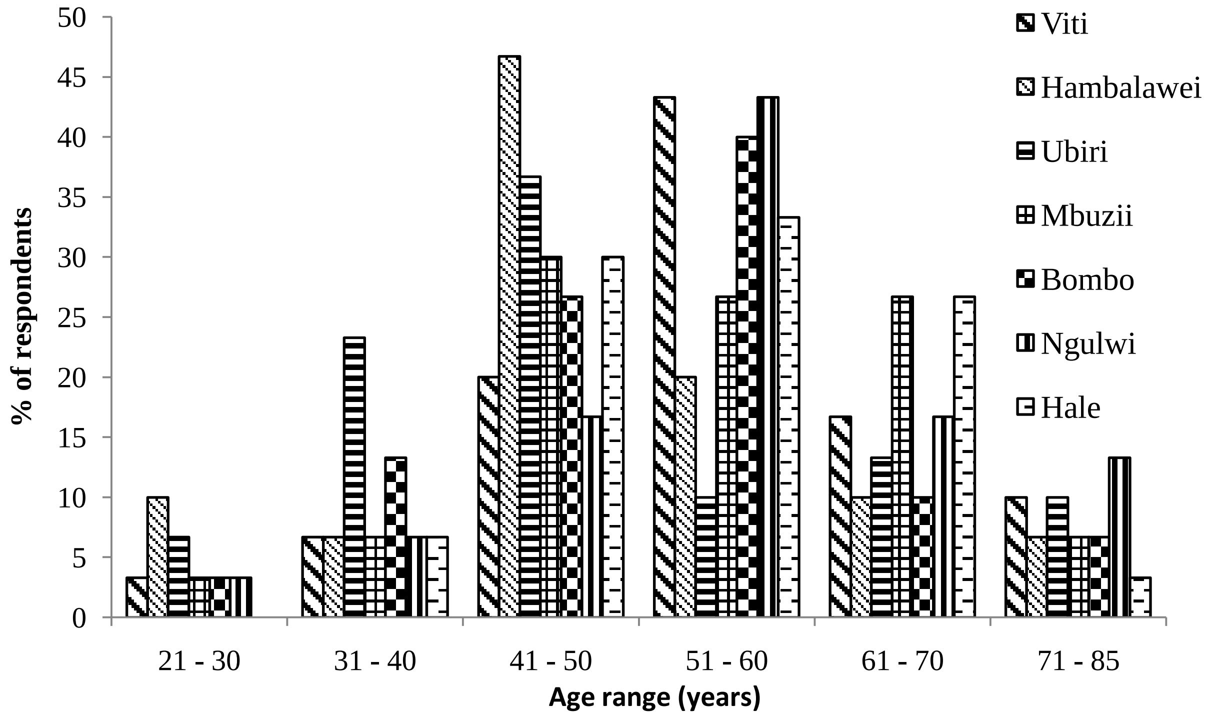

Figure 2: Age of respondent into the respective villages.

About 83.7% of smallholder farmers had achieved primary level education, 3.8% secondary education, 7.1% college education and 4.3% informal education (Table 2). Literacy was very low and this might contribute to negatively effects of adoption and perception of technology uptake and ultimately low production (Adeoti, 2008).

Table 2: Education level of the respondents in the study sites

Sites	**Primary Education**	**Secondary Education**	**Collage Education**	**Informal Education**
	% of respondents			
Viti	80	0	16.7	3.3
Hambalawei	90	3.3	3.3	0
Ngulwi	90	6.7	0	0
Bombo	96	0	0	3.3
Hale	60	13.3	26.6	0
Ubiri	86.7	3.3	0	10
Mbuzii	83.3	0	3.3	13.3
Average	**83.71**	**3.8**	**7.13**	**4.27**

4.1.2 Land tenure system

Land tenure system in the area of study showed that many farmers owned land (97.6%) through inheritance from parents while the rest hired or borrowed with certain agreements. This finding is closely related to the finding from Northern Ghana as reported by Cofie *et al.* (2005) where 84% also inherited land from the parents. This ownership is important for farmers because they will receive long-term use (Henao *et al.*, 2006) when investing to on-farm infrastructure i.e. houses, cowshed, biogas plant and production of perennial crops. On average farmers owned 0.5-3.3 acres which is almost within the range reported by Kiratu *et al.* (2011). Because of the land scarcity per family, 14.3% rent land for other farming production activities and the average renting price per acre is 35 000Tsh (16 USD) per season. Majority of the interviewed farmers allocated their piece of land for maize, beans and potato production (Table 3). The reason might be due to their importance in food security and income generation from the selling of potato and vegetables as a source of income but for Hale farmers mainly produced maize. Sixteen percent of interviewed households set aside 1.18 acre for maize as stable food production. It was further observed that majority of the farmers cultivate maize and beans for household consumption and not for commercial purpose. Maize and beans are produced once in a year compared with vegetables which are produced 3-4 times in the valleys that are close to homestead and are regarded as cash crops for their economies. Generally, vegetable plots commercially showed high value compared with maize/beans fields. Main labor force is family members though few families (6.2%) employed labor which is positively related to farm size as also reported in Kenya by Waithaka *et al.* (2007).

Table 3: Average land size (acre) per household allocated for various crops

Sites	**Maize**	**Beans**	**Maize-beans intercrop**	**Maize-beans-potatoes**	**Potato**	**Vegetable**
Viti	1.47 (20.86)	0.75 (10.64)	0.25 (3.55)	3.31 (46.91)	0.83 (11.83)	0.44 (6.21)
Hambalawei	1.03 (20.34)	0.53 (10.46)	1 (19.75)	1.53 (30.24)	0.47 (9.33)	0.5 (9.87)
Ngulwi	0.9 (17.55)	0.7 (13.66)	1.13(22.04)	1.15 (22.35)	0.5 (9.75)	0.75 (14.63)
Bombo	1.66 (25.2)	1.13 (17.16)	1.2 (18.22)	1.4 (21.26)	0.43 (6.5)	0.77 (11.64)
Ubiri	1.26 (24.72)	0.64 (12.56)	0.97 (19.03)	0.89 (17.52)	0.63 (12.26)	0.71 (13.89)
Mbuzii	1.97 (29.79)	0.8 (12.09)	1.7 (25.71)	1.44 (21.84	0.38 (5.67)	0.32 (4.89)
Hale	1.18 (16.6)	0	0.9 (10)	0	0	0

NB: Values in the brackets are the percentages of respondents while outside the bracket are the land size in acres.

4.1.3 Manure handling and management practice

Zero-grazing was observed as the most intensive livestock production system in the area, involving the 'cut and carry' method of feed management and this is due to the absence of communal grazing lands. However, this system is the best for manure collection. Farmers might collect enough manure per day because most of the farmers owned 2-3 dairy cows while the reported average of manure produced per day is 4.8% of live body weight (Vale *et al., 2004*). This amount of manure resources would be sufficient to fertilize the small-size farms in the area as presented in table 3 above. Majority of farmers (74.9%) collected manure and piled it out openly close to the cowshed and this was highly evident at Viti (90%), Hambalawei (93.3%), Hale (93.3%), and Mbuzii (83.3%) while few covering practices were observed at Ngulwi (3.3%) and Bombo (6.7%) (Fig.3). Generally, 78.8% of the sampled household stored manure close to cow pen openly and 12.5% practice pit compost. This implies that nutrients such as Nitrogen and Phosphorus were lost through leaching and volatilization due to effect of rain and temperature (Lekasi *et al*., 2003). Faso, (2004) reported that compost obtained from covered-shed composting are of high quality than from open-shed composting; and similarly from pit composting compared with heap or surface composting. However, in this study, it was found that farmers had no information of their manure in-terms of nutrient contents.

Storage period varied considerably across the study sites. It was observed that, 40% and 33.3% at Viti and Hambalawei respectively were reported to store manure for 5 – 11 months (Table 4). Plate 1 showing how surface storage of manure is done after collection from the cowshed. Absence of covering materials or shade structure to reduce temperatures, evaporation of urine and rainy water contribute to loss of potential nutrients (Lekasi *et al*., 2003). The piling of fresh manure was conducted daily after cleaning and there was no jelling of manure. In Hale, it was revealed that manure remained at the collection area and if not taken for use, was expected to be burnt. Few respondents (12.5%) who are found at Viti have 2 pits that enable rotation when one pit is full. This could be due to their reported belief that, high economic return from vegetable production in the two sites (Viti and Hambalawei) was contributed by the pit compost manure.

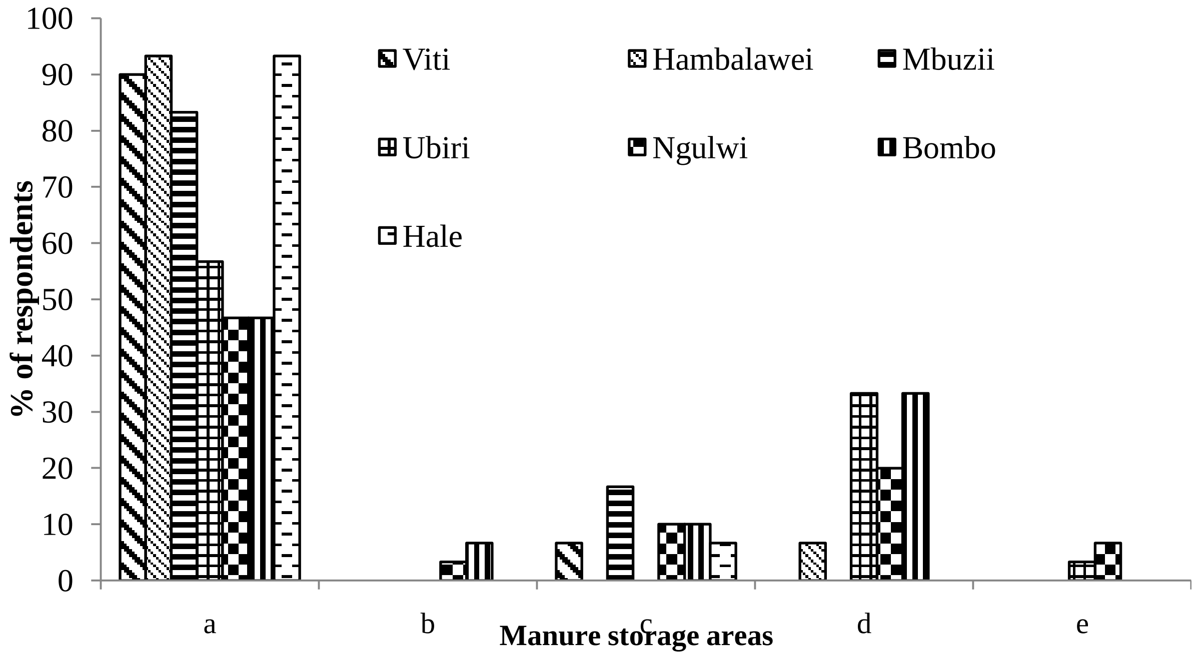

Figure 3: The common different storage areas after manure collection from the cow pen

NB: **a** = manure stored close to cowshed openly, **b** = close to cow shed with cover, **c** = Away from the cow shed openly, d = taking direct to pit after cleaning the cow shed and **e** = under banana shade.

During focus group discussion and personal discussion at Viti, farmers reported that assessment of compost manure is done by looking at the color. Preferred compost was black in color, mixed with soil and presence of white big worms. Other farmers reported that they inserted a stick in the entire heap or in the pit and the extent of heat, hotness or warmth of the stick gave an indication of whether the compost was partially or fully decomposed.

Table 4: Manure storage period identified by smallholder farmers in surveyed villages (%)

Sites storage period	**Viti**	**Hambalawei**	**Mbuzii**	**Ubiri**	**Ngulwi**	**Bombo**	**Hale**
1-2 month	1(3.3)	-	1 (3.3)	-	-	1 (3.3)	-
3-4 month	9(30)	8(26.6)	3 (10)	3 (10)	3(10)	-	-
5-6 month	12(40)	10(33.3)	4(13.3)	6 (20)	4 (13.3)	9 (30)	-
7-11 month	6(20)	6 (23.3)	8(26.6)	4 (13.3)	11 (36.6)	6 (20)	-
1 year+	2(6.6)	3(10)	7 (23.3)	8(26.6)	6 (20)	9 (30)	6 (20)
Un-identified period	-	3(10)	7(23.3)	9(30)	6 (20)	5(16.6)	-

NB: Values in the brackets are the percentages of respondents while outside the bracket are number of respondents per village.

Plate 1: Hip of surface storage manure practiced by majority of smallholder farmers at Hale village

Emptying the pit or heap was reported to start by taking the bottom part assuming that is completely decomposed. This could have effect to those who used manure 3-4 times because the time for decomposition could be shorter since the techniques used involving piling without turning does not ensure the maturity of manure for use. Farmers are advised to decompose manure for 17 weeks (Esse *et al.,* 2001) while monitoring aeration, nutrient balance, moisture content and temperature (Gamroth, 2012) because composting is more than just piling the material.

It was reported that during manure composting at Viti, farmers mixed manure with sawdust to increase the volume though if not mixed well might affect early decomposition process. This is the indigenous/local knowledge used as inherited from parents or copied from other farmers to improve manure quantity. Only 8.5% of the respondents who practiced pit compost obtained training outside their district though they practice as those who did not got training. This indicated that if training could be provided with a trial at farm level many farmers could practice appropriate pit composting. Lack of training (16.7%), time and fatigue work (15%), lack of proper facilities (43.3%) such as wheelbarrow and transportation cost/labour (8.3%) were the constraints reported to hinder pit compost practices. These constraints have also been reported by Rosen and Bierman (2005) in Rwanda.

4.2 Utilization practices of cattle manure in the smallholder dairy systems

Drilling or spot method of manure application was reported to be the most common amongst the farmers in Lushoto (70%). The practice is different from farmers at Hale who collects manure, heaps it and scatters in the field, during ploughing the land with the tractor manure are mixed to the soil. This tillage operation of leaving manure in the field contribute to a portion of the ammonia nitrogen continue to lost to the atmosphere (Chastain and Camberato, 2004). Other farmers reported to dig a hole and fill with manure and wait to sow/plant the seeds, a few days/hours before raining. These application differences could be due to farm size. For instance at Hale most farmers have large plot which would not allow them to put drops of manure per hole compared with the upland villages. At Hale village, farmers who do not apply manure burn the resource or gives to anybody who may be in need or just abandons around the homestead. Reasons which were given for this kind of practice were the distance to the farm as reported by 17% of the respondents and others explained that they didn't know how to apply manure (8%) while few (5%) were constrained by the cost of hiring motorcycles for transportation of manure to the farm. Smallholder farmers they don't have a common measurement/rate when applying manure in the field. This may cause individual farmer to apply too low or high and might lead to nutrient imbalance (Rosen and Bierman, 2016). The majority of farmers measure the manure with both two hands to a hole with the reason that the little manure they have should cover big area compared with the broadcasting method. Some effects reported by farmers when utilize partially composted manure were, plant death or unhealthy growth and poor yields. The effect of applying immature composts to the soil was pointed to cause severe damages to plant (Ko *et al.*, 2008).

In general, 27% of the respondents claimed the deficit of manure led to low production. Observable evidence during the survey showed that farmers with small herd (number of animals per household and animal body weight of their animals) and feed shortage contributed to the low volume of manure collected per day. According to Vale *et al.* (2004) manure production per day is averaged to 4.8% (range 3.3- 6.5%) of the live animal body weight. Further, it was found in this study that farmers applied manure at different times per year, for instance once per year (21.4%), twice per year (51.2%), thrice per year (4%) and four times (23.4%) depending on the season and type of crops (Fig. 4). Majority of the respondents applied twice, around November and March/April. In Hale village where manure application is done once in a year (November - December), was found to have fields located far away from the homesteads averaging to 2-5km and such distance is reported to have negative impact on manure utilization (Ketema and Bauer, 2011). Farmers who applied manure more than twice were those involved in production of horticultural crops and their farms were found in the valley and applied irrigation during drought season. However, it has been reported that repeated application of manure in the same season could result in building detrimental levels (Kuepper, 2000). It is important to avoid manure-induced imbalances of soil fertility through continuous monitoring of soil fertility using appropriate soil tests. Most notably, Lushoto farmers' fields are located in three areas (1) lower lands (valleys) where vegetable production is dominant (2) in the highlands (upland field) where maize and beans are grown and (3) around homestead (middle) where banana and potato are cultivated. The study observed that majority use manure in the valleys and around homestead where vegetable and potatoes are highly produced which is not similar to Vihiga western Kenya where manure use is more important to the production of food crops (Waithaka *et al.*, 2007). The finding from this study suggests that manure utilization is negatively affected by distance from the farms and landscape. This finding is similar to those by Ketema and Bauer (2011) who reported that the use of manure was decreasing with an increase in steepness of the slope and farmers preferred to apply manure in farms near the household (Harris and Yusuf, 2001).

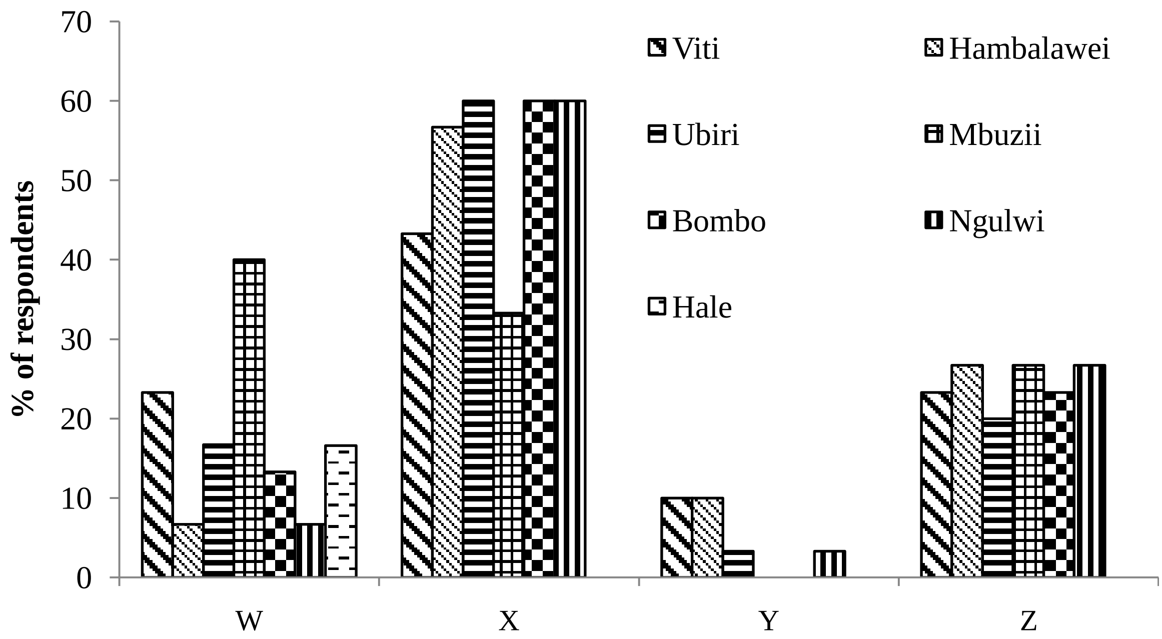

Figure 4: Extent of manure use in smallholder farms in the study sites
NB: Frequency of manure application per year where; W, X, Y and Z represent one, two, three and forth application respectively.

In the upland fields, it was observed that few farmers applied inorganic fertilizer as it was reported to be cheaper in-terms of transportation compared with manure in-terms of volume per area. Some respondents (7%) at Lushoto district reported that they used manure in the upland fields because when it rains the nutrients are washed to the valley plots. The reports from farmers' survey in this study on use and not using manure showed that the average production of maize was 0.5 t ha^{-1} - 1.4 t ha^{-1} (hybrid varieties) in farms that were not applied with manure. For farms were manure was applied the average maize production was 0.7 – 0.9 t ha^{-1} (local varieties) and 1.98 t ha^{-1}(hybrid varieties). In this study, results clearly show that applying manure boosted yield although these increases were still very low. Nkonya (1998) reported the potential yield and for expected yield under good husbandry is averaged to 7.5 t ha^{-1} and 5.4 t ha^{-1}. A study done in Kenya showed that in unfertilized maize farm, the yield ranged from 1.2 – 1.3 t ha^{-1} while the fertilized fields with manure the yield were higher and ranged from 3.8 – 4.2 t ha^{-1} (Smaling *et al.,* 1992). In view of the above, the use of manure in the study sites is contributing very little to yield increase in various crops grown in the area. Therefore, this call for proper analysis of the manure and to establish their nutrient status as this will enable to design appropriate manure management strategies that could boost crop production in the area.

4.2.1 Smallholders farmers' awareness on the use of manure for biogas production

Respondents were asked if they are aware of the biogas technology and it was found that, only in three villages where awareness was above fifty percent; Viti (63.3%), Ngulwi (53.3%) and Hale (80%) (Fig. 5). This result showed that biogas technology among smallholder farmers in Lushoto was like a new term. The majority showed the need to have cost sharing aspects. Three biogas plants were observed though they were no longer functioning (one at Viti and two at Hale). Poor management (Plate 2) of the unit was observed as the major factor that led malfunctioning of some parts. Insufficient water during dung feeding, daily plant feeding, servicing the plant on time was mentioned among the factors that contributed to failure of the system. Most of the biogas systems in Africa have been reported to operate for a short period due to poor technical quality (Amigun *et al.,* 2012) and management. Using manure for biogas production has several benefits (Alvarez *et al.,* 2006), such as energy source, by-product used as fertilizer and one way of reducing climate emissions partly by minimizing or eliminating the dependence of wood-fuel among smallholder farmers (Teenstra *et al.,* 2014). Capacitating technical skill to local members who are available within the community would help to maintain the biogas systems in case of minor problems.

Plate 2: Poor biogas plant management (insufficient water during dung feeding) observed at Viti village.

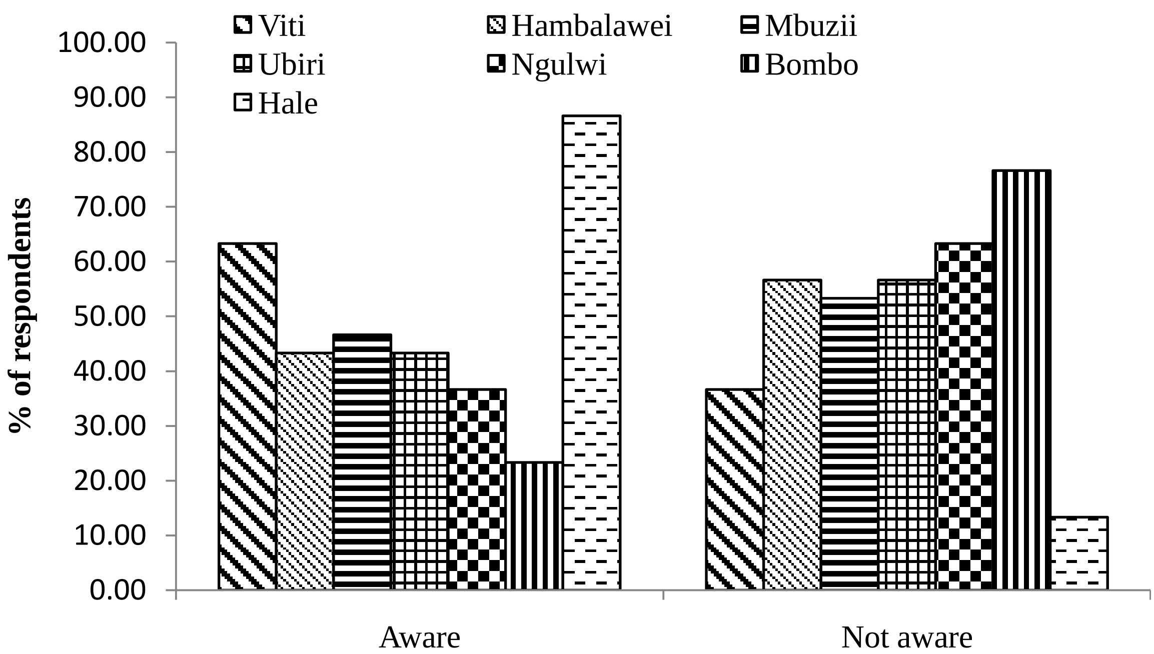

Figure 5: Awareness level of smallholder farmers on the biogas technology in the study area

4.2.2 Manure as the source of cooking energy

This study found that firewood was the most used by farmers for cooking in villages at Lushoto while charcoal was the predominant source at Hale village (Fig. 6). Manure was not used whether as a biogas or slice for cooking (dried manure). Over 70% of the smallholder farmers used firewood except at Hale where firewood was used by 23% of the respondents, charcoal 63.3% and rarely electricity (3.3%). In the rest of the six villages, charcoal use was below 14%. This finding is in agreement with the findings reported by Ngetich *et al.* (2009) in Njoro, Kenya where majority of smallholders depended on firewood. In Tanzania, energy access is about 2% in rural areas (Uisso, 2009) and more than 80% of energy delivered from biomass is consumed in rural areas. Most respondents reportedly sourced firewood from cutting/pruning trees at homestead, buying or cutting from the forest. If manure produced could be used for biogas production, this would reduce the number of trees harvested for firewood. This fact indicates that if there could be an increased number in the installation of biogas plants would reduce the percentage of forest clearing at Lushoto and Korogwe districts. This is then expected to reduce deforestation and carbon trading that increase the adaptive capacity against climate change (Chand *et al.*, 2012).

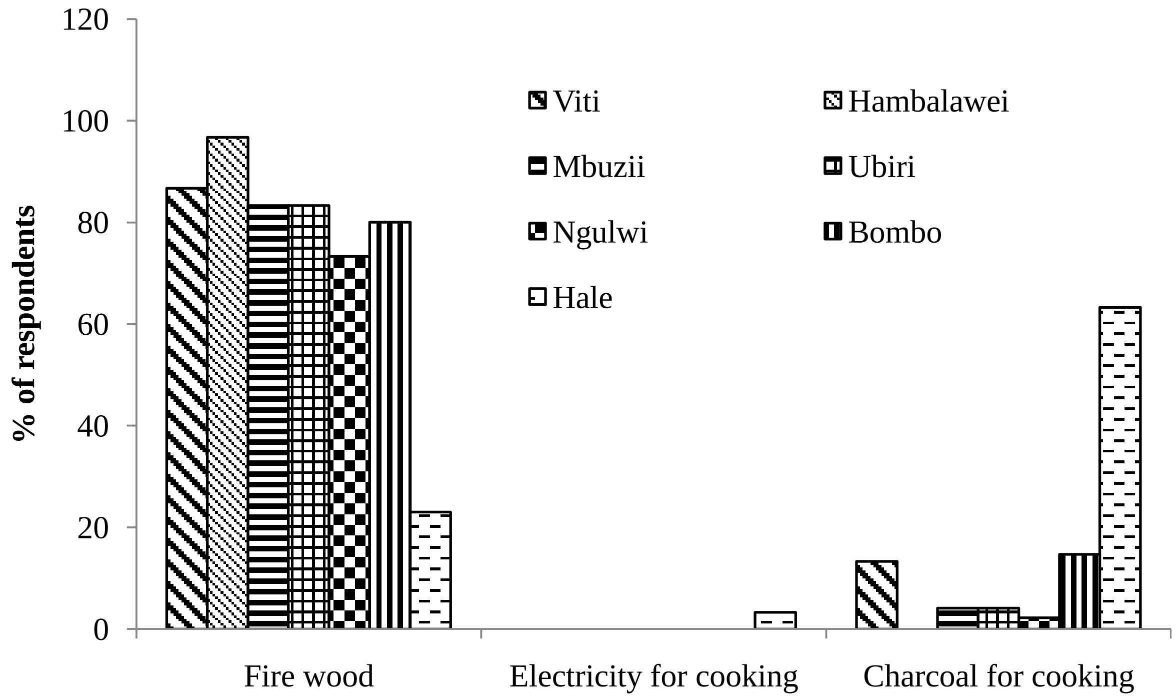

Figure 6: Sources of energy for cooking in the study villages.

4.3 Factors observed to contribute to the quality of manure in the study sites

4.3.1 Cowshed floor type

The type of the cowshed contributes to quality of manure as when the floor is made of concrete avoids runoff and enhance the collection process. In the study sites only 20% had cowshed made with concrete and roofed with iron sheet, 65.2% soil floor, timber and stone were 9 and 12.5%, respectively (Table 5). Hale village is where almost 90% of the respondents had concrete floor while Hambalawei had the least having only 3.3% of the cow shade made from concrete. According to Faso (2004) cattle house made by concrete floor rather than soil floors results in higher quality and quantity manure. The wall materials were mainly made of timber. Similar type of soil floor has been reported in Kenya whereby 96% of cowshed made from soil floor and only 4% had concrete or stone floor in the improved zero grazing unit (Lekasi *et al.,* 2003). It was further reported in Viti village that timber products are cheap and available that enables many smallholders to afford timber cowshed in this village compared with other sites. Results in the Table 5 show that, even if manure is produced as much, soil floor may limit collection. Also the results indicate that, urine excreted are no longer mixed with manure which also affects nutrient compositions especially N. An initiative to encourage farmers to have sheds with concrete floor should be taken as it improves quality of manure.

Table 5: The observed cow shed floor types in the study site

Floor type	Viti	Hambalawei	Ubiri	Ngulwi	Bombo	Mbuzii	Hale	Total
Concrete	2 (6.7)	1 (3.3)	2 (6.7)	3 (10)	2 (6.7)	5 (16.7)	27 (90)	42 (20)
Earth	21 (70)	26 (86.7)	23 (76.7)	21 (70)	24 (80)	20 (16.7)	2 (1.5)	137 (65.2)
Timber	6 (20)	3 (10)	2 (6.7)	3 (10)	3 (10)	2 (6.7)	0	19 (9.0)
Stone	1 (3.3)	0	3 (10)	3 (10)	1 (3.3)	3 (10)	1 (3.3)	12 (5.7)

NB: Values in the brackets are the percentages of respondents while outside the bracket are number of respondents.

4.3.2 Animal feed types

The total amount and proportion of N excreted in urine and manure depends on animal diet. The urine and manure excreted by animals fed highly digestible diets is more susceptible to N losses than excreta from diets containing greater amounts of roughage (Powell and Williams, 1993). Animals fed on high levels of concentrates produce excreta with larger amounts of N

(Lekasi and Kimani, 2003). According to the finding in Table 6, generally animals are fed with very low concentrates in the study sites, where a paltry 28% fed their animals with maize bran and 8.1% fed on sunflower cake. Basically maize bran and sunflower cake are given to milked while manure is collected from all available animals. This entails that the bulky manure produced per household might have low N content due to feeding regimes. Sixty percent of the respondents at Hale fed their cows concentrates and 73.3% fed rice straws which comprise 0.5-0.8% N, 0.16-0.27% P_2O_5 and 1.4-2.0% K_2O in dry matter basis (Dobermann and Fairhurst 2002). Majority of the farmers fed Napier grass (79.5%), Tree fodder (57.6%) and Guatemela (50.5%) to their cows. Napier comprises a total of 37- 45% DM, 10% CP (Aganga *et al.,* 2005). It was reported that Napier and Guatemala are fed by 32% and 8% respectively during wet season and 18% (Napier) and 17% (Guatemala) during dry season at Lushoto district (Maleko *et al.,* 2018). This has low nutritive value that might contribute to low nutritive value of manure. Crop residues are reported to provide an important source of feed for ruminant livestock during the dry season in study sites of which 73.8% and 66.2% feed maize stover and beans straw. However these are only available after crop harvesting and cannot persist for long time.

Table 6: Feed types offered to dairy cattle at the study sites.

Feed type	**Viti**	**Hambalawei**	**Ngulwi**	**Bombo**	**Hale**	**Ubiri**	**Mbuzii**	**Average responses**
	% respondents							
Napier	83.3	83.3	90	80	40	86.7	93.3	79.5
Guatemala	96.7	90	33.3	53.3	13.3	36.7	30	50.5
Green natural grasses	36.7	33.3	46.7	43.3	93.3	56.7	53.3	51.9
Maize Stover	70	96.7	86.7	80	16.7	73.3	93.3	73.8
Bean straw	70	70	80	73.3	16.7	66.7	86.7	66.2
Rice straw	-	-	-	-	73.3	-	-	10.5
Tree fodder	46.7	50	80	73.3	16.7	76.7	60	57.6
Banana trump/leaves	23.3	26.7	43.3	63.3	-	46.7	13.3	31
Maize bran	20	23.3	16.7	36.7	60	16.7	23.3	28.1
Mineral premix	26.7	20	13.3	16.7	43.3	30	20	24.3
Sunflower seedcake	10	3.3	3.3	-	33.3	6.7	-	8.1

4.4 Soil quality in farms applied (FAM) and farms not applied with manure (FNAM)

Farms applied and a farm not applied manure was identified following complains of low yield from smallholder farms from users and non-users of cattle manure. Soil samples were collected from farms which were previously applied with manure and those which were not.

To enable this, fertilizer and manure application history of the farms was sourced through the household survey. The consideration was at least for consecutively two years of manure application or not in the farms

4.4.1 Soil pH

In table 7, the results showed that there was a significant difference between sites and treatments ($p \leq 0.05$) in soil pH with a range of 6.4 - 7.6 and 6.5 – 6.9 for FAM and FNAM, respectively. However there was no significant difference at Ubiri (FNAM), Hale (FNAM), Mbuzii (FAM), Ngulwi (FNAM), Viti (FAM) and Hambalawei (FNAM) (Fig. 7). The reason at Bombo and Ubiri in FAM to have high pH might be the soil of those two villages is rich in calcium carbonate materials which also increase level of soil pH. The ranges are for most favorable agriculture soils according to Sanchez *et al.* (2003) and Magdoff and Bartlett (1985). However, the more pH may harm the plant life's, though pH of 6.5-7.5 is where most potassium is available for plants and pH ≤ 5 could be associated with deficiencies of phosphorus according to Ndakidemi and Semoka *et al.* (2006).

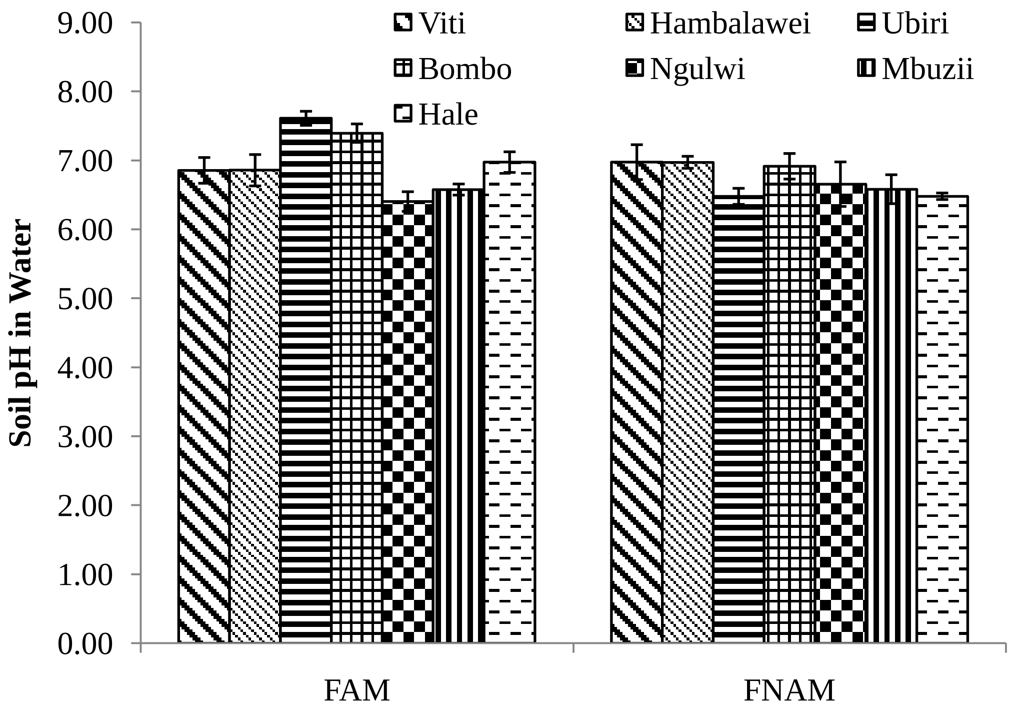

Figure 7: Soil pH in the FAM and FNAM

NB: FAM = Farm Applied Manure, FNAM = Farm Not Applied manure

4.4.2 Electrical conductivity (EC)

The EC of soils ranged from 0.01 to 0.21 and 0.06 to 0.17 dS/m of FAM and FNAM respectively (Table 7). EC of the soil is one among the indicators of soil productivity/soil fertility (Grisso *et al*., 2005). Sands have a low conductivity (0 – 0.04 dS/m), silts have a medium conductivity (0.04 – 0.15 dS/m), and clays have a high conductivity (0.1 - 10 dS/m) (Grisso *et al*., 2005). This indicates that the soils in the study sites are between clay and silt that have high electrical conductivity values which associate with soils that contain high levels of soluble nutrients (Richards, 1969). The findings across the study villages showed that there were significant differences ($p \leq 0.05$) between treatments and sites. The highest EC was found at Viti (FAM) and Hambalawei (FNAM) that indicate the soil has high clay soil while the lowest was observed at Mbuzii (FAM), Bombo (FNAM) and Hale (FNAM) that indicating the soil had high silt (Fig. 8).

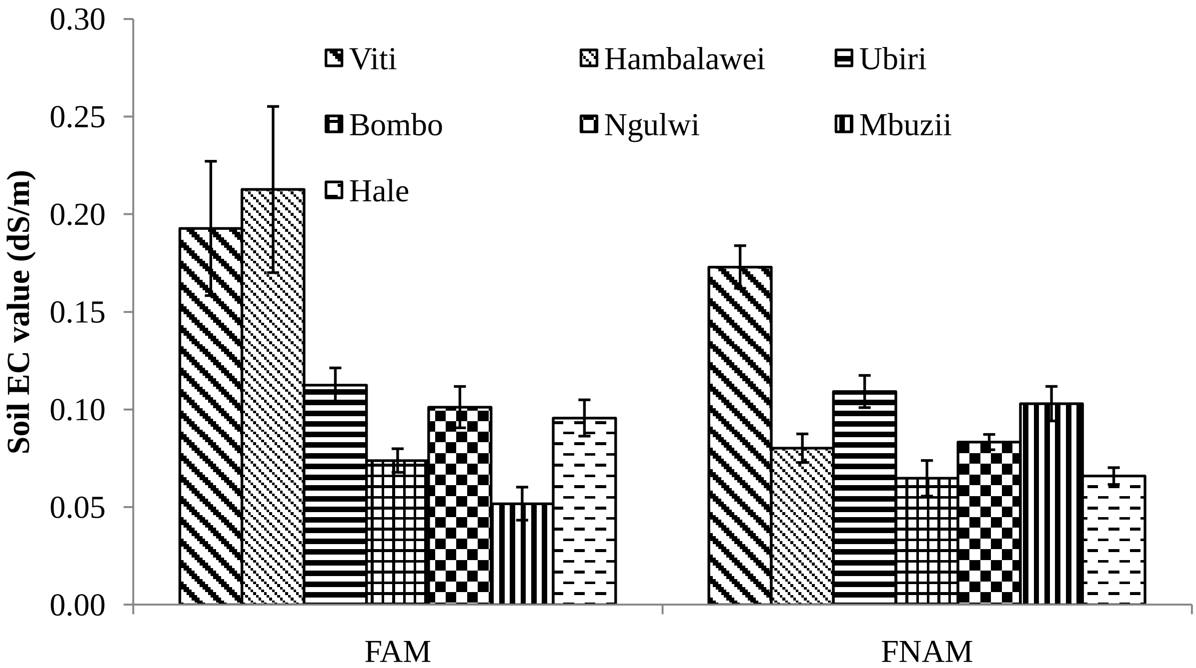

Figure 8: Soil Electro- conductivity in the FAM and FNAM

NB: FAM = Farm Applied Manure, FNAM = Farm Not Applied manure

4.4.3 Soil Cation Exchange Capacity (CEC)

The CEC of soils ranged from 13.6 to 38.2 and 8.2 to 13.2 Meq/100g[1] of FAM and FNAM respectively (Table 7). FAM had the highest value (13.60 – 38.20), implying that the soil have high capacity to absorb nutrients (e.g. copper, zinc, potassium) as supported by the finding of Grisso *et al.* (2005) who reported that the higher the CEC the greater is the capacity of the soil surfaces to adsorb trace elements without potential deleterious effects on plants and/or soil biological functions. The effect of treatment was low on FNAM (Fig. 9). The highest CEC in FAM might be due to more organic matter present in the soil as described in Table 7. The lower the CEC of a soil, the faster the soil pH will decrease with time (Gillman, 1981). To avoid the decrease of soil pH smallholder farmers are advised to apply manure in all crop fields.

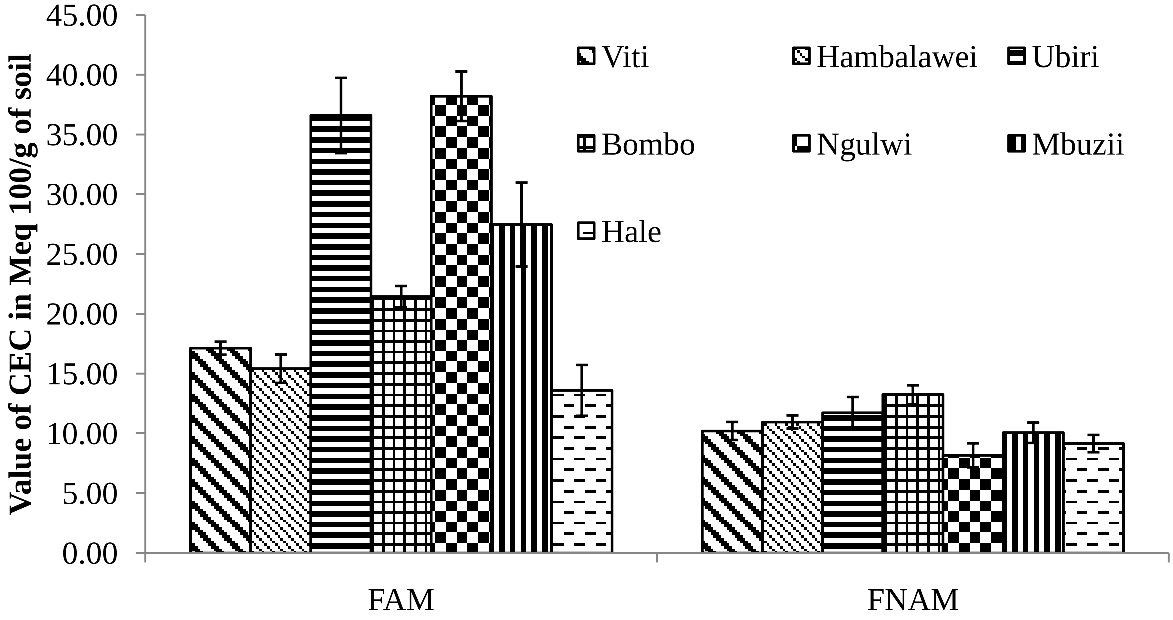

Figure 9: Soil Cation Exchange capacity in FAN and FNAM

NB: FAM = Farm Applied Manure, FNAM = Farm Not Applied manure

4.4.4 Soil Organic Carbon (SOC) and Soil Organic Matter (SOM)

SOM has a role in retaining some trace elements (such as Zn) and capacity to absorb other trace elements (such as Cu and Mn). There were no significant differences between sites and treatments (Table 7). Nevertheless, FAM had the highest value in both SOC (2.11 – 2.96%) and SOM (3.65 – 5.11%). These significant differences in values are similar to the one reported by Gyapong and Ayisi, (2015) in Ghana. Bot and Benites (2005) reported that most of SOM in soil range from 2 – 10 %. According to these results it is evident that addition of cattle manure in the soil increases organic matter (Reeves, 1997).

4.4.5 Soil Available Phosphorus (AP)

The AP ranged from 0.14 – 0.33% and 0.05 – 0.16% for FAM and FNAM, respectively. The significant differences were observed across sites and treatment ($P \leq 0.001$). Highest available phosphorus was found in FAM (Table 6). Rodríguez and Fraga (1999) reported that amount of AP in the soil to be 0.4 – 1.2% and 30 – 50% of total phosphorus which is constituted by organic matter (OM) in most soils. Low AP was found for both FAM and FNAM (Fig. 10) which might be attributed by soil degradation i.e. soil erosion in the steep lands (Lynch, 2011) due to improper agricultural management practices i.e. soil erosion in the steep lands. Another reason could be improper manure/fertilizer application rates. Nkonya, (1998) recommended amount of phosphorus in the low land is 20 kg P ha^{-1} and high land is 20-40 kg P ha^{-1}. Smallholder farmers could opt to use organic materials in their farm such as compost, plant or animal materials/waste, or green manure that influences the increase of AP (Mkhabela and Warman, 2005). FNAM in Hale had higher AP than the rest of the village, of which crop residues remain in farm after harvest might contributed to the relatively high AP observed.

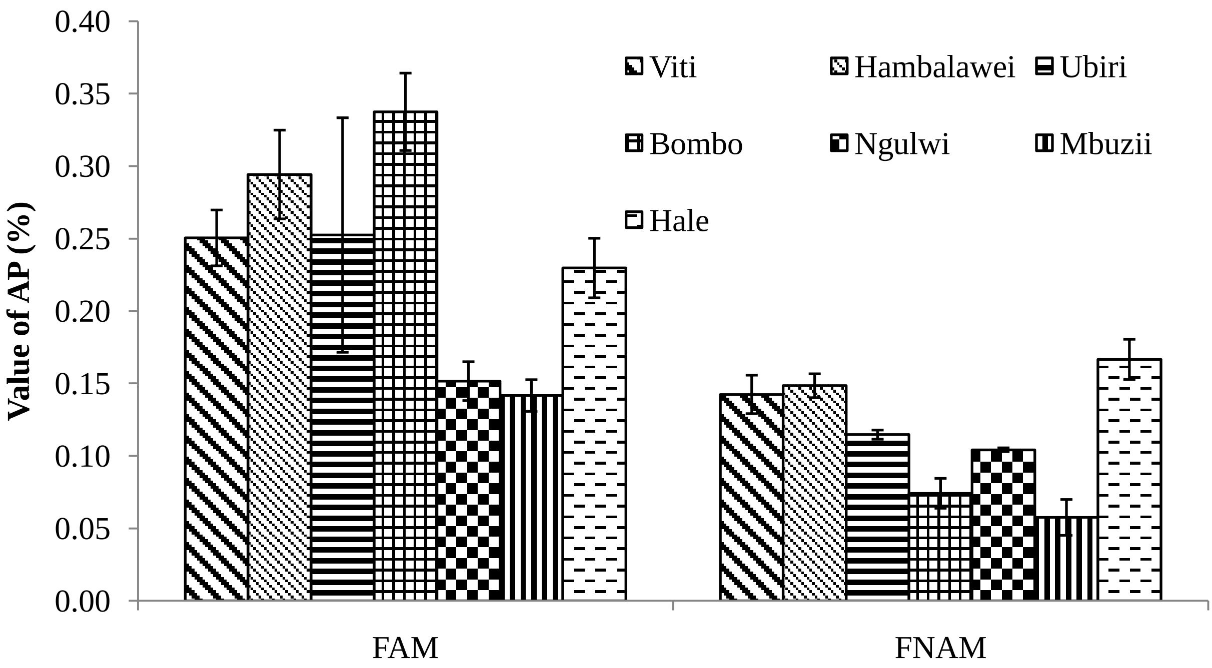

Figure 10: Soil Available phosphorus in FAM and FNAM
NB: FAM = Farm Applied Manure, FNAM = Farm Not Applied manure

4.4.6 Soil Total Nitrogen

Total nitrogen (TN) ranged from 0.17 – 0.23% in FAM and 0.09 – 0.16% in FNAM. There were no significant effects between site and treatments (Table 7). The recommended critical level in Tanzania is 2.0 g kg^{-1} for most crops (Ndakidemi *et al.*, 2006). The application rate of nitrogen based to altitude in the northern and eastern zones was reported to be 40-112kg N ha^{-1} (High altitude) and 20-45kg N ha^{-1} (low altitude) (Nkonya, 1998). These results indicate low nitrogen in all soils across the sites as per recommendations. The smallest variation of nitrogen concentration in FAM could be contributed by the low quality manure as a result of the poor cowshed and storage practices that enhance the loss of nitrogen through leaching and volatilization. Digested slurry also can be used to improve soil nitrogen as it contains 1.60% N, 1.55% P and 1.00% K and slurry compost comprises of 0.75% N, 0.65% P and 1.05% K (Karki and Expert, 2006). Poultry manure which was reported to have higher nitrogen than cattle manure (Gyapong and Ayisi, 2015) can be used as a fertilizer for crop production but the main challenge is the amount per household per farm. The low percent of chemical properties in FNAM could be contributed by the loss of top soil that transport soil organic matter during rainy season which is facilitated by the steepness of the slope at Lushoto while in Hale the rate of using manure is very minimal.

4.4.7 Potassium in soil

Potassium ranged from 0.43 – 2.95% in FAM and FNAM (table 6) and was significantly higher ($p \leq 0.001$) in FAM at Ubiri and Ngulwi. The lowest was in FNAM at all villages but a bit higher at Ubiri (Fig. 11). Hale (FAM) the K level was low and the reason could be majority of farmers (69%) do not apply manure. The value found in FNAM is similar to those reported by Bressers (2014) though was not indicated whether the soil was utilized with manure.

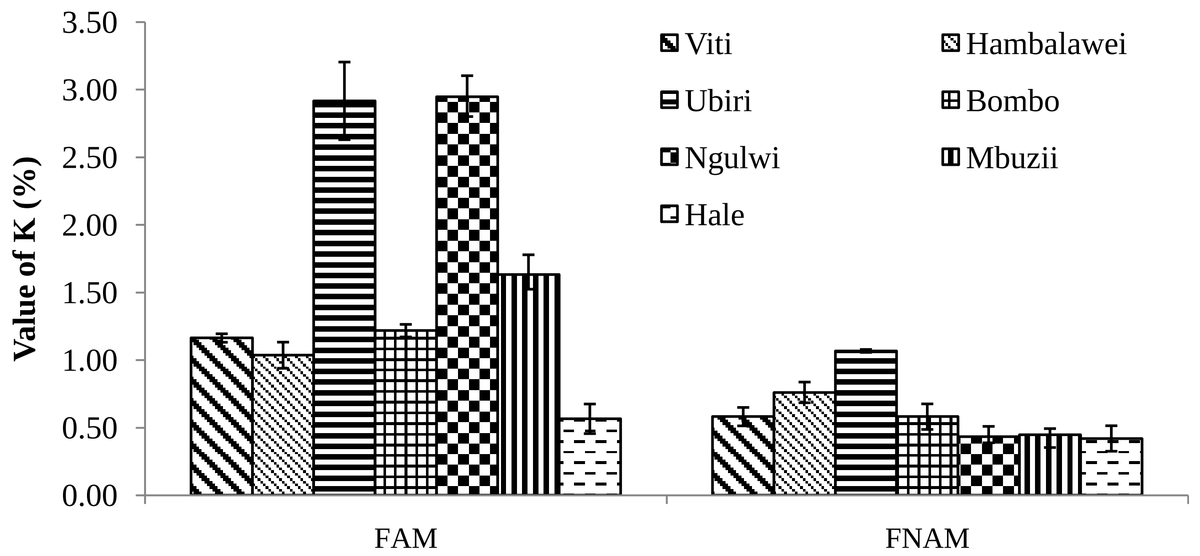

Figure 11: Soil Potassium in FAM and FNAM

NB: FAM = Farm Applied Manure, FNAM = Farm Not Applied manure

Table 7: Chemical properties of soil in the farms applied with manure (FAM) and farm not applied with manure (FNAM) at selected villages

Sites	Treatments (Soil categories)	pH	EC	CEC	SOC	SOM	AP	TN	K
			dS/m	Meq $100g^{-1}$ of soil	%				
Viti	FAM	6.86±0.2cd	0.19±0.03a	17.13±0.5cd	2.31±0.2abc	3.93±0.3abc	0.25±0.02b	0.21abc	1.16±0.03c
Viti	FNAM	6.98±0.3bc	0.17±0.01a	10.21±0.8fg	1.32±0.4e	2.28±0.6e	0.14±0.01de	0.16±0.02bcdef	0.58±0.07ef
Hambalawei	FAM	6.86±0.2cd	0.21±0.4a	15.41±1.2de	2.48±0.3ab	4.29±0.4ab	0.29±0.03ab	0.23±0.04a	1.03±0.1cd
Hambalawei	FNAM	6.97±0.1bc	0.08±0.01bcd	10.96±0.6efg	1.40±0.1e	2.41±0.2e	0.14±0.01de	0.12±0.01efg	0.76±0.08de
Ubiri	FAM	7.61±0.1a	0.11±0.01b	36.60±3.1a	2.11±0.4bcd	3.65±0.6bcd	0.25±0.08b	0.22±0.04abc	2.91±0.29a
Ubiri	FNAM	6.4±0.1cd	0.11±0.01b	11.73±1.3efg	1.34±0.2e	2.31±0.3e	0.11def	0.09±0.02g	1.06±0.01cd
Bombo	FAM	7.40±0.1ab	0.07±0.01bcd	21.45±0.9c	2.12±0.3bcd	3.65±0.4bcd	0.34±0.03a	0.17±0.04abcde	1.21±0.05c
Bombo	FNAM	6.92±0.2bc	0.06±0.01cd	13.24±0.8def	1.29±0.3e	2.23±0.6e	0.07±0.01ef	0.10±0.01fg	0.58±0.09ef
Ngulwi	FAM	6.40±0.1d	0.10±0.01bc	38.21±2.1a	2.73±0.2ab	4.71±0.3ab	0.15±0.01d	0.22±0.02ab	2.94±0.16a
Ngulwi	FNAM	6.66±0.3cd	0.08±0.1bcd	8.17±1.0g	1.63±0.2cde	2.82±0.4cde	0.10±0.1def	0.12±0.02efg	0.43±0.08ef
Mbuzii	FAM	6.58±0.1cd	0.05±0.01d	27.48±3.5b	2.96±0.2a	5.11±0.3a	0.14±0.01de	0.20±0.04abcd	1.63±0.15b
Mbuzii	FNAM	6.58±0.2cd	0.10±0.01bc	10.06±0.9fg	1.46±0.2de	2.52±0.4de	0.05±0.01f	0.15±0.01cdefg	0.44±0.05ef
Hale	FAM	6.98±0.2bc	0.10±0.01bc	13.60±2.1def	2.28±0.3abc	3.9±0.6abc	0.22±0.02bc	0.21±0.02abc	0.56±0.11ef
Hale	FNAM	6.48±0.1cd	0.07bcd	9.15±0.7fg	1.40±0.1e	2.42±0.2e	0.16±0.01cd	0.14±0.01defg	0.41±0.09f
F-Statistics	Sites	3.5**	12.86***	17.9***	1.5ns	1.5ns	5.6***	1.1ns	40.6***
	Treatment	6.01*	6.8*	238.3***	62.8***	62.8***	72.1***	44.9***	273.4***
	Sites*treatment	3.9**	5.6***	19.6***	0.5ns	0.52ns	3.7**	0.7ns	28***

Value presented in the table are means ± SE; *, **,***; whereby * = significant at $p \leq 0.05$, ** = $p \leq 0.01$, *** = ≤ 0.001 respectively, ns = not significant and SE = Standard Error. Means followed by same letter(s) in a column are not significantly different from each at P = 0.05 according to Fischer least significance difference (LSD).

Table 8: Total average of chemical properties in farms applied with manure (FAM) and farm with no manure application (FNAM)

Farm categories	pH	EC	CEC	SOC	SOM	AP	TN	K
		dS/m	Meq 100g^{-1}of soil			%		
FAM	6.95	0.12	24.26	2.43	4.19	0.23	0.21	1.63
FNAM	6.72	0.09	10.50	1.40	2.42	0.11	0.12	0.61

On average, FAM showed to have the highest chemical properties (Table 8). Generally, FAM in all villages recorded total nitrogen, available phosphorus and potassium of 0.21%, 0.23% and 1.63%, respectively while on FNAM the total nitrogen, available phosphorus and potassium was 0.12%, 0.11% and 0.61%, respectively. The soil nutrient indicators (Soil pH, electrical conductivity, and Cation Exchange Capacity) were also higher in FAM. These results indicated that when farmers use manure regardless of the handling process, still improves significantly the soil chemical properties in the soil.

4.5 Quality of Cattle Manure under Different Storage Practices

4.5.1 EC and pH

The average pH was 7.91 in Pit compost (PC) and 6.8 in surface storage (SS) and the highest was 8.9 in Fresh manure (FM) (Table 9). In the stored manure lowest pH and highest was 7.4 and 8.4 at Viti (PC) and Mbuzii (PC) while in surface storage, the pH range was 7.8 and 8.3 where the lowest and highest was found at Ngulwi and Mbuzii, respectively. The pH in manure and EC in PC, SS across the study sites was highly significant ($p \leq 0.001$). The range of EC was 1.47 – 1.89dS/m and 1.42 – 2.85 dS/m for PC and SS respectively. Figure 12 shows the pH in SS and PC are closely related. Too low EC levels indicated low availability of nutrients. From this finding, it is observed that SS manure has higher available nutrients compared to PC. The highest EC observed in SS at Hale and Mbuzii (Fig. 13).

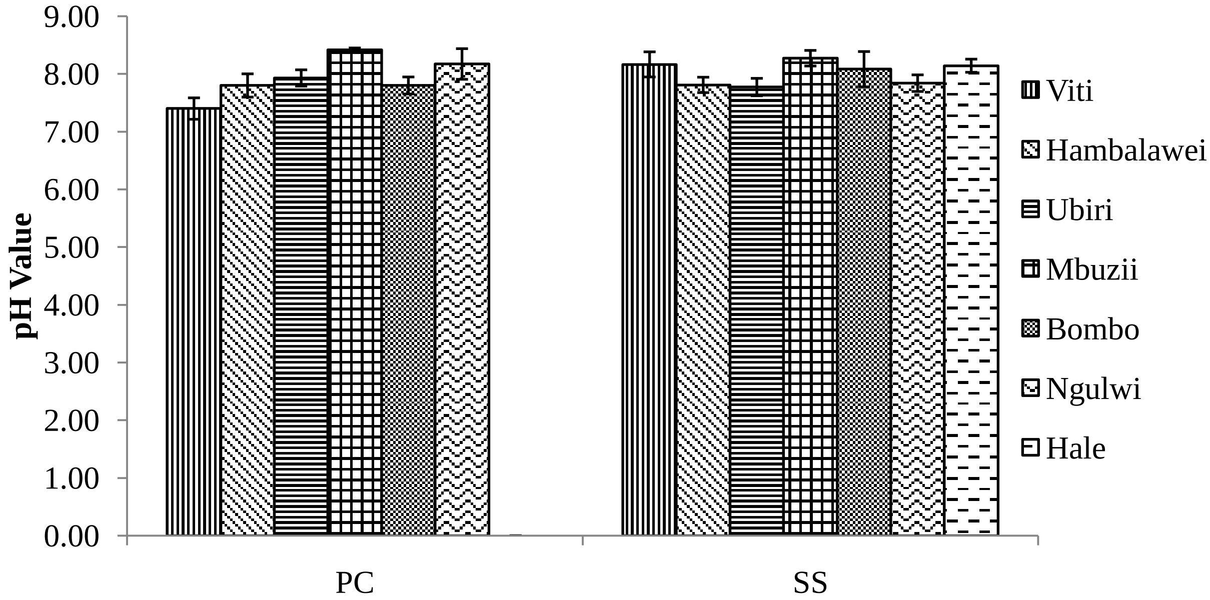

Figure 12: pH levels in manure under pit (PC) and surface storage (SS) practices

NB: PC = Pit Compost, SS = Surface Storage

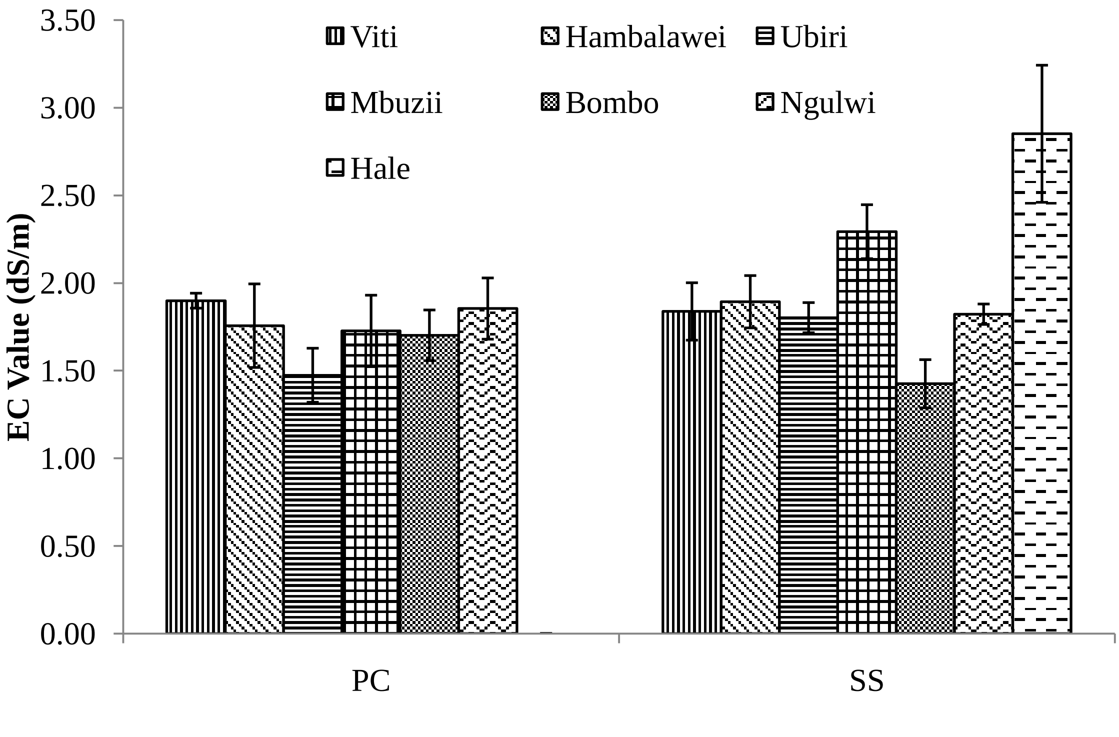

Figure 13: Content of EC in manure under pit (PC) and surface storage (SS) practices

NB: PC = Pit Compost, SS = Surface Storage

4.5.2 Total nitrogen (TN), available phosphorus (AP) and potassium (K) in manure stored in pits and on the surface

The average TN per storage practices was 1.78 and 2.51 for PC and SS, respectively. In fresh manure (FM) the average was 1.61% which was in agreement with Nandwa & Bekunda, (1998) findings who reported that most animal manures contain <2%N. The highest TN above 2% was found at Viti, Ubiri and Bombo in SS as well as Viti in PC. Figure 14 clearly shows highest TN was in SS.

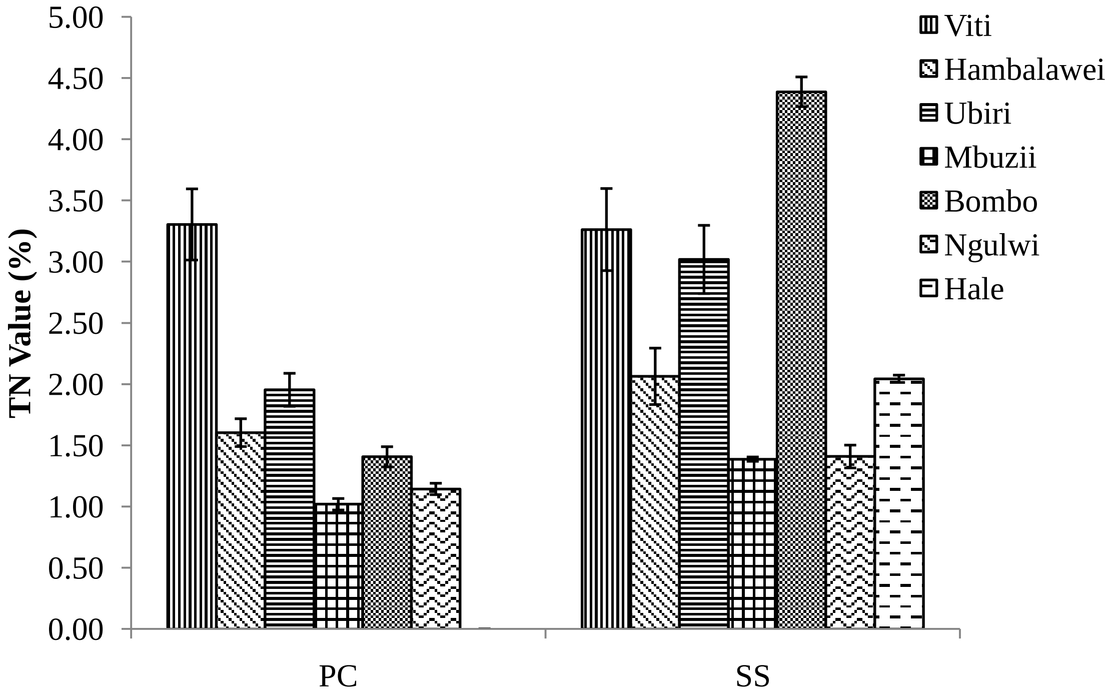

Figure 14: Content of TN in Manure under pit (PC) and surface storage (SS) practices

NB: PC = Pit Compost, SS = Surface Storage

The total nitrogen concentration could be affected by a type of cowshed of which more than half of the cowshed floors are made of soil (Table 5 above). Floor type positively contributes to leaching of nutrients and volatilization which occurs before manure collection. Lekasi *et al*. (2003) reported that proper roofing offered protection from the leaching effect of rain and from high temperatures, so it protects the loss of phosphorus and increases the manure quality. It was observed that, to some extent manure remain on the ground for number of days before subjected to pit of which volatilization and leaching might occur. Proper shade structure for all storage area may reduce the loss of nitrogen from manure and improve quality of feed materials because quality of manure is contributed with the type of feed (Rufino *et al*., 2007). Approximately 35% of total N and 78% of total P inputs into the farming system is from manure and inorganic fertilizer supplies 19% of N and 13% of P inputs (Harris *et al*., 2001). This implies that manure has a significant contribution to soil nutrients. Non-composted manure will generally have a higher N content than composted manure. However the use of composted manure contributes more to the organic matter content of the soil (Rosen and Bierman, 2016) which is an indicator of soil fertility (Muhmood *et al*., 2015). Figure 14 also shows that an effect of sites and treatments has contributed to the differences in TN.

Available phosphorus was found to be 1.53% and 1.78% for PC and SS, respectively (Table 9). Further, the result showed that there was a significant difference in SS and PC storage practice on the available P. The variation of AP per village is in Fig. 15. The highest of AP at Viti in PC might be due to addition of sawdust that are influencing the increased levels of phosphorus in manure when composted together with manure as reported by Aggarwal *et al.* (1984). Highest phosphorus was at Ubiri, Mbuzii and Bombo under surface storage.

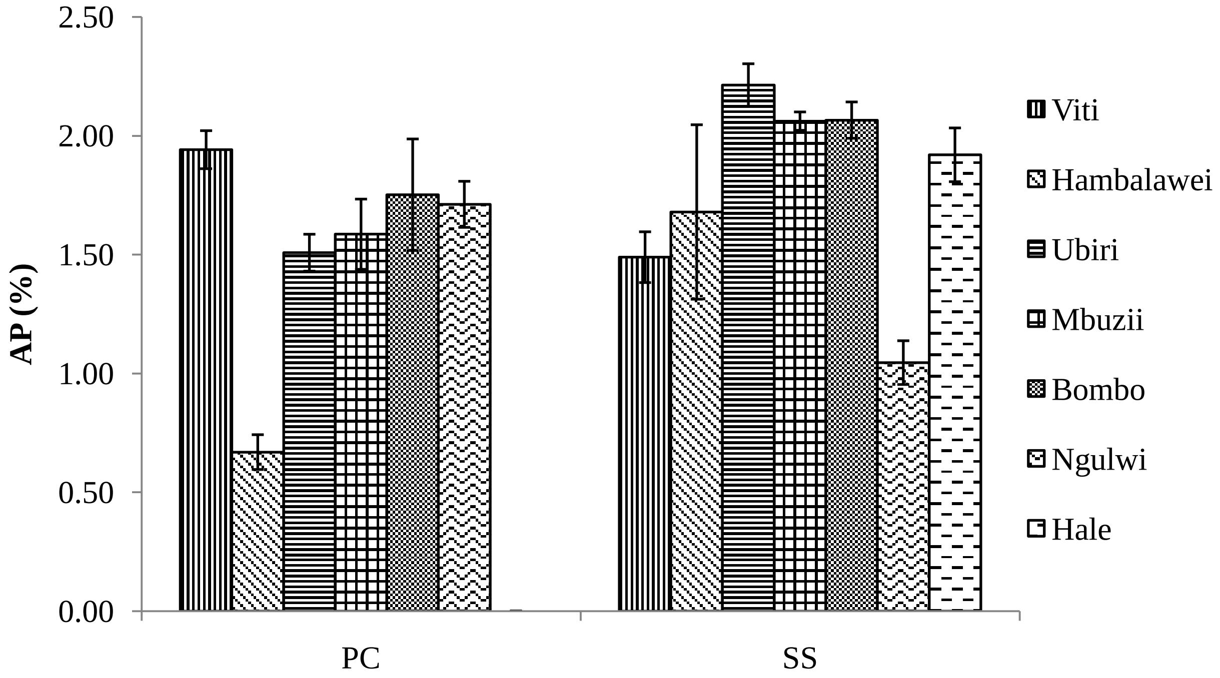

Figure 15: AP content under pit (PC) and surface storage (SS) practices

NB: PC = Pit Compost, SS = Surface Storage

K was found to be highest in fresh manure than in PC and in SS (Table 9). The average was 1.27, 1.23 and 2.40 in PC, SS and in FM, respectively. Lupwayi *et al*. (2000) also found nutrients in manure as 1.83%, 0.45% and 2.13% for NPK, respectively. The result also indicates that in both PC and SS, levels of K were below 2%. Generally, farmers could use digested slurry in addition to manure to improve soil K as it contains 1% K and slurry compost comprises 1.05% K (Karki and Expert, 2006) for Hale and Ngulwi (Fig. 16). Concluding this, the chemical properties in manure is also contributed by quality of feed/fodder. In order to improve the quality of manure there is a need also to understand the quality of feed offered to the animals.

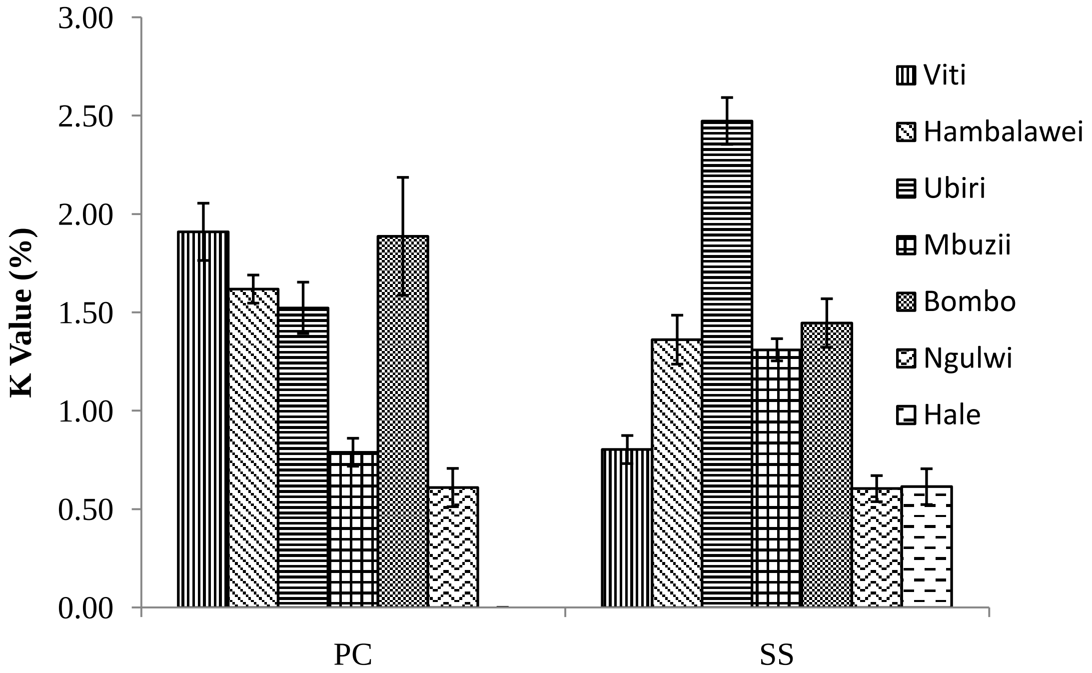

Figure 16: K content in manure under pit (PC) and surface storage (SS) practices

NB: PC = Pit Compost, SS = Surface Storage

Table 9: Nutrient value of manure storage under different practices in the study sites

Sites	Storage practices	pH	EC	AP	TN	K
			dS/m	%		
Viti	PC	7.4±0.2g	1.89±0.04bc	1.94±0.08abc	3.30±0.3b	1.91±0.2cb
Viti	SS	8.2±0.2cdef	1.83±0.2bc	1.49±0.1de	3.26±0.34b	0.8±0.07e
Hambalawei	PC	7.8±0.2fg	1.75±0.2c	0.67±0.07h	1.60±0.1cdef	1.62±0.07bd
Hambalawei	SS	7.81±0.1efg	1.89±0.2bc	1.68±0.4cde	2.06±0.2c	1.36±0.12d
A	FM	8.81±0.1ab	0.38±0.03c	0.68±0.09h	1.53±0.09cdefg	3.36±0.39a
Ubiri	PC	7.9±0.1def	1.47±0.2c	1.51±0.08de	1.95±0.1cde	1.52±0.13bd
Ubiri	SS	7.8±0.2fg	1.80±0.1c	2.21±0.09a	3.02±0.3b	2.47±0.12b
Mbuzii	PC	8.4±0.03bc	1.72±0.2c	1.59±0.2cde	1.02±0.1g	0.79±0.07e
Mbuzii	SS	8.3±0.1cd	2.29±0.2b	2.06±0.04ab	1.38±0.02efg	1.31±0.06d
Bombo	PC	7.8±0.14fg	1.70±0.14c	1.75±0.23bcd	1.41±0.08efg	1.89±0.3cb
Bombo	SS	8.1±0.13cdef	1.42±0.1c	2.07±0.08ab	3.39±0.12a	1.45±0.12bd
Ngulwi	PC	8.2±0.26cdef	1.85±0.2bc	1.71±0.1bcd	1.15±0.05fg	0.61±0.1e
Ngulwi	SS	7.8±0.14ef	1.82±0.1bc	1.05±0.09fg	1.41±0.09efg	0.6±0.07e
B	FM	8.9±0.03a	0.46±0.03d	0.75±0.1gh	1.85±0.5cde	1.56±0.05
Hale	SS	8.2±0.11cdef	2.85±0.4a	1.92±0.1abc	2.04±0.03cd	0.61±0.09e
C	FM	8.2±0.14cde	0.43±0.04d	1.34±0.06ef	1.48±0.03defg	2.43±0.14b
F-Statistics	Sites	1.71ns	8.38***	10.28***	19.49***	23.98***
	Practice	39.54***	180.06***	107.04***	37.16***	114.23***
	Sites*Practice	4.65***	3.05***	7.03***	11.74***	12.39***

Description of the abbreviation of PC, SS, FM are pit compost, Surface Storage and Fresh manure respectively while the Values presented in the table are means ± SE; *= significant at p = 0.05,**= significant at p ≤ 0.01, *** = p ≤ 0.001, ns = not significant, SE = standard error. Means followed by dissimilar letter(s) in a column are significantly different from each other at P = 0.05 according to Fischer least significance difference (LSD)

A- Represent fresh manure (FM) from upland villages
B- Representing fresh manure (FM) from midland villages
C- Representing fresh manure (FM) from lower village

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The general aim of this study was to explore the status of manure management and utilization practices that contribute to the effects of soil fertility in smallholder farms in 6 villages in Lushoto and one in Korogwe Districts. This study observed that, lack of proper and un-appropriate knowledge has significantly contributed to inappropriate management practices such as storage conditions and composting practice. The knowledge and awareness of biogas technologies was still unknown in some villages. The study asserted that according to farmers report, farms that manure was applied had relatively higher yields compared with farms that were not applied with manure. The lowest yield to farms that manure was applied might be due to the factors of agronomic practices i.e. seed type, season, time of planting or farm management. Type of feed offered to animal contribute to manure nutrients, the study observed the feed sources offered to animals are generally of low quality. Few of smallholder farmers are reported to supplement the animals with concentrates that have significant effects to nutritive value of manure. Surface storage of manure was identified as the common storage practice and has shown to have higher soil chemical properties than pit compost manure. This means leaching could be high or microbial activities does not work to its level and this call for further study to understand the factors contributes to these differences. Soil fertility indicators gave a clear implication that the soil has potential for crop production.

5.2 Recommendations

This study recommends that proper manure management is of importance to enhance and improve soil quality. To practice proper management and utilization, smallholder farmers are advised to accept new technology that is present or brought to their area particularly on manure management. This is because new technology improves the quality of the traditional practice i.e. biogas technology that improve the quality of manure (slurry) with a short period of time. This study recommends that in order to improve the quantity and quality of manure produced to ensure sustainability of high yield; the following could be adhered to:

(i) Storage area should provide shade to reduce temperatures, evaporation of urine and run-off due to rain water. To achieve this, on farm training by having a trials which is participatory among smallholder farmers and extension officer that will encourage farmers to practice the appropriate technologies while circulations of simple readable materials with an explanation of manure management from production level to utilization.

(ii) In the storage area better be installed with impermeable plastic at the base or concrete base below the manure collecting area to prevent leaching of nutrients and loss of urine before it is absorbed by bedding materials

(iii) Biogas as alternative use and source of energy from cow dung should be emphasized in Lushoto and Korogwe. This will ensure to use end product that is ready to use comparing with pit or surface stored manure.

(iv) At Hale village, smallholder farmers should be practically trained on the use of manure by having demonstration plots that will be judged by smallholder farmers' in-terms of yield to encourage many farmers to use manure for crop production.

(v) Integrated Soil Fertility Management is advocated (ISFM). Farmers should combine the use of mineral fertilizers and locally available soil amendments (such as lime and phosphate rock) and organic matter (crop residues, compost and green manure) to replenish lost soil nutrients.

The study recommends for further studies to evaluate the nutritive value of manure under different storage environments such as temperature, moisture and the quality of the feed/fodder on manure quality. This will help to understand the problems within the process so that could be scientifically proved and solved before encouraging farmers to engage in the two storage practices.

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APPENDICES

Appendix 1: Questionnaire used during baseline survey

Assessment of Manure Management and Utilization Practices for Enhancing Smallholder Dairy Farming Productivity in Lushoto and Korogwe District, Tanzania

Baseline Survey tool

A. Background/Personal information.

District Name ________________ Questionnaire No.______ Date: ____________

Site Name (Village) ______________________________ Ward ____________________

Enumerator name ______________________________ Enumerator mobile phone No. ___________

1. (a) **Household head name** ________________________ (b) Age ________________

   (c) Sex of household head 1. Male ☐ 2.Female ☐ (Tick as appropriate)

   (d) Level of education of household head ____

   (e) Main occupation of household head: ____________________________________

2. (a) **Name of respondent:** ________________________________ (b) Age ________

   (b) Sex of respondent 1. Male ☐ 2.Female ☐ (Tick as appropriate)

   (c) Relation of respondent to Household head ______________________________

   (d) Level of education of respondent ____________________________________

3. **Household Size**

Age-set(years)	Sex	Number	Number Resident (Including relatives and Workers)
< 5	Male		
	Female		
5-14	Male		

	Female		
15-17	Male		
	Female		
≥18	Male		
	Female		
Total	Male		
	Female		

B. Household resources

1. Type of Land tenure; where do you grow your crops

1. Communal ☐ 2. Individual ☐ (Tick as appropriate)

2. Indicate the type of land uses and acreage under each use and their production per area

Land Use	**Acres**	**Production per year (Kg)**
1.Cereal crops		
2. Vegetable Crop		
3. Pasture		
Others		
4		
5		

3. Number of animals owned by household

Cattle		**Goat**		**Sheep**		**Donkey**		**Chicken**	**Others**
Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**		
Total									

4. Rank the economic importance of your animals (Rank 4 – 1 in descending order according to its economic importance) (Description of ranking contribution; 1= 0-25%, 2=26-50%, 3=51-75%, 4=76-100%)

cattle		**Goat**		**Sheep**		**Donkey**		**Chicken**
Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**	

Reasons;____

5. Indicate the main sources of income and rank in order of contribution to the total household income (Rank 4 – 1 in descending order according to its economic importance)

Sources of income	**Rank**	**Contribution**	**Reason(s)**
Sale of cereal crops			
Sale of vegetable crops			
Sale of cattle			
Sale of milk			
Sale of manure			
Business			
Employment			
Any other: Specify 1			
2			

C. Information of manure Utilization

1. Do you know the importance of manure ___Yes☐ , ____No ☐ Tick appropriate answer
2. Can you mention uses of manure in your community?
   i. ____
   ii. ____
   iii. ____
3. Do you use manure in your farm? ___Yes ☐, ____No ☐ Tick appropriate answer.

4. How frequently do you use/apply manure per year in your farm? 1, 2, 3. Circle the correct number.
5. How much manure is produced from your cattle per year? _______ (Enumerator, estimate in meter cubic by observation)
6. How do you apply in the field?
   i. Broadcasting   ii. Direct to plant hole before planting
   iii. To plant line   iv. Other; ______________________________
7. Have you got any training concerning to manure management and utilization for crop production? ___Yes ☐, ____No ☐ Tick appropriate answer.
8. If YES, mention them (Project or NGOs) and year the training were provided. (mention)
   i. _________________________ ______ (year)
   ii. _________________________ ______ (year)
   iii. _________________________ ______ (year)
9. What is the common feed type your giving your animals
   i. ______________________________
   ii. ______________________________
   iii. ______________________________
   iv. ______________________________
10. Indicate types of manure status you're using in your farm for crop production. (**1**=Fresh manure, **2**=Dried manure, **3**=Composite manure)

Manure type	**Crops applied**						**Status of manure when applied, 1, 2, 3.**
	Maize	**Beans**	**Vegetable**	**Banana**	**Pasture**	**Others**	
Cattle manure							
Goat/Sheep manure							
Poultry manure							

11. When do you apply manure in your farm?

Time of manure application	Crops applied					
	Maize	Beans	Vegetable	Banana	Pasture	Others
1. Before planting						
2. After planting						
3. After harvesting						

12. What is the difference production per area (your area) when you started to use/apply manure in your farm?

Crops grown	Area size-acre	Production without use of manure (in bags)	Production when using manure - (bags)
1. Maize			
2. Beans			
3.			
4.			
5.			

D. Information of Manure storage

1. How long do you store manure before taken to the field? (circle the right letter)
    a) 1-2 month
    b) 3-4 month
    c) 5-6 month
    d) More than 6 month
2. How do you store manure before taken to farm/before decomposing (circle the right letter)
    a) Under tree shade
    b) Under Pit storage
    c) Under constructed shade structure
    d) In open area without covering
    e) In an open area with covering (of what material)_____________________

3. The manure that you collect from your cattle pen is enough for your farm? Yes ☐, ☐ No

E. Information on composite manure.

1. Do you compose manure __________ Yes ☐ , No ☐
2. If yes, how do you prepare for composting?

   ____

   How long do you decompose manure in the pit? 1-2month, 3-4month, 5-6month, above 6month.
3. Have got any training concerning manure composting? Yes , No
4. If YES, mention name of the Project or NGOs and year the training were provided.
   i. ___________________________ _______ (year)
   ii. ___________________________ _______ (year)
   iii. ___________________________ _______ (year)
5. What is the distance from cattle pen to farm where you use manure? Circle the right answer.
   i. Around homestead
   ii. Within 100meters
   iii. Within 100 – 200meters
   iv. 200-500meter
   v. Above 1000meters
6. What are the constraints in using compost manure? Circle the right answer.
   i. Lack of knowledge how to make compost
   ii. No enough manure
   iii. ____
   iv. ____

F. Cattle house information

1. Type of cattle pen you have. a) Roofed, b) Unroofed, c) Kraal
2. If the pen has roof, what type of roof? a) Iron sheet, b) Thatch grass c) Plastic materials d)
   Others;____
3. Wall material of your cattle pen. a) Block b) Brick c) Timber d) Tree pole
4. Type of floor. a) Concrete floor, b) Sand, c) Slatted floor.

H. Biogas information

1. Do you know/have you heard biogas technology? Yes ☐, No. ☐
2. Do you have biogas plant? Yes ☐, No ☐
3. If YES, where did you get it? (Circle the right answer)
   i. Project (mention the project name) ______________________________
   ii. I buy my self
4. Do you use it currently? Yes ☐, No. ☐
5. If No, Why you're not using/causes why does 'NOT' work
   i. ____
   ii. ____
   iii. ____
6. If it works, how does it help you?
   a)____

b)____c)_____

____

7. What is the main energy source in your family? (Circle the right)
   i. Electricity for lighting
   ii. Electricity for cooking
   iii. Firewood for cooking
   iv. Charcoal for cooking
   v. Kerosene for lighting
   vi. Biogas for cooking/lighting
   vii. Other sources. ________________, ______________________
8. Where do you get charcoal and firewood? a) Buying b) Cutting from the forest c) Other source;____
9. What is the distance to the forest where you're collecting/cutting firewood? ___(In km)

I. Industrial fertilizers information

1. Do you use industrial fertilizer in your farm? Yes. No
2. Which type of fertilizer do use? a) __________ b) ___________ c) _____________
3. In which crops do you use usually?

i. Maize
ii. Beans
iii. Vegetable (specify; ______________, ________________,
____
iv. Fruits plants
v. Other crop __________________, ____________________,
____

4. What is the price for a bag of 50kgs for______________________________________

Any observation by the enumerator

____
____

Thank you for sharing your experience

RESEARCH OUTPUTS

(a) Review and research articles

Patrick Rukiko, Revocatus Machunda, Kelvin Mtei (2018). Cattle dung production, management and utilization practices in the smallholding dairy farming systems of East Africa: A situational analysis in Lushoto District, Tanzania. *J. Bio. Env. Sci.* **12**(4), 84-95.

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REVIEW PAPER OPEN ACCESS

Cattle dung production, management and utilization practices in the smallholding dairy farming systems of East Africa: A situational analysis in Lushoto District, Tanzania

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Key words: Dung, Manure, Lushoto District, Smallholder dairy farmer, Biogas

Abstract

This focus review aims to update the dung and manure production, management and utilization in the East African countries and its associated challenges particularly in the case of Lushoto district, in northern Tanzania. Attention and efforts are continuously being made to promote the use of cattle dung though the challenges still exist. Majority of smallholder farmers in the East Africa poorly manage cattle dung such that its quality is impaired. Such practices include exposing the dung uncovered in a heap and applying directly to the crops. A survey conducted at Lushoto district in the smallholder dairy farmers observed poor management from collection of dung, processing or storage to utilization causing losses of potential nutrients when it's used as manure. Additionally, the knowledge on other uses of cow dung such as for biogas production is not adequately known. This review, therefore, revealed the need for training farmers on issues related to dung management and utilization such as the nutrient recycling at the farm scale. Cattle dung has been for a long time used as manure in agricultural production and recommendations especially on the applications and users have been generalized to a wide range of areas. There is a need to establish area specific recommendation on dung management from production to the final use. For sustainability of the knowledge, readable materials, an appropriate intervention of biogas plant, manure storage (shade structure) and decomposition process that will create awareness from production to farm application are required.

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Introduction

Cow dung is defined as the undigested residue of consumed food material being excreted by bovine animal species in particular cattle and buffalo (Gupta *et al.,* 2016). Nutrient concentration in cow dung varies with diet, water intake, genetic, health and feed conversion efficiency of a specific bovine animal especially for indoor systems whereby diet selection by animals is replaced by human perceptions of animal needs (Powel, 1994). Cow dung has many uses including; used as building materials, as fuel (Jahnke, 1982; Saadullah, 2002) and as fertilizer when processed from the biogas plant (Islam, 2006). In general, cow dung is perceived as plenty resource in the majority of the smallholding dairy farming in East Africa and thus can be used for soil fertility improvement to enhance crop production (Scoones, 1992). Therefore, manure from smallholder dairy keepers contributes to food security by increasing crop output and income in the poor households (Lekasi *et al.,* 2001).

It has been reported by Snijders *et al.,* 2009 that the major benefits obtained from the use of cow dung as manure include the increase of crop yields by 52.5% and disease reduction by 30%. Moreover, maize yields from improved cattle manure applied at a rate of 2.5 t ha^{-1} increase production by 50% in Uganda as reported by Zake *et al.* 2010. At Vihiga, western Kenya, it has been reported that manure use is more important to the production of food crops than of cash crops, and this is critical to low-income households (Waithaka *et al.,* 2007). Also, in Kenya, manure create income by 75% through selling to individual traders or brokers by 20% through selling directly to farmers, and by 5% through selling directly to large and small horticultural farms (Njoka *et al.,* 2013).

Despite those benefits cow dung is still given less emphasis by smallholder farmers who are primary producers of agriculture products (Kiratu *et al.,* 2011). Recently, smallholder farmers have been experiencing a decline in agricultural productivity, mostly due to soil fertility depletion that leads to food insecurity (Ngetich *et al.,* 2012).

Such deterioration in productivity is considered to be among the major constraints to economic development in Sub-Saharan Africa (Lunge, 2002). Soil fertility depletion or soil nutrient mining in Sub-Saharan Africa and many tropical cropping systems is contributed by traditionally cleared land while giving nothing back to the soil (Zake *et al.*, 2005; Henao *et al.,* 2006; Baitilwake *et al.*, 2011). Soil nutrient mining is also contributed by the majority of smallholder dairy farmers who do not allow cattle to graze in the maize fields after harvest as a way of adding manure to the field (Materechera, 2010). Therefore, there is a need for cow dung management from excretion to utilization as manure for replenishment of the lost nutrients from agricultural fields.

Many mixed farming systems in Sub-Saharan Africa rely upon organic matter recycling to maintain soil productivity (Lekasi and Kimani, 2003). It has been reported that un-affordability of mineral/inorganic fertilizers due to escalating prices, anticipates more smallholder farmers in Sub-Sahara Africa to turn to the use of organic sources that are not only available but also affordable for low-cost for enhancing crop productivity and improves soil water holding capacity, cation exchange capacity, and soil structure (Harris *et al.,* 2001; Achieng *et al.,* 2010). Currently, the human population is exponentially growing and most of the smallholder dairy farmers live in peri-urban areas, so farmers are encouraged to maximize crop yields per unit area through intensive cultivation (Henao *et al.,* 2006; Muhmood *et al.,* 2015).

Information on nutrient losses between excretion and application of manure is still limited under smallholder conditions in the tropics, due to the wide variation in farming conditions and variation in livestock and manure management (Snijders *et al.,* 2009). Therefore, in order to maintain the consistency of dung and manure quality, it is important to disseminate proper knowledge on dung collection, management, storage, and utilization that would minimize nutrient loss and allow the nutrients to be readily available to the plants for maximizing crop yield.

Cow dung production

Dung production from a cow is influenced much by the amount of feed intake related to fodder resources which in smallholder systems especially in tropics depend on rainfall that is extremely variable in amount and distribution over the season. The estimated dung production for cattle is 4 to 5 and 2 to 2.5kg DM day^{-1} for crossbred and local cattle respectively according to Raussen, 1997 as was cited by Jackson *et al.,* 2005 and the average value of moisture content of dung is 60% (Aggarwal *et al.,* 1984). Other study reported in Zimbabwe indicated that; daily production of fresh wet dung averaged 4.8% (range 3.3-6.5%) of the live body weight (Vale *et al*., 2004). El-Mashad and Zhang, 2010 reported that 1800 cows produce 83.1 ton of wet manure daily in the USA, which is an average of 46.26kg^{-1} cow while Jackson *et al.,* 2005 reported that in an average of two herds of cattle per household, farmers are likely to produce 2 to 3 tons DM of manure per year. The significant differences could be influenced by body weight and food as reported by Vale *et al.,* (2004). It was reported in another study of estimating manure production in 15 households whereby 1300kg ha^{-1} and 3800kg ha^{-1} was collected during dry and wet season with an approximately of 22kg N ha^{-1}, 2.7kg P ha^{-1} and 45kg N ha^{-1} and 5.7kg P ha^{-1} for dry and wet season respectively (Powell and Williams, 1993). This means manure production depends much on the availability of fodder which is perceived to be plenty at wet season than in dry season.

In West Africa for instance, palatable crop residues are harvested at the end of the cropping season and stored for consumption at a later period to reduce the fodder shortage as well as to maintain dung production (Harris, 2002). Weiss *et al.,* 2007 pointed out that dung excretion increased on average with increasing milk production although this is not necessary due to increased milk is the result of adequate feed which may contribute to dung excreted. The total amount of dung that needs to be removed from the cowshed is affected by on stocking rate, digestibility of the diet, moisture content, frequency of cleaning and techniques.

Indoor rearing system of dung collection is also affected by floor type. Cattle house made by concrete floor rather than soil floors results in not only higher quality but also quantity of dung (Bationo *et al.,* 2004) which provide maximum opportunity for dung collection compared to traditional "kraal" which have poor drainage (Lekasi *et al.,* 2001; Snijders *et al.,* 2009). Lenkaitis, 2014 reported techniques for dung collections in USA that *flush system* involve dilution of the solid content of the available materials which can vary from 10:1 to 2:1 parts of water to dung while *Scrape Systems* does not use any additional liquid for dung collection. Dung is collected as close to as excreted solids concentrations as possible, but depending on the amount of bedding and the amount of water used in cow and collection is accomplished by mechanical means and the last is *Cross Gutter* Collection Systems whereby collection system requires an additional transfer system to move dung from each alley across the barn to pit outside of the animal housing system. Majority of farmers in East Africa practice the same way as *scraping system* as reported by Kim *et al.,* 2013; Lupindu *et al.,* 2012 probably due to water shortage or lack of knowledge but also the rest two systems need an investment of facilities for storage of slurry of which many smallholder farmers cannot afford. Introducing an affordable, cheap and efficient system for dung collection to enhance manure collection after dung production is important in the smallholder dairy systems especially in Sub-Saharan Africa.

Cow dung management and utilization practices

Cow dung handling

Cattle dung is the primary on-farm manure resource and is generally of low quality due to poor management practices in Sub-Saharan Africa (Zake *et al.,* 2010). Cow dung management encompasses all activities associated with management of dung and urine; from excretion, collection, housing, and storage (Teenstra *et al.,* 2014). The practice of management determines the usefulness of dung. Dung can be used for biogas production and as well as fertilizer or manure. Management strategies identified in some areas of Kenya include covering, turning and adding ash or water.

Only the small and medium farmers practice a single strategy, the most notable being covering (Lekasi *et al.,* 2001) and the nutrient composition is highly influenced by the way the dung was stored (Bayu *et al.,* 2005). In Kenyan highlands, manure is stored for about 6 months (Tittonell *et al.,* 2010). The longer manure remains in the housing or storage area before removal, the more chances for nitrogen loss (Barker *et al.,* 2002).

Covering of manure heaps influences all microbial changes and biochemical reactions during the decomposition process (Dewes, 1995) if well covered. According to the experiment reported by Dewes *et al.,* 1991, 24.8 to 44.4% of nitrogen was lost through NH_3 emission compared to 2.5 to 3.4% of nitrogen content leached with liquids. Other study in Kenya reported that the amount of N lost from manures that were covered was lower than that of uncovered manures and the N loss was equivalent to 19.23% with cover and 46.13% without cover, respectively (Gichangi *et al.,* 2006). From that finding covering of heap manure is important for minimizing loss of nutrients. However, many farmers leave manure uncovered in a heap as the most common storage method while others apply the manure directly as fresh (dung) to crops (Lupindu *et al.,* 2012; Muhereza *et al.,* 2014). Lindgren, 2013 reported that one methods of preventing ammonia emissions from storage facilities is to change a system that generates solid manure to a system that gives liquid manure because the ammonia emissions can be decreased since liquid manure is stored under anaerobic conditions. Biogas plant is working under anaerobic condition so efforts are required to smallholder farmers to invest in this technology to reduce the loss of ammonium which is the product of nitrogen nutrients.

In central Uganda, as reported by Zake *et al.* 2010 manure was delayed and irregularly collected ranging between 1 to 2 weeks after deposition by cattle. Formally, in Uganda storing of the manure collected in roofed stacks gave the best results in terms of their fertilizing qualities; however, this technique was found to encourage the breeding of flies and had the possibility of carrying human disease (Wejui *et al.,* 2002).

In Morogoro Tanzania, Lupindu *et al.,* 2012 had reported that, after collection into a heap, manure was moved to storage area either by bare hands or water splash using utensils such as spade, bucket, wheelbarrow, plastic bag or rawhide. Kim *et al.,* 2013 observed that farmers at Garinka, Rwanda; primarily used tridents, hoes, and baskets to facilitate manure handling and transportation and over 60% of farmers used their hands, often with banana leaves to collect cow dung. Significantly more female farmers were observed to practice in this local collection method than men.

Some practice of leaving manure uncovered in a heap has also reported by Muhereza *et al.,* 2014 in Central Uganda as the most common storage method although some farmers are providing shade to heaped manure, others applying it directly to crops while in the mixed systems most manure is not returned to grazing land (Herrero *et al.,* 2013). The recommended method for making farmyard manure in Uganda was to store the manure under the cattle until required and cattle be kept in a covered shed, darkened as much as possible to reduce the breeding of flies, and bedded down daily. It is further reported that little labor was involved in this process before the final transportation to the field and was suitable for use by the native farmer (Wejuli *et al.,* 2002). On contrary, Zake, 2005 in his study reported that covering cattle manure is not widely adopted practice by farmers the main reason being lack of covering materials. However, still there could be undiscovered alternative covering ways to reduce volatilization loss of nutrients. From these reports, it is therefore evident that the knowledge and skills on cow dung collection and manure handling is undoubtedly limited which then calls for a need to invest on practical training especially to smallholder systems.

Cow dung utilization

Cow dung is composed of feces and urine while manure consists feces, urine and materials used for bedding/left over-feeds (Tisdale and Nelson, 1958) which can be used manure as fertilizer and dung for biogas production.

The by-product from the biogas plant (bio-slurry) used as organic fertilizer to enhance agricultural productions and 50% use bio-slurry for their production in rural Bangladesh (Khan and Martin, 2016) while 68 and 52% use manure in rural and urban areas respectively (Saadullah, 2002). Bio-slurry maintains soil fertility and can be applied directly to crops without prior composting; this is evident from adopters in Arusha, Tanzania as reported by Laramee and Davis, 2013. Therefore, instead of composting manure for six months, farmers could use this technology to increase the value of their manure.

Cow dung as manure

Dung can be used as manure by providing nutrients for crops and positive effects to plant growth when directly applied to the soil. However, Dung may inhabit some harmful as well as beneficial insects (Halling-Sorensen *et al.*, 1998), may have relatively high temperatures that could harm the plant and may contain weed seeds that could germinate when applied in the farm (Pleasant and Schlather, 1994.) The reasons above justify the need for complete decomposition of the cow dung before applying in the crop fields. Manure releases nutrients (from composted dung) (Aggarwal and Singh, 1984) and has the ability to increase soil productivity by improving organic matter content and soil physical properties (Bayu *et al.,* 2012). Manure has also been found to reduce the population densities of *Heterodera rostochiensis* in potato roots (Van der Laan, 1956). Manure contains all the nutrients needed for plant growth including trace elements and has the potential for improving soil fertility (Achieng *et al.,* 2010; Ngetich *et al.,* 2012). In most farms, animal manure used is mainly from cattle (65%) with the rest coming from diverse sources such as sheep and goats (6%) and 4% poultry (Lekasi *et al.,* 2001).

In Kenya more than 95% of smallholder farmers growing maize use animal manure (Ngetich *et al.,* 2012). Most cattle keepers dispose the manure either as fertilizer or waste within a radius of 10 m from their residential house (Lupindu *et al.,* 2012). Manure is mostly used in maize fields (Jackson and Mtengeti, 2015) and due to transportation need, its use decreases with an increase in steepness of the land (Ketema and Bauer, 2011).

The efficiency of manure utilization by a crop is determined by the method of application, time of incorporation and rate of decomposition in the soil (Achieng *et al.,* 2010). Efficiency also determined by the right amount of the composition of manure and an accurate estimate of crop requirements (Schröder, 2005). If manure is spread on the ground without being mixed into the soil then a large portion of the ammonia nitrogen can be lost to the atmosphere (Chastain *et al.,* 2004). Repeated applications of manure can result in their building to detrimental levels (Kuepper, 2000). A study done in South Africa showed that the majority (78%) of the farmers broadcast the manure and plows it under with a hoe or tractor before planting. The second most used method was applying manure in open fallows either as a continuous line (63%) or spot application and 7% farmers were mixing the manure with water and applied the solution to the soil around the root zone of the plant (Materechera, 2010). To ensure maximum utilization of manure contents and to reduce any environmental effects, therefore, proper application rate, time and application methods should be adhered to by farmers.

In Africa, the average nutrient losses of nitrogen (N), phosphorus (P) and potassium (K) in soils range from 9 to 88kg of NPK/ha per year (Henao and Baanante, 2006). In Tanzania, the amount of nitrogen and phosphorus removed from the soil every year by the main crops was estimated to be 251,448 tons N, and 115,112 tons P_2O_5 by the year 2000, only 21% and 14% of N and P removed respectively was projected to be replaced through fertilization (Kaihura, 2001). Other losses were reported from Kenya, Uganda, Rwanda, and Burundi for the rate of 68, 66, 77 and 77 respectively of NPK kg/ha/year (Henao and Baanante, 2006). The fact that many smallholder dairy farmers have small plots and if the manure produced per cattle could be managed properly, it will suffice the respective farmers' plots for enhanced land/soil productivity. It's approximated that farmers could use 6,000 kg ha^{-1} $year^{-1}$ of manure on their fields as reported at Garinka, Ngoma district in Rwanda (Kim *et al.,* 2013).

According to Materechera, 2010 high ranges in values of most of manure are reflected by differences in management such as feeding, housing, application method, rate and frequency of application of manure at the household/farm level. Harris, 2002 reported that the quality of manure produced by livestock varies according to their diet. The manure from improved management practices performed considerably better than the farmers' manure management practice in terms of cattle manure quality (Zake *et al.,* 2010). Tethering system of livestock has also been reported to affect the collection of good quality manure (Waithaka *et al.,* 2007). Animals fed on high levels of concentrates produce excreta with larger amounts of N (Lekasi and Kimani, 2003). The use of cattle concentrate feeds would be a way of improving the levels of phosphorous in manures and because of the economic aspects, this is only feasible in areas where milk production is intensive (Waithaka *et al.,* 2007). According to Lekasi *et al.,* 2003 roofing offered protection from the leaching effect of rain, from high temperatures and the loss of phosphorus thus increasing the quality of the manure. It is therefore evident that the qualities of animal feeds and animal housing are essential for improving the manure quality.

Cow dung as energy sources

Cow dung can be used for producing energy as biogas (Teenstra *et al.,* 2014). Cow dung from 3–5 cattle/day can run a simple 8–10m^3 biogas plant which is able to produce 1.5–2m^3 biogas per day sufficient for the family of 6–8 persons for cooking 2-3 times/meal or may light two lamps for 3 hours (Werner *et al.,* 1989). The biogas produced can also be fed into biogas generators to provide lights and run other types of equipments on the farm (Amankwah, 2011). In Tanzania, energy access is about 2% in rural areas (Uisso, 2009) and more than 80% of energy delivered from biomass is consumed in rural areas. Heavy dependence on biomass as the main energy source contributes to deforestation (Msyani, 2013). In Kenya, wood fuel is accounting up to 95% of total energy consumption in rural households and nearly 60% of urban dwellings (Wamuyu, 2014) while few using charcoal occasionally and rarely gas (Ngetich *et al.,* 2009). Although the technology is more advantageous, there are constraints facing smallholder dairy farmers. Some factors that reported from Rungwe district by Mwakaje, 2012 are the relative too high installation costs, lack of credit facilities, lack of expertise and inadequate water to run the plants. Most of the plants in Africa have only operated for a short period due to poor technical quality (Amigun *et al.,* 2012) and management. Capacitating technical skill to local members who are easily available within the community would help to maintain the plants in case of minor problems at a reduced cost. Teenstra *et al.,* 2014 reported using cow dung for producing biogas as one way of reducing climate emissions partly by minimizing or eliminating the dependence of wood-fuel among smallholder farmers.

Nonconventional uses of cow dung

In African traditions, cow dung has been used since time in memory for various purposes. For instance, smoke from burning cow dung has been used to drive away or kill insects and other pests when burnt in clay pots or on the open ground and the smokes engulf the sick animal or the entire herd (Dharani *et al.,* 2015). In Addis Ababa, cow dung is used as plastering material for houses and can also be used as fuel in form of dried cow dung cakes which are also sold for income earning (Desjeux, 2001; Guendel and Richards, 2002; Taddesse *et al.,* 2003). Cow dung is often applied to the floors of rural homes in India and may be applied to the walls as well (Udayani *et al.,* 2008). However, Taddesse *et al.,* 2003 cited in Girma, 2001 reported that the practice reduces soil fertility and nutrient recycling in grazing land. The Maasai people of sub-Saharan Africa traditionally apply cow dung to the umbilical stump of a baby born to underline the close connection (Meegan *et al.,* 2001).

Therefore, cattle dung act as one of the traditional assets passed from one generation to another explaining way of living from ancestors.

Situation Analysis on Cow Dung Management and Utilization Practices in Lushoto District, Tanzania

Preamble

Lushoto district is found in Tanga region, in the North Eastern corner of Tanzania with an altitude of 1000 – 2100m above sea level and is famous for horticultural products. The district had a number of projects such as SECAP (1980-2000), TDDP (1991-2005) and Heifer International (1986-2006) that implemented developmental and research activities mainly on milk production, dairy cattle management, and agricultural production. The manure produced by the same animals has not been significantly investigated by such research activities in terms of its management and utilization to explore its potential in this area.

The current Community Action Research Project (CARP) conducted a household survey through direct observation and interviewing three households per village to assess cow dung production and the consequent manure handling and utilization. It was generally observed that poor manure management and utilization practices are common in Lushoto Districts and that there is a need to undertake a detailed study.

Cow dung production

Lushoto has a total of 90929 cattle; indigenous cattle 68197 and cross breed 22,732 and the surveyed villages comprise a total cross breed of 2159 (summarized in Table 1) that if fed well could produce an average of 25908kg day^{-1} of dung. With this dung production, respective farmers could have sufficient cow dung for manure, energy source and other uses.

Table 1. Dairy cattle population in surveyed villages in Lushoto district.

Village	Number of Household keeping dairy cow	Dairy cow population	Estimated cow dung production (fresh weight kg day^{-1})**
Ngulwi	134	402	4824
Bombo	89	267	3204
Viti	167	501	6012
Hambalawei	129	388	4656
Ubiri	96	428	5136
Mbuzii	65	173	2076
Total	680	2159	25908

**Fresh dung was estimated by taking the average production 4.8% (Vale *et al.*, 2004) per day times average Tropical Live body weight per dairy animal (250kgLBW) (Thornton and Herrero, 2010).

Cow Dung Management and Utilization

It was observed that dung is collected from the cattle pen and piled outside the pen for an average of six months until the pile is big enough to be shifted to the farm or into a pit. However, some farmers reported that the manure is gathered into large pits for about 12 months before being transferred and spread to the crop fields, particularly the nearby banana, maize and beans farms. For all that period, the manure is left uncovered (Fig. 1) resulting in accelerated loss of nutrients such as nitrogen and phosphorus through leaching and volatilization and might pose environmental risks. Majority of cowshed had poor quality with no concrete floor which might contribute to low manure collection and of poor quality.

Manure application is normally done 2 to 4 times a year depending on the type of crop grown and seasons, this is the evidence that manure is much used in the area and farmers require high quality manure for soil nutrient improvement. Another improper practice observed was the time and rates of application whereby there was an unknown amount of manure applied per area in which farmers could use the rate that may lead to negative effects on either plant or soil. Farmers point out that, the majority has 0.25–1.5 acre for their agriculture activities implying that if the manure produced in a household was applied at average rates of 2.5 t dry matter ha^{-1} with 50kg of nitrogen and 9kg of phosphorus (Probert *et al.,* 1995) could suffice the need for such a small farm.

The ratio of 2.5t ha^{-1} could replenish the average annual loss of 22kg N and 2.5kg of phosphorus (Sanchez, 2002). Therefore, there is a need for further study to know the available amount nutrients in soil and in manure so that the study could recommend the proper application rate for manure per land size.

Fig. 1. Uncovered cattle manure heaped behind cowshed indicated poor storage that poses environmental pollution risks and nutrient loss, Ubiri village.

As for the alternative dung utilization especially for domestic biogas, out of eighteen households that were surveyed in the six villages, only one household owned a biogas plant. The biogas plants were no longer function due to poor management (Fig. 2). Moreover, when was function, was underutilized and the use of bio-slurry was rather limited or completely unused. Observations and farmers opinion depicted the need for interventions by practical training on manure management techniques and promotion of biogas production from dung, especially at the household level. Every interviewed/visited household was excited with the biogas idea.

Fig. 2. Biogas plant at Viti village indicates poor management that lead to low gas production and destruction of the plant system.

Conclusion and recommendations

According to various literatures proper cow dung handling could lead to the production of manure which when appropriately used among smallholder farmers, it evidently increases crop production and securing sustainability in smallholding farming system. The major challenges identified to be facing farmers include limited knowledge and skills of cow dung handling and its benefits- from excretion to collection (e.g. importance of urine for nitrogen), manure handling and awareness of the associated losses of available nutrients due to poor handling, storage practice/duration, manure utilization especially in terms of application rates and cow dung alternative uses such as biogas production. Similar challenges were observed in the surveyed villages of Lushoto. Further to the poor management of cow dung and the manure, farm production is not up to the level is supposed to be when using manure. Farmers need to be practically trained on appropriate cow dung collection and proper manure handling and utilization as well as the alternative use of cow dung, especially on biogas production. Due to the potential of the area for agriculture activities, farmers could be trained on the importance of nutrient recycling to reduce nutrient mining as a factor for nutrient depletion which is predominant to farms that are at the hill where maize is produced but the return of nutrients through fertilization is very minimal. This focused review and the situational analysis in the smallholder dairy systems of Lushoto reveals the need to investigate on cow dung production, handling practices and the ultimate uses with emphasis on manure and biogas production. Proper recommendation on manure or biogas slurry application to the farms requires establishing the quality of the manure and characterizing soil from the intended farms. The appropriate farm-level cow dung management practices and manure/slurry uses could be documented for all-time use and for sustainability of the adequate practices.

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Research article 2

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RESEARCH PAPER OPEN ACCESS

The use of cattle manure and their implication on soil chemical properties amongst the smallholder farms in Lushoto District, Tanzania

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Key words: Manure management, Manure utilization, Farm applied with manure, Farm not applied with manure.

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Abstract

The use of cattle manure in agricultural fields improves soil quality in terms of nutrients and physical properties. This study was conducted at Lushoto District, in Tanga region, to understand the cattle manure management and utilization practices undertaken by smallholder farmers to improve soil productivity. 180 smallholder farmers in six villages were surveyed, and sixteen composite soil samples collected in each village from farms were manure has been applied and were manure not applied. Important soil nutrients and some important physical-chemical parameters namely Nitrogen, Phosphorus, Potassium, Organic Carbon, Organic Matter, soil pH, Cation Exchange Capacity and Electro Conductivity were analyzed. On average, farms applied with manure were found to have better soil fertility compared to those without manure application. The average NPK for farms with manure application was 0.21%, 0.23%, 1.63% and 0.12%, 0.11%, 0.61% for farms where manure were not applied respectively. For soil pH, EC, CEC, SOC and SOM the average value recorded were 6.95, 0.12 dS/m, 24.26 Meq $100g^{-1}$ of soil, 2.43%, 4.19% and 6.72, 0.09 dS/m, 10.50 Meq $100g^{-1}$ of soil, 1.40, 2.42 for the farms applied with manure and farms where manure was not applied respectively. With regard to manure management, the data show that only 37.7% of respondents practice pit compost and the average range for the composting period reported being 5-6 month. The study asserts that improper manure management and utilization practices might contribute to the low levels of the potential nutrients and therefore appropriate manure management and utilization are recommended.

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Introduction

Cattle manure is an organic vital resource that can supply plant nutrients and replenish organic matter content of most agricultural soils, particularly in the tropics (Reddy *et al.*, 2000). The use of manure in agricultural fields can improve soil quality relative to the inherent chemical properties of the soil. This reduces the use of synthetic fertilizers that are associated with high cost, limited access and technical capabilities on their use, attributes that are not always attractive to small-scale farmers (Carmo *et al.*, 2016). The animal manure applied back to the soil contributes to nutrient recycling and assist in preventing further deterioration of the land resource (Liu *et al.*, 2008). Both cattle and crops production makes an important contribution to household income and food security (Lekasi *et al.*, 2001). Majority of small-scale farmers in Tanzania apply onto their crops manure obtained from their cattle. However, due to poor storage and handling, such types of manure have the low capability to conserve nutrients and low soil fertility improvement and thus contributing less to sustaining agricultural production (Ndakidemi 2015).

Generally, animal manure has become an important factor in maintaining land productivity in various areas (Lekasi *et al.*, 2001). Manure accounts for about 14% of Nitrogen, 25% Phosphorus and 40% of Potassium (Herrero *et al*, 2009) inputs into the soils. Poor soil fertility has been pointed as the fundamental biophysical cause of declining per capita food production on smallholder farms in Africa (Sanchez, 2002). Low or no agricultural residues are returned to the soil (Baitilwake *et al.*, 2011) and as a result soil nutrient mining becomes a major cause of decreasing crop yields and per capita food production in Africa (Henao and Baanante, 2006). Maerere *et al.* (2001) reported that efficient use of animal manure could alleviate the problem of declining land productivity in most parts of Tanzania.

In Tanzania, amount of nitrogen and phosphorus removed from the soil every year by the main crops was estimated to be 251,448 tons N and 115,112 tons P by the year 2000 and only 21% N and 14%P removed was projected to be replaced through fertilizer application (Kaihura *et al.*, 2001). Due to the low income, the majority cannot afford to purchase expensive agricultural inputs (Ndakidemi, 2015) and most of them raise cattle for milk production which guarantees the presence of manure. However, poor manure handling was reported at Lushoto that might result in accelerating the loss of potential nutrients (Rukiko *et al.*, 2018). So the overall objective of this study was to explore the status of manure management and utilization practices that contribute to the soil fertility status in smallholder farms.

Materials and methods

Study site description

The study was conducted in Lushoto district, Tanga region. The district is situated in the North Eastern corner of Tanzania at latitude 4°25'–4°55'and 30°10'–38°35' with an altitude range of 1000–2100 m.a.s.l. Rainfall seasons in Lushoto are divided into three: the short rainy season (October-December), the long rainy season (March-May) and an intermediary season (July-September). Lushoto district is covered by steep-sided, narrow valleys, which limit mechanized farming and require substantial soil erosion control. The average temperature is between 18-23°C with the maximum occurring in March and minimum in July while rainfalls are between 600-2000mm per annum. According to NBS (2012), the population of Lushoto District Council is estimated to be 332436 (153847 Male and 178589 female) with the population growth rate of 1.1%.

Study design

The Households survey

A cross-sectional survey was conducted from September to October 2016. A combined qualitative and quantitative method was used whereby focus group meetings, observations, and household surveys were conducted. Villages were selected based on the pre-set criteria which included at least 50% of the households keeping dairy cattle and practicing crop-livestock production systems. Six villages namely Viti, Hambalawei, Bombo, Ngulwi, Ubiri and Mbuzii were selected into which farmers were pre-selected based on the number of herds (Three or more dairy cattle) and land size of not less than 0.25 acre. Thirty (30) households (in each village) were randomly sampled from a list of farmers in a village interviewed through a structured questionnaire and ten (10) household were identified for focus group discussion. The selection process involved the resident village extension officers and village executive officers to provide the list of the farmers in respective villages and take part in the focus group discussion as key informants.

Soil sampling

Soil samples were taken from farms which were previously applied with manure and those which were not applied with manure. To enable this, fertilizer and manure application history of the farms was sourced through the household survey. A total of one hundred and twelve (112) soil sample from farms applied with and farms not applied with manure was sampled. The soil was taken using soil auger from five points of the farm (four points from the corner and one at center) at a depth of 0-20cm and mixed together to make one representative sample per farm of approximately 0.5kg was taken. The samples were then stored in plastic bags, well labeled and transferred to the Nelson Mandela African Institution of Science and Technology laboratory for analysis.

Laboratory analysis

The samples were air-dried, then sieved through 0.25mm for enabling the analysis. Soil pH and EC were determined at a soil to water ratio of 1:2.5 using pH meter and electrical conductivity (EC) meter respectively. The determination of organic carbon was done according to Walkley and Black, (1934) and soil organic matter concentration was computed by multiplying the organic carbon values by 1.724 (Ellert and Bettany, 1995). Total nitrogen (N) was determined by the Kjeldahl method, Potassium (K), available phosphorus (P) were determined through atomic absorption spectrophotometry as described in Mehlch III procedure (Gregorich and Carter, 2007) Cation exchange capacity (CEC) was determined by ammonium acetate method (Ross and Ketterings, 1995).

Statistical analysis

Data obtained in the survey were analyzed using Statistic Package for Social Science (IBM-SPSS) Computer Software. Descriptive statistics namely means, frequencies, percentages and cross-tabulation were used to determine relationships between variables.

Laboratory data were subjected to analysis of variance (ANOVA) and the computation was performed with the software program STATISTICA 8. The fisher's least significance difference (L.S.D.) was used to compare treatment means at $p = 0.05$ level of significance.

Result and discussion

Socio-economic and demographic characteristics of the respondents

Focus group discussion (FGD) and questionnaire administering were held in six villages; Viti, Hambalawei, Ubiri, Bombo, Ngulwi and Mbuzii of the Lushoto District. The average response was between 6 to 12 smallholder farmers per village; whereby men were 38 (73.08%) and women were 14 (26.92%).

The discussion was held in the respective government office in the village. Many respondents were aged between 40–60 years (Fig. 1), and these were adults who had various family responsibilities, therefore they were investing in agriculture to solve a number of their family problems. Farmers marital status was; 156 (86.67%) married, 21 (11.67%) widow, 2 (1.28%) divorced and 1 (0.5%) single (Table 1).

This implies that smallholder farming provides employment to widows and this is facilitated by traditional way of life or culture, whereby villagers give an animal to anybody who requests regardless of gender and in the future, she/he is expected to return a female cow compared with other tangible resources.

This finding is in agreement with the study done by Herrero *et al.* (2013) who reported that it's often easier for women to acquire livestock through inheritance or market than land or other physical assets. About 86.67% had primary education, 2.22% secondary education and 3.87% college education. Literacy was very low and this might contribute to negative effects of adoption and perception of technology uptake and ultimately low production (Adeoti, 2008).

Table 1. Gender and marital status of respondents in the study sites (%).

Villages	Viti	Hambalawei	Bombo	Ngulwi	Mbuzii	Ubiri	Total %
Gender							
Male	86.7	96.7	80	96.7	73.3	73.3	84.44
Female	13.3	3.3	20	3.3	26.7	26.7	15.55
Marital Status							
Single	-	-	-	-	3.3	-	0.5
Married	90	96.7	80	100	80	73.3	86.67
Divorced	-	-	-	-	-	6.7	1.28
Widow	10	3.3	20	-	16.7	20	11.67

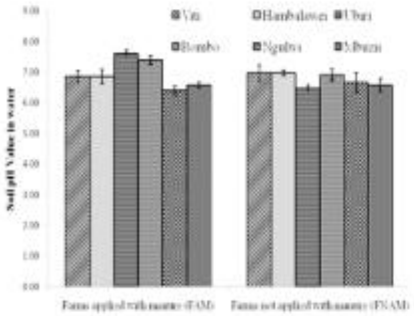

Fig. 1. Soil pH in FAM and FNAM

Land tenure system from the study area showed that majority of smallholder farmers own land (98.6%) through inheritance from parents. This finding is closely related to the finding from Northern Ghana as reported by Cofie *et al.* (2005) where 84% also inherited land from the parents. This ownership is important for farmers because they will receive long-term use (Henao *et al.*, 2006) when investing in on-farm infrastructure i.e. houses, cowshed, biogas plant and production of perennial crops.

On average farmers owned 0.5-3.3 acres which are almost within the range reported by Kiratu *et al.*, (2011). Small land size owned could be attributed to high population density recorded in the area which is due to the agricultural productivity potential of the areas that encourages settlement. Most of the farm activities among smallholder are done by family members who are positively related to farming size (Waithaka *et al.*, 2007).

About 13.8% of smallholder farmers rent land for other farming production activities as reported during the survey. An average price per acre is 35,000 Tsh (16 USD) per season and the priority crops grown were maize, beans, and potato.

Maize and beans are produced 1-2 times in a year for family consumption and vegetables such as cabbage, onion, spinach, carrot, etc are produced 3-4 times in a year and are regarded as cash crops for household income. Vegetable and potato alone were allocated to a smaller area (Table 2) and the reason could be those crops are not stapled food and they are the short season and produced 3-4 time per year compared with beans and maize which are meant for ensuring household food security.

Generally, vegetable plots commercially reported to have early and high return in terms of cash compared with maize/beans fields because they mature in a short period of time and are highly valued fetching high market prices.

Table 2. Average land size (acre) per household allocated for various crops.

Villages	Maize only	Beans only	Maize-beans intercrop	Maize-beans-potatoes	Potato alone	Vegetable
Viti	1.47*(20.9)**	0.75 (10.64)	0.25 (3.55)	3.31 (46.91)	0.83 (11.83)	0.44 (6.21)
Hambalawei	1.03 (20.34)	0.53 (10.46)	1 (19.75)	1.53 (30.24)	0.47 (9.33)	0.5 (9.87)
Ngulwi	0.9 (17.55)	0.7 (13.66)	1.13(22.04)	1.15 (22.35)	0.5 (9.75)	0.75 (14.63)
Bombo	1.66 (25.2)	1.13 (17.16)	1.2 (18.22)	1.4 (21.26)	0.43 (6.5)	0.77 (11.64)
Ubiri	1.26 (24.72)	0.64 (12.56)	0.97 (19.03)	0.89 (17.52)	0.63 (12.26)	0.71 (13.89)
Mbuzii	1.97 (29.79)	0.8 (12.09)	1.7 (25.71)	1.44 (21.84	0.38 (5.67)	0.32 (4.89)

*Number of acres, ** Percentage of respondents.

Manure handling and management practices

Zero-grazing was observed and reported the most intensive livestock production system in the area, involving the 'cut and carry' method of feed management, which is the best for manure collection. The system is common due to the absence of communal grazing land. Most farmers (69%) collect manure and pile out close to the cowshed as the storage area without covering and are done much at Viti (90%), Hambalawei (93.3%) and Mbuzii (83.3%) while few reported to cover at Ngulwi (3.3%) and Bombo (6.7%) (Fig.2.). Faso, (2004) reported that compost obtained from covered-shed composting are of high quality than from open-shed composting; and similarly from pit composting compared with heap or surface composting. However, in this study, it was found that farmers had no information of their manure in-terms of quality. More than 62% of the respondents do not practice pit compost, instead of piling on the ground without turning. This implies that nutrients such as Nitrogen and Phosphorus were lost through leaching and volatilization due to the effect of rain and temperature (Lekasi *et al.*, 2003) and significantly increase soil electrical conductivity and soil pH levels (Eghball *et al.*, 2004). The piling of fresh manure was conducted daily after cleaning and there was no jelling of manure.

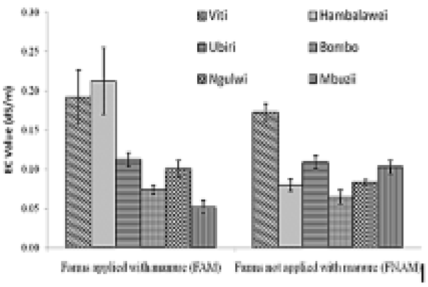

Fig. 2. Soil electro- conductivity in the FAM and FNAM

NB: a = manure stored close to cowshed openly, b = close to cow shed with cover, c = Away from the cow shed openly, d = taking direct to pit after cleaning the cow shed and e = under banana shade.

Storage period varied considerably across the study sites (Table 3). Twenty-five percent practice compost manure for 5-6 months. The same period was reported from Maragua District in Kenya (Lekasi *et al.*, 2003). The result shows that, 19.4% store for more than one year and 16.6% for the un-identified period. Twenty-seven percent of the respondent claimed the deficit of manure produced and the biggest Fig. 3. Was reported at Viti (40%) and Bombo (33%). Anecdotal evidence during the survey showed that farmers with the small herd (number of animals per household and animal body weight of their animals) and feed shortage contributed to the low volume of manure collected per day.

According to Vale *et al.* (2004) manure production per day is averaged to 4.8% (range 3.3-6.5%) of the live animal body weight. However, the majority of smallholder farmers own 2-3 dairy cows, if manure could be managed well would be sufficient to fertilize the small piece of land owned.

During the focus group discussion and personal discussion at Viti, farmers reported that assessment of compost manure is done by looking at the color. Preferred compost was black in color, mixed with soil and presence of white big worms. Other farmers reported that they inserted a stick in the entire heap or in the pit and the extent of heat, hotness or warmth of the stick gave an indication of whether the compost was partially or fully decomposed. It was reported that during manure composting at Viti, farmers mixed manure with sawdust to increase the volume. This is the indigenous/local knowledge used as inherited from parents or copied from other farmers to improve manure quantity.

Only 3.5% of the respondent who practices compost got training outside their district. This indicated that if training could be provided with a trial at farm level many farmers could practice appropriate pit composting. Lack of training (16.7%), time and fatigue work (15%), lack of proper facilities (43.3%) such as wheelbarrow and transportation cost/labor (8.3%) were the constraints reported to hinder pit compost practices. These constraints have also been reported by Rosen and Bierman (2005) in Rwanda.

Table 3. Manure storage period identified by smallholder farmers in surveyed villages (%)

Village	Viti	Hambalawei	Mbuzii	Ubiri	Ngulwi	Bombo	Total
Decomposition/storage period							
1-2 month	1*(3.3)**	-	1 (3.3)	-	-	1 (3.3)	3 (1.6)
3-4 month	9 (30)	8 (26.6)	3 (10)	3 (10)	3 (10)	-	26 (14.4)
5-6month	12 (40)	10 (33.3)	4 (13.3)	6 (20)	4 (13.3)	9 (30)	45 (25)
7-11 month	6 (20)	6 (23.3)	8 (26.6)	4 (13.3)	11 (36.6)	6 (20)	41 (22.7)
1 year +	2 (6.6)	3 (10)	7 (23.3)	8 (26.6)	6 (20)	9 (30)	35 (19.4)
Un-identified period	-	3 (10)	7 (23.3)	9 (30)	6 (20)	5 (16.6)	30 (16.6)

*Number of respondents per village, ** Percentage of respondents.

Utilization of cattle manure by smallholder dairy farmers

Before manure utilization, the heap of manure (surface storage) is emptied in every cropping season starting from the bottom with the assumption that manure is completely decomposed. Application of manure by the respondent from the surveyed villages reported to use drilling application method put manure followed by seed at the same time. Smallholder farmers they don't have a common measurement when applying manure in the field. This may cause an individual farmer to apply too low or high and might lead to nutrient imbalance (Rosen and Bierman, 2016). The majority of farmers measure the manure with both two hands to a hole with the reason that the little manure they have should cover big area compared with the broadcasting method. Some effects reported by farmers when utilize partially composted manure that results to plant death or unhealthy growth and poor yields. The effect of applying immature composts to the soil was pointed to cause severe damages to plant (Ko *et al.*, 2008).

It was further observed that manure is applied in different times per year as follows: once per year (17.7%), twice per year (52.2%), thrice per year (4%) and four times (24.4%) depending on the cropping season and type of crop. Although repeated applications of manure can result in the building detrimental levels (Kuepper 2000). Majorities do apply two times, in November and March/April. Most notably, Lushoto farmers' fields are located in three areas as follows: 1) lower land areas (valleys) where vegetable production is dominant; 2) in the highland area (upland field) where maize and beans are grown and 3) around homestead (middle) where banana and potato are produced. The study observed that majority use manure to valleys and around homestead where vegetable and potatoes are highly produced which is unlike to Vihiga western Kenya where manure use is more important to the production of food crops (Waithaka *et al.*, 2007). The finding from this study suggests that manure utilization is negatively affected by distance and landscape. These findings are similar to those by Ketema and Bauer, (2011) who reported that the use of manure was decreasing with an increase in steepness of the slope and farmers preferred to apply manure in farms near the household (Harris and Yusuf, 2001).

The common inorganic fertilizer reported to be used are Urea (11.1%), Nitrogen, Phosphorus, and Potassium (NPK) (6.1%), Diammonium phosphate (DAP) (46.1%). In Viti and Hambalawei villages, the mineral fertilizers are mostly used in vegetable plots and little in maize but the rest of the villages apply mostly to upland farms. A similar trend was also reported by Nkamleu and Adesina, (2000) in Cameroon. Some reported that they use manure to the upland fields because when it rains the entire nutrients drop to the valley bottom plots. The reports from farmers survey on use and not using manure showed that the average production of maize was 0.5t ha^{-1} - 1.4t ha^{-1} (hybrid varieties) in farms that were not applied with manure, while 0.7–0.9t ha^{-1} (local varieties) and 1.98t ha^{-1} (hybrid varieties) were obtained where manure applied. In this study, our results clearly show that applying manure boosted yield although these increases were very low. The increase in maize yield ranged from 1.4t ha^{-1} and 1.98t ha^{-1} in non-manured and manured fields respectively.

Nkonya (1998) reported the potential yield and for expected yield under good husbandry is averaged to 7.5t ha^{-1} and 5.4t ha^{-1}. A study done in Kenya showed that in unfertilized maize farm, the yield ranged from 1.2–1.3t ha^{-1} while the fertilized fields with manure the yield were higher and ranged from 3.8–4.2 t ha^{-1} (Smaling *et al.*, 1992). In view of the above, the use of manure in Lushoto district is contributing very little to yield increase in various crops grown in the area. Therefore, proper analysis of manure to establish their nutrient status is of paramount importance and this will enable to design appropriate manure management strategies and boost crop production in Lushoto district.

Soil quality in farms applied (FAM) and farms not applied with manure (FNAM) Soil pH

In table 4, the results showed that there was a significant difference between sites and treatments ($p \le 0.05$) in soil pH with a range of 6.4-7.6 and 6.5–6.9 for FAM and FNAM respectively. However, there was no significant difference at Ubiri (FNAM), Mbuzii (FAM), Ngulwi (FNAM), Viti (FAM) and Hambalawei (FNAM). The reason at Bombo and Ubiri in FAM to have high pH (Fig. 4) might be the soil of those two villages is rich in calcium carbonate materials which also increase the level of soil pH. The ranges are for most favorable agriculture soils according to Sanchez *et al.* (2003) and Magdoff and Bartlett, (1985). However, the more pH may harm the plant life's, though pH of 6.5-7.5 is where most potassium is available for plants and pH ≤ 5 could be associated with deficiencies of phosphorus according to Ndakidemi and Semoka *et al.* (2006).

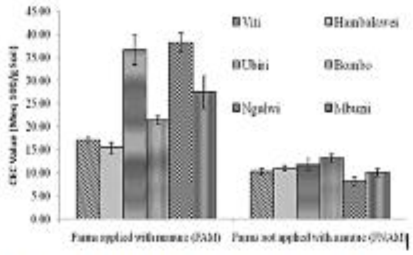

Fig. 3. Soil cation exchange capacity in FAM and FNAM

Electrical conductivity (EC)

EC of the soil was ranged from 0.05–0.21 dS/m across the study sites and was significant different ($p \le 0.001$) between site and treatment, however, the value of the same number has no significantly different (Table 4). EC is one of the indicators for measuring soil attributes that influence soil productivity/fertility (Grisso *et al.*, 2005).

Sands have a low conductivity (0–0.04 dS/m), silts have a medium conductivity (0.04 – 0.15 dS/m), and clays have a high conductivity (0.1-10 dS/m) (Grisso *et al.*, 2005). The highest EC was found at Viti (FAM, FNAM) and Hambalawei (FAM) that indicate the soil has high clay soil while the lowest was observed at Mbuzii (FAM) and Bombo (FNAM) that indicating the soil had high silt (Fig. 2).

Richards, (1969) reported that high electrical conductivity values associate with soils that contain high levels of soluble nutrients.

Table 4. Chemical properties of soil in farms applied with (FAM) and farms not applied with manure (FNAM).

Sites	Treatments (Soil categories)	pH	EC	CEC	SOC	SOM	AP	TN	K
			dS/m	Meq 100g^{-1}of soil			%		
Viti	FAM	6.86±0.2cd	0.19±0.03a	17.13±0.5cd	2.31±0.2abc	3.93±0.3abc	0.25±0.02b	0.21abc	1.16±0.03c
Viti	FNAM	6.98±0.3bc	0.17±0.01a	10.21±0.8fg	1.32±0.4e	2.28±0.6e	0.14±0.01de	0.16±0.02bcdef	0.58±0.07ef
Hambalawei	FAM	6.86±0.2cd	0.21±0.4a	15.41±1.2de	2.48±0.3ab	4.29±0.4ab	0.29±0.03ab	0.23±0.04a	1.03±0.1cd
Hambalawei	FNAM	6.97±0.1bc	0.08±0.01bcd	10.96±0.6efg	1.40±0.1e	2.41±0.2e	0.14±0.01de	0.12±0.01efg	0.76±0.08de
Ubiri	FAM	7.61±0.1a	0.11±0.01b	36.60±3.1a	2.11±0.4bcd	3.65±0.6bcd	0.25±0.08b	0.22±0.04abc	2.91±0.29a
Ubiri	FNAM	6.4±0.1cd	0.11±0.01b	11.73±1.3efg	1.34±0.2e	2.31±0.3e	0.11def	0.09±0.02g	1.06±0.01cd
Bombo	FAM	7.40±0.1ab	0.07±0.01bcd	21.45±0.9c	2.12±0.3bcd	3.65±0.4bcd	0.34±0.03a	0.17±0.04abcde	1.21±0.05c
Bombo	FNAM	6.92±0.2bc	0.06±0.01cd	13.24±0.8def	1.29±0.3e	2.23±0.6e	0.07±0.01ef	0.10±0.01fg	0.58±0.09ef
Ngulwi	FAM	6.40±0.1d	0.10±0.01bc	38.21±2.1a	2.73±0.2ab	4.71±0.3ab	0.15±0.01d	0.22±0.02ab	2.94±0.16a
Ngulwi	FNAM	6.66±0.3cd	0.08±0.1bcd	8.17±1.0g	1.63±0.2cde	2.82±0.4cde	0.10±0.1def	0.12±0.02efg	0.43±0.08ef
Mbuzii	FAM	6.58±0.1cd	0.05±0.01d	27.48±3.5b	2.96±0.2a	5.11±0.3a	0.14±0.01de	0.20±0.04abcd	1.63±0.15b

Sites	Treatments (Soil categories)	pH	EC	CEC	SOC	SOM	AP	TN	K
			dS/m	Meq 100g⁻¹of soil			%		
Mbuzii	FNAM	6.58±0.2cd	0.10±0.01bc	10.06±0.9fg	1.46±0.2de	2.52±0.4de	0.05±0.01f	0.15±0.01cdefg	0.44±0.05ef
F-Statistics	Sites	3.5**	12.86***	17.9***	1.5ns	1.5ns	5.6***	1.1ns	40.6***
	Treatment	6.01*	6.8*	238.3***	62.8***	62.8***	72.1***	44.9***	273.4***
	Sites*treatment	3.9**	5.6***	19.6***	0.5ns	0.52ns	3.7**	0.7ns	28***

Value presented in the table are means ± SE; *, **,***; whereby * = significant at $p \le 0.05$, ** = $p \le 0.01$, *** = ≤ 0.001 respectively, ns = not significant and SE = Standard Error. Means followed by same letter(s) in a column are not significantly different from each at P = 0.05 according to Fischer least significance difference (LSD)

Cation Exchange Capacity (CEC)

CEC of soils ranged from 13.6 to 38.2 and 8.2 to 13.2 Meq/100g of FAM and FNAM respectively (Table 4). FAM had the highest value (13.60–38.20), this implied that the FAM had the highest capacity to absorb trace elements as supported by the finding of Grisso *et al.* (2005) who reported that the higher the CEC the greater is the capacity of the soil surface to adsorb trace elements without potential deleterious effects on plants and/or soil biological functions. Treatment effects were low in FNAM (Fig. 3). Highest CEC recorded in FAM might be due to the presence of high organic matter in the soil (Table 4). The lower CEC of a soil, tend to decrease the soil pH faster with time, (Gillman, 1981). To avoid decrease of soil pH in FNAM smallholder farmers may be advised to apply manure in all crop fields.

Soil Organic Carbon (SOC) and Soil Organic Matter (SOM)

SOM has a role in retaining some trace elements (such as Zn) and capacity to absorb other trace elements (such as Cu and Mn). There were no significant differences between sites and treatments (Table 7). Nevertheless, FAM had the highest value in both SOC (2.11–2.96%) and SOM (3.65–5.11%). These significant differences in values are similar to the one reported by Gyapong and Ayisi, (2015) in Ghana. Bot and Benites (2005) reported that most of SOM in soil range from 2–10 %. According to these results it is evident that addition of cattle manure in the soil increases organic matter (Reeves, 1997).

Available Phosphorus (AP) in soil

AP ranged from 0.14–0.33% and 0.05–0.16% for FAM and FNAM respectively, Table 4. The significant difference was observed across the villages ($P \le 0.001$).

Highest available phosphorus was found in FAM. Phosphorus values in the soil were found to be 0.4 1.2% and 30–50% of total phosphorus which is constituted by organic matter (OM) in most soils (Rodrı´guez and Fraga, 1999). Low AP was found in both FAM and FNAM (Fig. 4) which might be attributed to soil degradation (Lynch, 2011) resulting from poor agricultural management practices i.e. in steep areas managing the loss of topsoil. Another reason could be improper manure/fertilizer application rates. Nkonya, (1998) recommended amount of phosphorus in the low land is 20kg ha⁻¹ and high land is 20-40kg ha⁻¹. Smallholder farmers could opt to use organic materials in their farms such as compost, plant or animal materials/waste, or green manure that influences the increase of AP (Mkhabela and Warman, 2005).

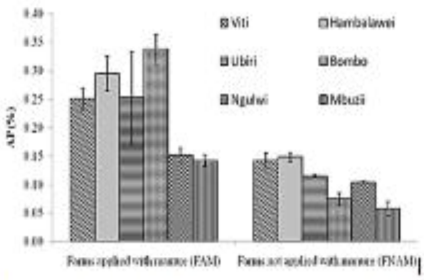

Fig. 4. Soil available phosphorus in FAM and FNAM

Total Nitrogen in soil (TN)

Total nitrogen (TN) ranged from 0.17–0.23% in FAM and 0.09–0.16% in FNAM. There were no significant effects between site and treatments (Table 7). The recommended critical level in Tanzania is 2.0g kg⁻¹ for most crops (Ndakidemi *et al.*, 2006).

The application rate of nitrogen-based to altitude in the northern and eastern zones was reported to be 40-112kg N ha^{-1} (High altitude) and 20-45kg N ha^{-1} (low altitude) (Nkonya, 1998). These results indicate low nitrogen in all soils across the sites as per recommendations. The smallest variation of nitrogen concentration in FAM could be contributed by the low-quality manure as a result of the poor of cowshed where the manure is collected. Poultry manure is reported to have higher nitrogen than cattle manure (Gyapong and Ayisi, 2015), so this can be used as a fertilizer for crop production but the challenge is the amount per household per farm. Digested slurry also can be used to improve soil nitrogen as it contains 1.60% N, 1.55% P and 1.00% K and slurry compost comprises of 0.75% N, 0.65% P and 1.05% K (Karki and Expert, 2006).

The low percent of chemical properties in FNAM could be contributed by the loss of topsoil that transports soil organic matter during the rainy season which is facilitated by the steepness of the slope at Lushoto.

Potassium in soil (K)

K ranged from 0.43–2.95% in FAM and FNAM (Table 4) and was significantly higher ($p \leq 0.001$) in FAM at Ubiri and Ngulwi (Fig. 5). The FAM had statistically higher potassium than FNAM. Lowest K was recorded in FNAM at all villages but a bit higher at Ubiri. The value found in FNAM is similar to those reported by Bressers (2014) though was not indicated whether the soil was utilized with manure.

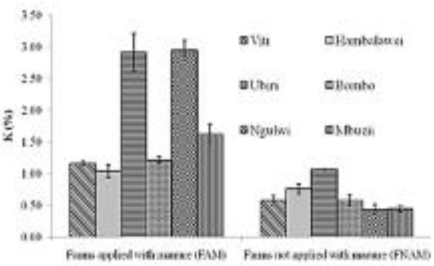

Fig. 5. Soil potassium in FAM and FNAM

Conclusions and recommendation

In conclusion, the study asserts that the use of manure in the farms was contributed to improving the level of soil chemical properties compared with farm not applied manure. Some soil fertility indicators (e.g. soil pH, CEC, EC and SOM) indicate the potential for crop production. This study revealed that manure in the studied villages is poorly handled and the following should be adhered to smallholder farmers as part of management. 1. Construction of appropriate manure storage facilities that provide shade to reduce temperatures, evaporation of urine and rainy water 2. In the storage area, it's better to install an impermeable base/concrete base below the manure collecting area to prevent leaching of nutrients and loss of urine before it is absorbed by bedding materials 3. Application of manure in the field should base on the recommended rate of manure per a given area to prevent detrimental effects to plant and soil. Furthermore; there is a need to have on-farm training by having a trial which are participatory among smallholder farmers and extension officers that will encourage farmers to practice the appropriate technologies.

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(b) Poster presentation

Assessment of Manure Management and Utilization Practices for Enhanced Smallholder Dairy Productivity at Lushoto and Korogwe District, Tanzania

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Introduction

Cow manure is an important source of macronutrients (N, P, K) for improving land fertility for crop production. Manure application practices are important for replenishing the lost soil nutrients because synthetic fertilizers are rather expensive to most smallholder farmers. Improper manure management contributes to Green House Gases (GHGs) (methane and nitrous oxide) emission. However, CH_4 can be used as biogas for heating, cooking, and lighting. Therefore the use of manure may contribute to soil fertility improvement and provide affordable and sustainable energy for smallholders. This study intends to explore the management and utilization practices of manure in Lushoto and Korogwe districts, where such have not been reported much.

When taken to the farm, manure may remain unutilized for 1-3 month which also contribute to loss of nutrients

Some farmers reported that manure is used for neither seasonal crops nor vegetables.

Study site and Methods

Lushoto and Korogwe districts situated in the North Eastern part of Tanzania with altitude ranging from 1000 – 2100ASL and 300-1200ASL respectively. The average temperature for Lushoto is 18-23^{0}c and high rainfall is between 600-2,000 mm per annum.

District Livestock officers (DLOs) were involved and additionally the Village and Ward extension officers participated effectively in selecting the farmers for the study. The aim was to explore the manure management practices and the technologies that are in current use.

The reconnaissance survey was done in March 2016. Seven villages were involved namely Viti, Ubiri, Mbuzii, Ngulwi, Bombo, Hambalawei & Hale.

Few farmers were observed to own biogas plants that were poorly managed or maintained, while some were no longer functioning.

Findings and implications

Manure gathered into large pits or on the surface near cattle pen for about 6 months before being transferred to the farm.

Conclusion

Poor manure management and utilization practices are common in both Korogwe and Lushoto Districts. Farmers have limited knowledge and technical know-how to manage and utilize animal manure. Further studies to understand the soil and manure nutrient status is important, where such information will guide on how much of the manure needs to be applied in order to reach the productive levels of crops and training.

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Academia for society and industry