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Factors Affecting the Adoption of Forage Technologies in Smallholder Dairy Production Systems in Lushoto, Tanzania

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AI	artificial insemination
CBPP	contagious bovine pleuropneumonia
CIAT	International Center for Tropical Agriculture
DDP	dairy development programs
GDP	gross domestic product
HPI	Heifer Project International
ICRAF	World Agroforestry Centre
ILRI	International Livestock Research Institute
LGP	length of growing period
QAToCA	Qualitative Assessment Tool for CA adoption
QATo-FT	Qualitative Assessment Tool for Forage Technology adoption
SSA	sub-Saharan Africa
TALIRI	Tanzania Livestock Research Institute
TASA	Tanzanian Agricultural Seed Agency
TSHZ	Tanzanian shorthorn Zebu
ZALF	Leibniz Centre for Agricultural Landscape Research

Abstract

Despite population pressure and the urgent need for dairy production to be doubled by 2050, there is still a significant deficit in milk production in sub-Saharan Africa (SSA). Lack of quantity and quality feed is one of the major factors causing unsatisfactory milk yields. This *Working Paper* assessed the adoption potential of forage technologies in Lushoto, Tanga district, Tanzania. We carried out an extensive literature review of past work on smallholder dairy production in SSA and Tanzania, and the adoption rate of forage technologies; visited and observed farmers' fields in Lushoto; carried out interviews with farmers; and used a Qualitative participatory expert-based Assessment Tool for Forage Technology adoption (QATo-FT) in a multi-stakeholder workshop. Results showed that the adoption rate of improved forage technologies in Lushoto is still in the early stages following classical diffusion theories. The farmers' interviews revealed that while the triggering factors for adoption were related to the shortage of feed and soil conservation problems, the potential economic advantages were not as dominant as expected. Farmers reported the reasons for sustaining the practices of growing improved forages as the year-round availability of fodder, increased fodder demand and accumulated benefits. The low actual adoption rates contrasted with results from the QATo-FT assessment that revealed a high overall adoption potential for Lushoto. The following factors all exerted a positive influence on adoption potential: the general receptive nature of the community towards the technology; the expectations of improved forages on ecological benefits; and the role of promoting institutions. Factors exerting a weaker influence included the political and institutional framework at regional level, and products and input markets conditions for forage and overall livestock farming. Most important barriers to adoption were related to the whole farming system and the wider environment. The opportunity cost for labor was low due to lack of off-farm income possibilities, hence making it favorable for farmers to collect fodder from distant places instead of saving labor through growing forages closer to the homestead. Further, several other livestock management factors confounded potential gains in milk production through improved forages: current breeds were often not sufficiently high yielding to respond to improved feeding; providing water to zero grazing animals was not always achievable for labor-constrained farms; many farmers let forages overgrow for use in times of scarcity (dry season) which led to lower-than-necessary forage being fed to animals; sufficient planting material and extension advice on forage management and harvesting was not always available; milk prices were low and would not be increased if the volume of milk production did not increase (the collection center was operating at < 50% capacity). To increase future forage adoption rates, it is recommended to invest in knowledge transfer, more effective local authority and extension structures, stronger multi-stakeholder partnerships, access to loan and credit facilities, improvement of off-farm income possibilities, better access to input markets including AI and forage planting material, and more favorable output markets. By doing this, the performance of existing heads of cattle for the region would be improved, milk yields would increase and eventually farmers' income levels would be enhanced. This could improve nutrition, and eventually contribute to poverty alleviation in SSA.

1 Introduction

1.1 Problem statement

Agriculture is the economic backbone of most African countries. Back in 1987, it had contributed up to 29% of the continent's gross domestic product (GDP) (FAO 1988). As an integral part of many African traditions (Ndambi, 2008), livestock rearing still plays a vital role in sub-Saharan Africa's (SSA) agricultural practice. And the traditional techniques that have dominated the sector for decades are still widespread. The region has a huge cattle population of about 191 million head (FAOSTATS, 2000) but dairy productivity is below potential. Jahnke et al. (1988) stated that although developing countries (in the 1980s) owned 70% of the world's bovines (including buffaloes), they only produced 29% of the global meat and 23% of the global milk output.

In 2016, Africa's deficit in dairy productivity does not seem to have changed; in fact, it is expected to grow worse as population growth puts more pressure on it. In 2014, 1.2 billion of the world's population lived in Africa (UN, 2015). As the fastest growing major area (rate of 2.55% per annum), more than half of global population growth between now and 2050 is expected to occur in Africa. Such a fast-growing population will not only impose strain on food resources but on land, thus pushing for higher productivity of dairy production in SSA.

The current demand for dairy products has been found to largely outweigh their production in Africa (Ndambi, 2008; Lukuyu et al., 2009; Smith, 2015). According to Alexandratos and Bruinsma (2012), the average per person meat consumption per year in SSA was 10 kg and this is projected to reach 16 kg/person/year in 2050, while that of milk consumption was 31 liters/person/year in 2005/2007 and is projected to reach 37 liters/person/year in 2050. Ndambi et al. (2007) compared the demand growth rate of dairy products in Africa (4.0%) with their production growth rate (3.1%) between 1990 and 2004. The 0.8% deficit stands out because Africa's dairy imports grew at a rate of 2.1% per annum during the same period. These numbers demonstrate that Africa's dairy production capacity is yet to be optimized and self-sufficiency in dairy production has not yet been achieved.
As a substantial increase in Africa's milk production potential could yield multiplier effects such as poverty alleviation, improved nutrition and income generation (Gillah et al., 2012), organizations such as Heifer Project International, Land O'Lakes, Send a Cow, International Livestock Research Institute (ILRI), and the International Center for Tropical Agriculture (CIAT) have been working on strategies to bridge the gap between the demand and supply of milk and its by-products in Africa. Some of the main strategies have been the introduction of improved animal breeds and quality feed for livestock. For over 50 years, researchers have tested and introduced nutritive and low-cost legumes and fodder shrubs to improve cattle's protein intake and increase the productivity of dairy farms in SSA (Sumberg, 2005; Wambugu et al., 2011; Njarui et al., 2012).

However, their adoption by smallholder livestock farmers has proven to be unsatisfactory. Franzel and Wambugu (2007) found that despite heavy sensitization on more nutritive forage technologies in East Africa, only 10% of smallholder farmers had started using them by 2005. And the number of shrubs planted was largely inadequate. Poor rates of adoption for improved forage technologies have been reported in most parts of SSA where they were introduced i.e. in Malawi (Ngwira, 2003); Ethiopia (Gebremedhin et al., 2003); Central Kenya (Mwangi and Wambugu, 2003); and Kenya, Uganda and Rwanda (Lukuyu et al., 2009). The question is why forage technologies, which have the potential to greatly improve dairy farm outputs and even the livelihoods of a people, do not seem to be meeting the targeted responses. Why are smallholder dairy farmers in SSA (and Tanzania in particular) unable to adequately adopt the forage technologies introduced to improve the performance of the dairy cows? This report is focused on exploring avenues for answers to this question.

1.2 Purpose of the study

The study was exploratory in nature, conducted with the aim of identifying opportunities and constraints for the adoption of forage technologies in smallholder dairy production systems in Lushoto (northeastern Tanzania). While the focus has been limited to the two villages of Ubiri and Mbuzii in Lushoto, the comprehensive literature review part of the study examines issues of general livestock production and forage adoption across the entire SSA region. The study therefore unveils contextual influencing forces on the promotion, adaptation, and adoption of improved forage technologies in SSA. Specifically, it examines the institutional, socioeconomic, policy, cultural, local gender rules and dimensions that are in place and how these all influence the wider adoption and diffusion process of forage technologies in SSA, with a special focus on Lushoto.

2 Methodology

To realize the study objectives, a literature review in combination with empirical social research methods such as semi-structured qualitative interviews, focus group discussions and structured observations were carried out in 2016. In addition, a Qualitative Assessment tool for Forage Technology (QATo-FT) was designed and used in a multi-stakeholder learning workshop.

2.1 Literature review

Using an explorative approach, literature was gathered using four online search engines: ResearchGate, Google Scholar, Web of Science and JSTOR. The initial search terms were: dairy farming in Africa/Tanzania/Lushoto[1]; smallholder dairy farming in Africa/Tanzania; forage technologies and adoption in Africa/Tanzania/Lushoto; and forage problem in Africa/Tanzania/Lushoto. However, given the limited number of articles found under these search terms, new search terms were developed to widen the potential results. The new search terms included: livestock farming in Africa; milk production in Africa/Tanzania/Lushoto; small-scale dairying in Africa/Tanzania/Lushoto; agricultural technology adoption in Africa/Tanzania/Lushoto; and dairy development in Africa. The review results were an outcome of a thorough analysis of the researchers' findings and experiences on forage technology introduction in SSA from the literature. The facts found were compared and contrasted to find patterns, which could be binding for most of SSA and especially for Tanzania.

2.2 Empirical research

2.2.1 Field visits and interviews

After the first round of field visits from 17 to 24 January 2016, 22 farmers who were involved in the project across the villages of Mbuzii and Ubiri participated in follow-up interviews on adoption issues. The main aim was to check and derive a first appraisal with regards to the sustainable adoption decision of farmers from first knowledge of improved forages to actual implementation (see interview questions –Table 1).

Field visits in Mbuzii - Lushoto: Photo credit: ZALF / T. Ndah

In preparation for the QATo-FT workshop, a second round of field visits was organized from 30 October to 4 November 2016. For the first two days, a selection of farmers was visited at their farms in the villages of Mbuzii and Ubiri. The talks with the farmers were again guided by the questions from Table 1. However, the conversation at this stage was kept open to other aspects the farmers might raise during the visits, such as on general forage production, livestock production, and other organizational issues. The issues discussed were clustered by the participating researchers to provide emerging patterns that could add information provided by the specific answers from the semi-structured questions and the outcome of the QATo-FT workshop.

Table 1: Questions for farmer interviews

1. What was the source of first knowledge on forage technologies?
2. What was the year of this first knowledge?
3. What was the actual starting year, e.g. the first year you planted materials?
4. What reasons made you start? (trigger)
5. What reasons keep you going on? (supporting forces)
6. At what point did you feel uncomfortable, and if yes, why? (inhibiting forces)
7. What recommendations do you have for further improving this technology as a farmer?

2.2.2 QATo-FT approach and workshop

The Qualitative Assessment Tool for Forage Technologies (QATo-FT) was derived from the QAToCA approach (see Ndah et al., 2015), which was initially designed to assess the adoption potential of conservation agriculture. It is a multi-category and scale-based approach that focuses on analyzing the influence of an innovation as an object of adoption, stakeholder capacities, institutional conditions, markets and gender dynamics on the adoption potential of forage technologies. Selected questions of the tool strive, amongst others, to investigate if there are any existing conventions or local gender rules that may negatively influence the successful introduction and dissemination of new forage technologies. QATo-FT therefore is designed to assess the socioeconomic conditions that might hinder or promote the adoption of improved forage technologies.

1. Individual searches were carried out for each place i.e. Africa, Tanzania and Lushoto.

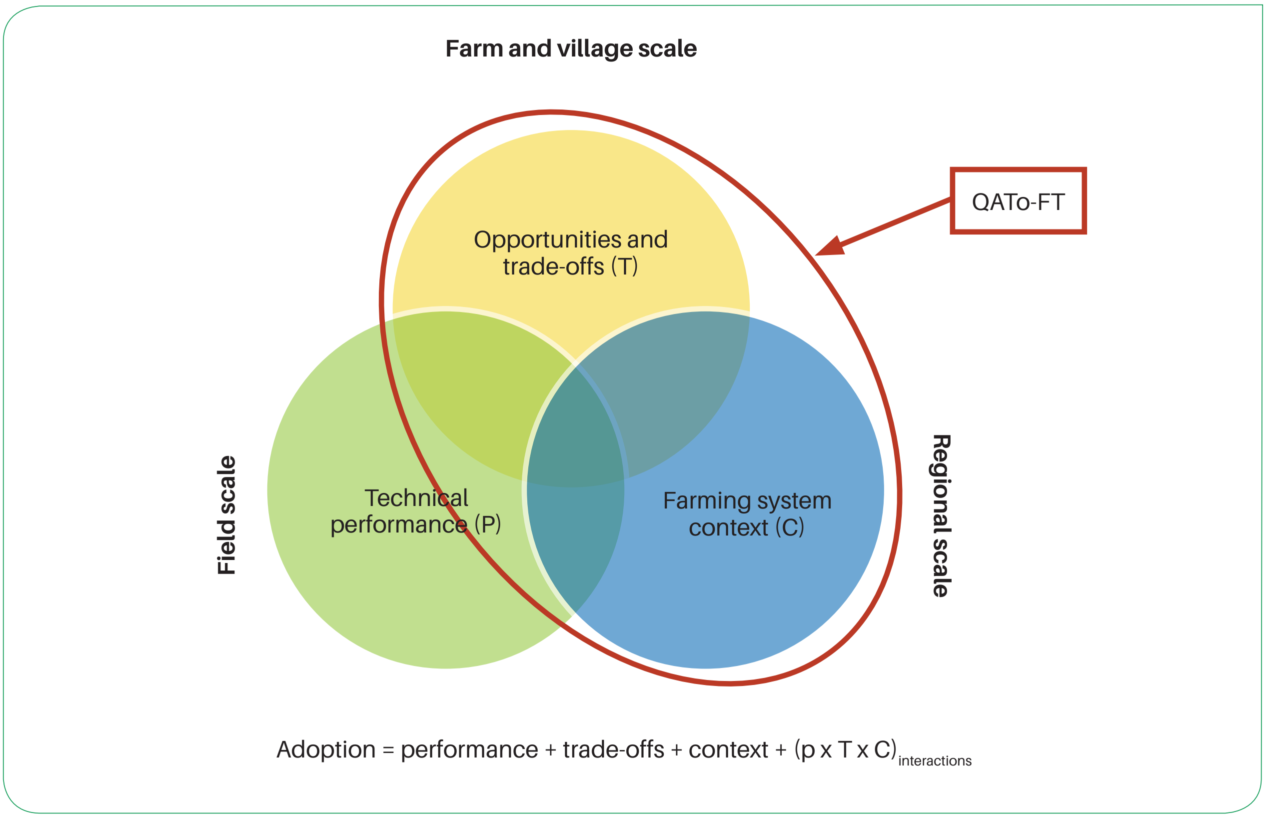


Figure 1: Scales of coverage of QATo-FT

Forage technology (FT) adoption is conditioned by its technical performance (P), subject to the opportunities and trade-offs (T) that operate at farm and village scales and constrained by different aspects of the context (C) in which the farming system operates, including market, socioeconomic, institutional and policy conditions defining the innovation system and the variability inherent to the physical environment. Source: adapted from Corbeels et al. (2014).

To meet the above-described objectives, the tool makes use of a conceptual framework that distinguishes three scales of analysis: field, farm, and village, as well as regional levels (Figure 1). It is assumed that the performance of forage technologies at field scale can be assessed using biophysical observation or crop/soil models. At farm and village scales, trade-offs in the allocation of resources can be analyzed using bio-economic farm or household models.

At the regional scale, i.e. the context or external environment, conceptual models, and adoption theories have been reviewed as frameworks and specific questions from these frameworks have been translated in the form of thematic questions into the QATo-FT tool. These thematic questions are grouped into nine categories (Table 2).

QATo-FT training session: Photo credit: ZALF / T. Ndah

Table 2: Thematic categories of QATo-FT

Category	
A	Object of adoption (FT)
B	Farm and household characteristics/constraints
C	Capacity of implementing institution
D	Attributes of dissemination strategy
E	Political/institutional framework at village level
F	Political/institutional framework at regional level
G	FT products and inputs market conditions
H	Perception of community towards FT
I	Knowledge of FT role on climate change and other ecological benefits

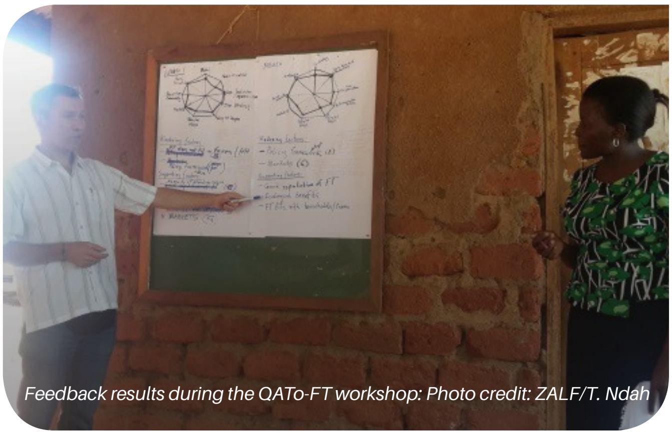
QATo-FT is developed as an approach, meant for assessing the relative likelihood of forage technologies adoption under the different agro-ecological, socioeconomic and cultural conditions of Africa (e.g. Lushoto – Tanzania). It is a more generic and less data-intensive approach that complements modeling approaches (biophysical and bio-economic models) in meeting the objective of the project.

An intensive training of local researchers and facilitators took place a day before the actual workshop (2 November 2016). In attendance were participants from TALIRI (three researchers), CIAT (two researchers) and two facilitators from ZALF. The training lasted for most of the day where participants were briefed on the conceptual background of the tool including the main purpose and usefulness, and guided through the different working steps of the tool, the procedure and preconditions for carrying out a QATo-FT workshop. The last phase of the training was preparation for the next day's workshop where the trainees were allocated to subgroups according to the different categories of the tool. Each subgroup was asked to lead a corresponding sub-working group during the workshop.

QATo-FT workshop session: Photo credit: ZALF / T. Ndah

The QATo-FT workshop, which was organized on 3 November 2016, had 34 participants drawn from the extension, policy, farming (adopters and non-adopters) and research sectors. Farmers and extension staff from Mbuzii and Ubiri villages were invited, and most of them were already members of innovation platforms formed under previous projects in this region.

The entire workshop, which lasted for over 5 hours, with 34 participants, began with a brief plenary report from the visiting team on key observations gathered during the farm visits and interviews on general livestock production, and adoption of improved forages. This led to a general discussion with participants from both villages with the aim of either agreeing or disagreeing with the presented observations hence, adjusting the observed picture where necessary.



Feedback results during the QATo-FT workshop: Photo credit: ZALF/T. Ndah

The purpose of the QATo-FT workshop was explained, after which the main group regrouped into working groups by village (Mbuzii and Ubiri). Within these groups, there was a further split into smaller subgroups with each subgroup allocated two or three different categories (questions) (Table 2) of the QATo-FT tool to work on. In each subgroup, a trained facilitator recorded the consensus scores on paper. These scores were then gathered and computed into a spreadsheet version of the tool to produce the first joint draft results. These drafts were presented in a general plenary session for feedback, reflection and adjustment of the final results.

3 Results

This results chapter starts with the literature review, giving an overview of dairy farming in Africa and its related problems, then proceeds to an examination of dairy farming in Tanzania and provides details about the situation in the case study region in Lushoto. The next section is dedicated to the first part of the empirical research, i.e. field visits and interviews, which examined the factors that may have limited the adoption of forage technologies in Africa and their implications for Tanzania and Lushoto district. The last section presents the results of the QATo-FT multi-stakeholder workshop.

3.1 Literature review

3.1.1 Smallholder dairying in sub-Saharan Africa

Currently, dairy farming plays a critical role in the lives of the world's rural and poor populations. It is currently estimated that between 60 and 80% of rural households in most countries in SSA keep livestock, especially cows (Smith, 2015). Livestock provides a substantial part of people's cash incomes, capital assets, employment and nutrition (Ndambi, 2008; Gollin, 2014; Smith, 2015). At a time when about 70% of the population in Africa lives below the poverty line, the maximization of yields from dairy farming is a great opportunity for poverty alleviation, improved nutrition, and income generation (Gillah et al., 2012). Smith (2015) argues that SSA is where the sustainable intensification of agriculture and livestock systems could yield the 'most significant benefits' for food security, incomes, smallholders' competiveness and ecosystem services. In 2004, Africa's cow milk production stood at 21 million tonnes from 46 million dairy cows, suggesting an average production rate of 461 kg of milk per cow per year which is only one-fifth of the global average yield (Ndambi et al., 2007). This low cow milk production rate has been associated with several factors ranging from the lower production potential of local cow breeds that make up about 90% of cattle in SSA (Njarui et al., 2012; Franzel et al., 2014) to poor feed resources (Shelton et al., 2005; Franzel and Wambugu, 2007; Lukuyu et al., 2009). Other reasons for SSA's low milk yields are: socioeconomic and geographic factors such as poor education, low incomes, demographics and unfavorable climatic conditions.

Over the years, developing countries have increased their share in global dairy production but FAO associates this with an increase in the total number of cattle rather than an increase in the productivity of existing ones (FAOSTATS, 2000). Despite a huge potential for increased milk production, there continues to be a deficit in Africa's milk output. The continent's milk production has been found to be growing at a slower rate than other developing regions mainly because of poverty and adverse climatic conditions. Worse still, the demand for milk and its by-products in the region are increasing at a greater rate than milk production. Statistics show that between 1990 and 2004, demand for milk products in Africa grew at a rate of 4% per annum; meanwhile milk production only grew at a rate of 3.1% per annum (Hemme and Otte, 2012). It is projected that more than half of the global population growth between now and 2050 is expected to occur in Africa (UN, 2015), and so the need to address the continent's insufficient milk production is even more urgent.

Smallholder dairying systems are mainly categorized as intensive dairy production systems. They are mainly the result of a growing population, diminishing land availability and higher demand for milk products. They are characterized by small farm sizes of about 1–2 ha and about 2–10 cows, generally Holstein Friesian or Ayrshire cow breeds. Milk output is comparably high and destined for the market. Only a small proportion of the milk produced is consumed at home, usually between 1 and 2 liters/day (Swai and Karimuribo, 2011). As population and economic power in SSA continue to grow, urbanization has encroached on masses of land that was formerly used in traditional livestock systems such as pastoralism. Many smallholder farmers are now moving towards more intensive and small-scale livestock production systems (Warren, 1995). These smallholder systems are typically composed of individuals who own a few dairy cattle confined to stalls under 'zero-grazing' conditions (Franzel et al., 2014).

To date, researchers agree that the inadequacy of feed resources for livestock is the greatest limiting factor for milk production in SSA (Cramb, 2000; Shelton et al., 2005; Ndambi 2008; Lukuyu et al., 2009). Paradoxically, the adoption rate of forage technologies, which is meant to improve milk production, has remained low among smallholder farmers in the region (Shelton et al., 2005; Franzel and Wambugu, 2007; Lukuyu et al., 2009).

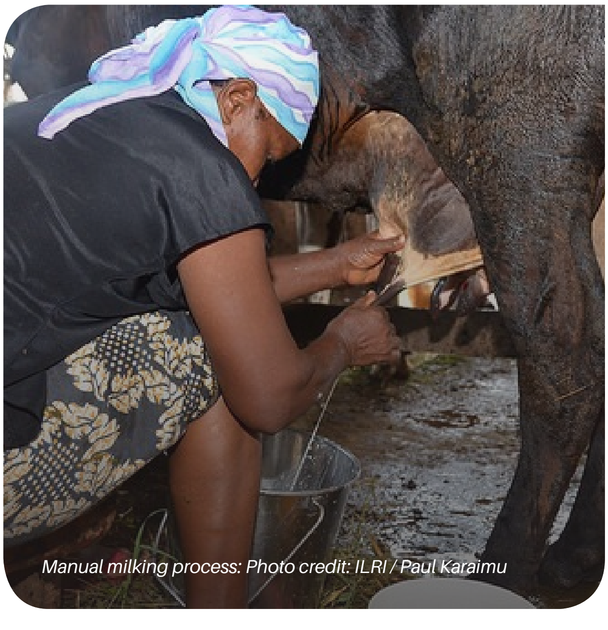
The main source of feed for cattle under these confined grazing systems is Napier grass (*Pennisetum purpureum* or elephant grass), supplemented during the dry season with crop residues such as maize stover, banana leaves and pseudostems. Naturally occurring forages collected


Cut and carry feeding in smallholder systems: Photo credit: CIAT / Georgina Smith

for example from the roadsides, and indigenous fodder shrubs also form a substantial part of cattle's food intake (Franzel and Wambugu, 2007). Farmers feed their cattle through 'cut and carry' methods where forages are cut and brought to feed animals in their indoor stalls. Many have reported a strong deficit of energy and crude protein, indicating that the diet of most dairy animals in Africa is inappropriate (e.g. Galvin et al., 2004). Napier grass could support a milk production rate of 7–10 kg/crossbred cow/day, but its digestibility and nitrogen concentration declines rapidly as the grass matures thereby reducing the potential milk output of animals (Mwangi and Wambugu, 2003). In fact its protein content is too low to sustain a higher milk yield (Franzel and Wambugu, 2007). Crop residues form the main source of roughage for livestock during the dry season, but have an extremely low protein concentration that makes them unfavorable for optimal milk production. The purchase of commercial feed and concentrates could improve feeding, but most farmers in this region lack the financial means to purchase feed (Lukuyu et al., 2009). The high climate variability and seasonal changes in SSA also produce fluctuations in feed availability. Kurwijila et al. (2012) reported that feed resources could drop by up to 56% in the dry season due to inadequate rainfall. And there were no efficient means of storing feed during surplus seasons for the dry days. Kavana et al. (2005) demonstrated how seasons affect the quality and quantity of feed by proving that cows in Tanzania receive only 30 kg of fresh weight/cow/day in the dry season and attain only between 71 and 83% of their usual output during this period. Water supply was also inadequate in many parts of Africa. During periods of water shortage, the free water intake of animals is reduced, which negatively affects their productivity and health (Kavana and Msangi, 2005).

3.1.2 Smallholder dairying in Tanzania

Tanzania has the third largest cattle population in Africa after Ethiopia and Sudan. Its cattle population is estimated at 21 million heads (Kurwijila et al., 2012). However, more than 95% of the cattle are of the indigenous shorthorn East African Zebu breed. The crossbred and exotic dairy cattle are mainly of the Friesian and Ayrshire types and have a production potential which is ten times greater than that of the Zebu cattle. Njombe et al. (2011) stated that the total number of improved dairy cattle in Tanzania only amounts to about 1 million, providing 30% of the total milk produced.


Manual milking process: Photo credit: ILRI / Paul Karaimu

A total of 1.7 million smallholder farmers (37% of the country's rural households) keep Tanzania's cattle. About 71% of these small-scale dairy farmers own between 1 and 10 heads of cattle (Kurwijila et al., 2012). The cattle are concentrated in only a few of the 26 mainland regions and in Zanzibar. Regions with more than 1 million heads of cattle include: Shinyanga, Mwanza, Arusha, Mara, Manyara, Singida, and Dodoma, which are mainly lowland and humid. Most of the improved dairy cattle are concentrated in the cooler highland regions with subtropical climates around Kilimanjaro, Arusha, Tanga, and Mbeya (Kurwijila et al., 2012). The use of other areas for livestock production has been limited by tsetse infestation.

The livestock sector accounts for up to 22% of the country's rural income (Kurwijila et al., 2012) and holds unexploited potential for more. Milk production in Tanzania has witnessed an increase in recent past decades. Production rate increased from 814 million liters in 2000/01 to 1.65 billion liters in 2009/10 (Njombe et al., 2011). This increase was not linked to an increase in the productivity per head but to an increase in the total number of cattle in the country. Milk yields for improved dairy cattle are far from satisfactory. Instead of the expected output of at least 15 liters/cow/day for dairy cattle under tropical conditions, exotic cows under smallholder farmers in Tanzania only yield 6 to 10 liters/cow/day (Chang'a et al., 2010) and the output drops by 2 to 3 liters during dry periods (Lusato et al., 2012). This indicates that dairy breeds that are expected to be 10 times more productive than the local breeds are operating below capacity in Tanzania. The total milk yield from smallholders in Tanzania amounts to 1,940 kg/cow/year and its annual growth rate is between 20 and 30% compared to 80% in neighboring Kenya (Swai and Karimuribo, 2011). Many researchers (Kaliba et al., 1997; Kavana and Msangi, 2005; Mapiye et al. 2007; Lukuyu et al., 2009; Wambugu et al., 2011) have associated this not only with the genetic disadvantage of the TSHZ cattle breeds, but also with the poor quality and quantity of feed for cattle. Moreover, the increase in milk production has been credited to an increase in the overall number of cattle rather than to an increase in dairy productivity per head (Njombe et al., 2011).

The problem of an inadequate rate of milk production in Tanzania is made more pressing by the steady increase in the demand for milk. The country's population growth has been rated at 3.3% per annum and its economic growth rate is 7% per annum (Kurwijila et al., 2012), which results in a steep increase in demand for dairy products. Consequently, milk imports into Tanzania have been forced to increase at a rate of 9% per annum to meet demand (Kurwijila et al., 2012). In recent years, Tanzania has imported between 30 and 40 million liters of milk in the form of milk powder, infant formula, butter, and cheese. Worse still, locally processed milk has declined by more than 80% in the last 15 years.

The low milk production rate is caused by several factors including the inadequate supply of feed, which is largely the result of climate variability in the country (Kavana and Msangi, 2005; Ndambi et al., 2007; Lukuyu et al., 2009; Gillah et al., 2012). Depending on the part of the country where the dairy farms are located, feeding could either be 'zero-grazing' i.e. in areas of year-round sufficient feed such as the highlands regions of Kilimanjaro, Arusha, Iringa, and Mbeya, or pasture grazing and mixed-feeding in a few parts that still have communal grazing lands (Swai and Karimuribo, 2011). However, the most common system countrywide for dairy livestock is 'zero-grazing' where feed is cut and brought to animals in confined stalls, typically twice a day.

Zero-grazing feeding in Tanzania is similar to other systems in SSA as described above, with collected natural grasses, Napier grass, and crop residues in the dry season as the main feeds (Chang'a et al., 2010).

Many of the cows in Tanzania live under unhygienic conditions. In a study of 129 farms around the country, Chang'a et al. (2010) found that more than half of the cow stalls had potholes and poor drainage systems. Dung was left in the stalls and it created unhealthy conditions and propagated diseases, especially diarrhea, which was common among most of the studied cows (Chang'a et al., 2010; Swai and Karimuribo, 2011). Due to their milk producing potential, female cows were given preferential treatment in the barns. They either received a greater quantity of feed or were fed exclusively at the expense of their male counterparts, and in some cases resulting in the death of male cattle. In some cases, male cattle were sold to avoid incurring the 'unnecessary' costs of feeding them.

Lukuyu et al. (2009) argued that artificial insemination (AI) plays a vital role in small-scale dairy farms because it is cheaper and less cumbersome than maintaining an "exotic" bull (e.g. Friesian and Ayrshire types). However, AI service provision and the necessary cooling chain are poorly developed in Tanzania. In addition, few farmers in Tanzania can afford the cost of AI. Many of them depend on government and donor-driven breeding programs for improving the genetic potential of their cattle.

Most of the milk produced from smallholder dairy systems is destined for the market and only a small proportion (1–2 kg/day) is kept for home consumption (Swai and Karimuribo, 2011). Nevertheless, only about 10% of smallholders' milk output gets to urban markets because of infrastructural and market constraints such as unfavorable prices and poor farm-to market links for dairy products (Kavana et al., 2005; Swai and Karimuribo, 2011; Pham et al., 2015). Smallholders' access to formal markets is limited due to the unreliability of markets and the high costs involved in preservation of milk for long-distance transportation. Consequently, milk is sold mostly raw to neighbors and local restaurants (Omore et al., 2004; Swai and Karimuribo, 2011).

3.1.3 Smallholder dairying in Lushoto

Lushoto is one of the Tanga region's eight districts in the northeast of Tanzania. It is bordered to the northeast by Kenya; to the east by the Muheza district; to the northwest by the Kilimanjaro region; and to the south by the Korogue district. Formerly known as 'Wilhelmstal'[2], Lushoto is made up of 32 administrative wards, which contain: Mbuzii, Ubiri, Bangha, Bumbui, and Lushoto villages. The district enjoys a cool mountain climate with temperatures ranging between 18 and 23°C. The temperatures are favorable for keeping improved dairy breeds. It is characterized by high rainfall with an annual precipitation rate ranging between 600 and 2000 mm (Jambiya, 1998). Rains reach their maximum in March and their minimum in July. Crop cultivation in Lushoto occurs in the following known rainfall patterns: 'Vuli' (short rains) between October and December; 'Masika' (long rains) between March and June; and 'Mluati' (intermediate rains) between July and September. The length of the growing period (LGP) is estimated to be greater than 200 days (Sijmons et al., 2013), which makes it suitable for crop/fodder cultivation. Lushoto is one of the most densely populated districts of Tanzania with between 50 and 250 persons/km^2 (Sijmons et al., 2013). In 1998, the district had a population excess of 400,000 persons and was still growing at a rate of between 2.2 and 2.8% per annum (Jambiya, 1998). As it is characterized mostly by steep slopes and protected forests, there is a much competition for arable land in the district. Smallholder farmers dominate its agriculture and they typically own small farms and operate on low budgets. Studies report that between 80 and 100% of the people in Lushoto are living below the poverty line with less than US$2 per day (Sijmons et al., 2013). Despite having a high population density and a limited land area, the region has a significant dairy cattle population and presents an opportunity for dairy improvement in the country.


Cow shed in smallholder farm in Lushoto, Usumbara highlands. Photo credit: CIAT / An Notenbaert

Smallholder farmers usually practice intensive dairy farming and they typically own between 2 and 10 dairy cows each.[3] Dairy farmers in Lushoto practice mostly 'zero-grazing' where the cattle are housed in small pens all year-round and are provided with feed in situ. The most common forms of feed among smallholders in Lushoto, like in most of Tanzania, is natural grass. Napier grass, Leucaena and fodder trees (i.e. 'Huzini', 'Kungili', 'Mlalo', 'Shume') are also planted along contours and field edges to be used as cattle feed by some farmers. Natural grasses and weeds from common areas and roadsides also make up a substantial part of feed in Lushoto. Morris et al. (2015) report that in Lushoto, very few plots were dedicated to the cultivation of forages for immediate use. Even fewer fields were dedicated to haymaking and silage, probably due to the damp weather conditions in the district. Crop residues such as those from maize and beans were of major use to dairy farmers in the district but most concentrates and their processing by-products (e.g. maize bran and sunflower cake) were only available outside Lushoto. Dairy farmers were able to get them from Dar es Salaam, Moshi, Iringa, or Tanga. Molasses came from Mvomero and Kilosa, making it difficult for farmers to rely on them for regular use.

2. William's Valley in honor of Kaiser William during German colonial rule.
3. Dairy cows are mostly crossbreeds between the local TSHZ and exotic breeds such as Fresian and Jersey. Pure exotic cow breeds are shunned because of their poor adaptability to local climatic conditions.

Cattle health in Lushoto was maintained through on-site spraying as farmers generally had less than 10 cows. Unfortunately, spray kits were not always available, making government action indispensable. The government of Tanzania therefore provides a free annual vaccination for cattle against contagious Bovine Pleuropneumonia (CBPP). The district also has seven cattle dips and nine veterinary centers although their services are deemed inaccessible by poor smallholders. According to Morris et al. (2015), cattle reproduction is mostly through bull servicing; and AI is not common.

Most of the milk produced is aimed for the market. Lushoto has one cattle market and four small-scale milk cooling units. *Tanga Fresh* (located in Tanga 153 km from Lushoto) is the major milk buyer in the district. The milk price paid by these collecting facilities is too low for most dairy farmers; this is why the predominant form of milk sales continues to be to neighbors, restaurants, local vendors, and individuals. There are also five local milk collection centers at Bumbuli, Lushoto, Mwangoi, Shume, and Mlalo. All have cooling facilities except that at Bumbuli which send its milk to be cooled in Lushoto. However, milk collection is not well organized and is ineffective. Jambiya (1998) reports that in Lushoto the transport network has been ameliorated and its market access[4] is rated to be less than 5 hours (Sijmons et al., 2013).

3.1.4 The adoption of improved forage technologies in SSA

The problem of providing feed for livestock is widespread in SSA, Africa, and both national and international research institutions have been preoccupied with the introduction of higher quality forages for livestock in the developing world (Shelton et al., 2005). Researchers consider the introduction of improved forages as a way of delivering multivariate benefits to dairy farmers in poorer parts of the world. Their uptake in resource-poor areas such as SSA can yield benefits such as:

- An increase in the milk output of existing cattle
- An increase cattle body weight and the potential amount of beef produced
- A decrease in soil erosion and an increase in the nitrogen concentration of soils, hence enhancing soil fertility
- A reduction in the labor burden of fetching fodder from far away
- Higher income and improved capacity of smallholder farmers i.e. contributing to poverty alleviation

Despite these potential benefits, the adoption of improved forages in SSA has proven to be slower than in other parts of the developing world (Mwangi and Wambugu, 2003; Ayantunde et al., 2005; Franzel and Wambugu, 2007; Wambugu et al., 2011; Njarui et al., 2012). In Kenya, forage species such as *Leucaena trichandra anspecies*, *Morus alba* (mulberry) and *Sesbania sesban* have been widely tested and disseminated, but their adoption has not been optimal (Franzel and Wambugu, 2007). Gebremedhin et al. (2003) report that despite being aware of the benefits of adopting oats–vetch forage technologies in Ethiopia, its adoption by farmers is slow. The non-adoption rate of improved legumes such as *Lablab, Desmodium, Calliandra* and *Leucana* have shown glaring deficiencies in Kenya and Uganda where Njarui et al. (2012) reported that only 10% of dairy farmers had taken them up despite widespread publicity. Smallholder farmers have been reported to be the most reluctant to adopt these improved forages in Africa. A study by Franzel and Wambugu (2007) on the adoption of fodder shrubs revealed low adoption rates in the whole of East Africa. Their findings show that despite the extensive testing and introduction of fodder shrubs in the area (since the 1990s), very few cases of adoption have been found. In fact, cumulatively only 200,000 farmers in Kenya, Uganda, Rwanda, and northern Tanzania have planted fodder shrubs in the past decade and the numbers of trees per individual farmer were inadequate for the year-round feeding of their cattle (Mwangi and Wambugu, 2003).
A plethora of reasons have been advanced for the observed reluctance to adopt improved forage technologies. Shelton et al. (2005) argue that the diffusion of a forage technology is a gradual process that could take many years (typically between 10 and 50 years) before the results of its introduction become evident. In the same vein, Abdulai and Huffman (2006) purport that the diffusion of any new agricultural technology varies significantly across space and time. Franzel et al. (2014) have stated that adoption studies are highly site specific and often incomparable. Therefore, the factors presented here do not in any way suggest that the poor rates of adoption witnessed in SSA are definite; there is a high probability that they will vary over time. Reasons for the slow adoption are clustered into four broad categories: Nature of the introduced forages; economic factors; farmers' characteristics; and institutional factors.

a) Nature of introduced forages: Many studies on the rate of the adoption of improved forage technologies have been criticized for dwelling on

4. Market access is the measure of accessibility in time/hours taken to reach the nearest urban center/town or city with a population of 50,000 people or more, taking different means of transportation into account.

the external limiting factors while downplaying the specific characteristics and suitability of an introduced forage technology (Sumberg, 2005). Sumberg (2005) argues that the most important influence on the adoption of any forage technology is in its characteristics. The geographical differences between temperate regions, from which most improved forages originate, and the tropical conditions in SSA, are important. The predominantly humid climatic conditions in the tropics favor the prevalence of insects and tropical diseases (e.g. Napier Head Smut in Uganda and Kenya) which could adversely affect the performance of temperate forages and hence discourage their adoption by smallholders. The type of forage introduced therefore matters and this has been proven by adoption studies in some parts of Africa. In Tanzania for instance, the poor performance of Buffel grass *(Cenchrus ciliaris)*, hardy forage legumes *(Stylosanthes scabra cv.)* and *S. hamata* cv. *verano* introduced by the MilkiT project between 2012 and 2014, has been blamed on the unpredictability of the country's climate. The forage's growth period was characterized by an unexpected drought and excessive water logging which marred the process (ILRI, 2014). In Lushoto district, the incompatibility of haymaking and the characteristic dampness in the area made its adoption difficult (Morris et al., 2015). Despite numerous demonstrations of haymaking and silage making in Mbuzii, no individual dairy farmer was found to be practicing it in the district. Although Lushoto is characterized by heavy rainfall, there are pockets of drought, which necessitates the use of drought-resistant forage species. A thorough examination of the prevalent climatic conditions in any specific area must be carried out before cultivated forages are introduced.

Despite the importance of improved forage technologies, their benefits still tend to be long term and indirect i.e. human only benefit from fodder shrubs after dairy cows have consumed them and produced either milk or meat in return. The complexity of forage benefits is easily forgone when rural farmers are faced with more directly beneficial crops. In cases of land scarcity for instance, forage crops are less likely to win in competition with food crops. This is the case in Lushoto district of Tanzania where there is pressure on the existing plots of land (Morris et al., 2015). Farmers are reported to prefer using their plots for the cultivation of food crops and horticulture (which offer direct cash) than for planting forages whose benefits are rather indirect.

For smallholder dairy farmers in Africa to become fully engaged in the cultivation of newly introduced forage technologies, their benefits must be clearly demonstrated (Mwangi and Wambugu, 2003).

Cut and carry feeding in Tanzania: Photo credit: CIAT/Georgina Smith

Smallholder farmers should also be informed of the short-term benefits of introduced forages instead of focusing exclusively on the long-term gains.

b) Economic factors: With roughly 70% of the people in Africa living in poverty, the overall costs of forage technology plays a considerable role in its adoption. The costs include those used in purchasing seeds and farm inputs, employing labor, and the time involved. The high cost of forage seeds and farm inputs are one of the reasons for the non-adoption of some improved forage in Africa (Gebremedhin et al., 2003; Mwangi and Wambugu, 2003; Ngwira, 2003; Morris et al., 2015). The current shortage of forage seeds results from a past governmental and commercial forage company initiative to increase the supply of forage seeds. Unfortunately, the mass production of improved forage seeds was met with difficulties in maintaining the forage crops and low demand, which led to a general decrease in the seed business.

Currently, supply has become limited and out of the reach of smallholder farmers, and has negatively affected the rate of forage adoption. Almost all of the available pasture seeds are obtained either from researchers conducting on-farm experiments or from international research centers (e.g. ICRAF[5] and CIAT). Recommended quantities of imported forage seeds cost about 12% of rural farmers' monthly income, which makes their purchase rare given the poverty levels. Tanzania's forage seed scarcity is aggravated by the fact that its national seed agency does not deal in pasture/forage seeds. The imported ones are therefore, expensive and inaccessible to remote areas. Ngwira (2003) also identifies the high cost of farm inputs such as fertilizers and the cost of fencing forage crop plots as potential cost limitations to the adoption of forage technologies in Malawi.

The adoption of some forage technologies has been found to be labor-intensive and thus unfavorable for smallholder farmers. The adoption of *Desmodium intortum (DI)*, for instance, has not been widespread in central Kenya because farmers found the forage seeds to be extremely small and delicate and difficult to handle (Mwangi and Wambugu, 2003).

An assured and steady market for milk and its by-products motivated dairy farmers to increase the productivity of their cattle through the uptake of measures such as improved forage technologies (Swai and Karimuribo, 2011; Gillah et al., 2012; Kurwijila et al., 2012; Njarui et al., 2012). Nonetheless, smallholders in many parts of Africa do not always enjoy market access. Many dairy markets in the region e.g. Ethiopia (Gebremedhin et al., 2003), Zimbabwe (Mapiye et al., 2006) and Malawi (Ngwira, 2003), suffer from the inadequacy of established institutions that regulate milk market related concerns such as price stabilization and quality control. In Tanzania, smallholders have restricted access to formal milk markets because of their inefficiency and small outputs. Swai and Karimuribo (2011), view the fall of Tanzania Dairies Limited[6] as the main cause of market insecurity for rural dairy farmers in most of Tanzania. In the case of Lushoto, the low prices offered by collection units do not encourage farmers to sell to them.

Overall, the farm-to-market transactions costs play a considerable role in the adoption of new forages. Poor farm-to-market links have been reported in most areas of small-scale milk production on the continent (Gebremedhin et al., 2003). Worse still, most of the milk is transported to markets either by bicycles or on the head. The absence of all-weather

Livestock in Tanzania.
Photo credit: CIAT/Georgina Smith

road networks in areas of milk production is a major threat to the efficiency of milk delivery and could discourage its mass production. Many of the rural areas where smallholder dairy farmers operate in Africa lack milk cooling facilities (Ndambi, 2008; Gillah et al., 2012).

c) Farmers' characteristics: This is by far the most common factor which affects the rate of adoption of forage technologies in Africa. These are the farmers' attributes that either increase or reduce their likelihood to adopt new agricultural technologies. Factors in this group include the physical and social capital holdings of individual farmers and their educational achievements and demographic groups. In technology adoption, the smallholder's income level is important (Cramb, 2000; Shelton et al., 2005; Mapiye et al., 2006; Gillah et al., 2012). Most small-scale dairy farmers in Africa are poor and do not have the resources to use to adopt new technologies. In past cases, wealthier farmers

5. International Center for Research in Agroforestry
6. Tanzania Dairies Limited was a milk-processing unit that operated under the country's Livestock Development Authority between 1970 and 1994. It had 7 highly organized and effective plants in Tanzania that collected, cooled, processed and channeled milk from smallholders to organized city markets.

have been more likely to take up new forage technologies than poorer ones (Mapiye et al., 2006; Chang'a et al., 2010; Mwakaje, 2012). For farmers with additional sources of income from off-farm activities (e.g. civil servants) pressure on income for subsistence was reduced, so they were able to afford the additional costs through the uptake of fodder technology (Kaliba et al., 1997; Cramb, 2000; Kassie et al., 2013).

The low-income level is likely to be the greatest limiting factor in Lushoto. As the district's poverty index is between 80 and 100% of the inhabitants at less than US$2/day (Sijmons et al., 2013), the availability of extra cash is extremely difficult. This might explain why very few plots of cultivated forages can be found in the district.

The absence of land resources has also been found to influence the adoption of forage technologies in Africa. Given the growing population and massive urbanization schemes, many farmers no longer have the opportunity to use more land. The shortage of land, therefore, has made it difficult for many farmers to afford the land required for the planting of improved forages (Lukuyu et al., 2009). The frequency of land disputes (ILRI, 2014) and the scarcity of secured land tenure have made the situation worse (Gebremedhin et al., 2003). In Lushoto, the situation is made worse by the predominantly mountainous landscape,[7] leading to strong competition for arable land in the district. The level of education of most dairy farmers influences the rate at which they take up newly introduced feeding methods for their livestock. Literacy enhances the level to which farmers can interpret and appreciate new methods and increases the likelihood of them adopting useful strategies (Njarui et al., 2012). Unfortunately, most dairy farmers in Africa have low educational backgrounds, which often limit their capacity to appreciate and take up complex technologies (Ndambi et al., 2007). However, a study on the adoption rate of forage legumes in Zimbabwe found that most of dairy farmers (93%) were literate with at least primary school education. Results of the rate of forage technology adoption were exactly as predicted in cases of good literacy levels (Mapiye et al., 2006). However, Abdulai and Huffman (2006) insist that the part played by education fades with time and improved overall literacy levels.

Information on newly introduced forage technologies also plays a vital role in their adoption (Mwakaje, 2012; Kassie et al., 2013). Kassie et al. (2013) recommend that robust information campaigns accompany all efforts to introduce improved forage technologies, especially in rural areas. Electronic and print media use has been particularly useful in the dissemination of forage related information in Tanzania (ILRI, 2014).

Social capital is all the formal or informal human networks that could support farmer's decisions and serve as insurance (informal) for their actions (Kassie et al., 2013). There are several ways in which social capital can influence a farmer's decision to take up (or not take up) a forage technology. One of them takes the form of strong farmers' associations (Abdulai and Huffman, 2006). They hold the power to address milk price fluctuations that are rampant on African dairy farms. Membership to such networks could easily increase individual farmers' bargaining power and reduce their transaction costs, thus making room for excesses that could be used to introduce improved forages for dairy cows (Kassie

7. Most of the land in lowland areas of the district is being used for horticulture, which has become the main breadbasket of the district.

et al., 2013). The absence of these associations especially in East Africa (Pham et al., 2015) tends to curbs the powers of individual dairy farmers to break through the market and makes them less likely to engage in yield maximization ventures such as improved forages.

The mere concentration of many dairy farmers in one area increases the probability of their uptake of improved forage technologies (Abdulai and Huffman, 2006). This happens because of competition among neighboring farmers which can spur on the need for innovative practices among them as well as the possibility for more informed farmers to share their knowledge with less informed ones.

Furthermore, the size of a family matters as it provides a ready and cheap work force. In a study of the rate of adoption of forage technologies in the Tanga region of Tanzania, Swai and Karimuribo (2011) found that families with more members had access to a greater labor force, which eased their adoption of forage technologies (which was considered to be labor intensive). In Lushoto, family labor is declining due to the vast outmigration of youth, especially young men in the working age group. This leaves families with fewer options for cheap labor and could discourage the adoption of labor-intensive forage technologies.

Shelton et al. (2005) found age to be one of the factors that affected the adoption of forage technologies all over the world. They argued that older farmers generally lack interest in innovation and are reluctant to abandon their past experiences to pursue new ideas on the best practices in dairy farming. They are generally more risk averse and less likely to take up new forage technologies than their younger counterparts (Mwakaje, 2012; Kassie et al., 2013).

Researchers were almost unanimous in the view that female dairy farmers in SSA were less likely to adopt forage technologies than their male counterparts. The first reason for this disparity is that female farmers in Africa often dispose of fewer critical farm resources (i.e. land, labor, and capital) than male ones (Kassie et al., 2013). Women in many parts of SSA have less managerial power than men. The male head of the household is generally the main decision maker (Kavana et al., 2005) and controls most cattle-related activities and decisions (Pham et al., 2015). In Tanzania, women equally own less managerial powers than their male counterparts (Lukuyu et al., 2009) and despite being responsible for dairy husbandry and feeding, they are not in charge of decision making (ILRI, 2015), which puts female Tanzanian dairy farmers at a disadvantage.

d) Institutional factors: For dairy farming to take the right form and produce the expected results in Africa, institutions must be present to offer support and guide dairy farmers in their uptake of the best available practices (Ndambi et al., 2007). This indicates that institutions have specific roles to play in the adoption process. The following section examines the various institutions concerned and how they affect smallholder farmers' decisions to take up new forage techniques.

Governments could indirectly influence the rate of adoption of forage technologies through the use of extension services (Kaliba et al., 1997). Unfortunately, formal extension systems are reported to be in general decline throughout Africa (Franzel and Wambugu, 2007). The negative influence of absent extension services on adoption rates has been highlighted in several studies (Elbasha et al., 1999; Shelton et al., 2005). However, bad governance has marred the positive influence of government extension workers in Africa (Kassie et al., 2013). In Tanzania, Chaussa (2013) reported that most of the government extension service workers were unreliable and slowed down the flow of information.

Ready access to credit would be greatly beneficial in the adoption of improved forage technologies. Unfortunately, individual farmers in these poor regions lack the surety required to obtain loans from formal institutions (Reynolds, 1989; Kurwijila et al., 2012; Mwakaje, 2012). In most of SSA, credit procedures are complex and banks are reluctant to lend money to individual farmers.

The interplay between poverty, high costs of forage inputs, and the difficulties that smallholders encounter in the quest for credit, is a discouraging factor in the adoption of forage technologies in SSA. However, this factor can be overcome through the formation of organized dairy farmer groups and associations (Kassie et al., 2013). This would improve the credibility of individual farmers and ease their access to credit.

In most of SSA, and Tanzania in particular, the top-down approach to development is the norm (ILRI, 2014). Unfortunately, many of the organizations involved have engaged in what has been termed as 'the failure approach' (Shelton et al., 2005) i.e.: failing to create effective and working partnerships between dairy farmers, public and private institutions; failing to secure a ready supply of seeds for newly introduced forages; and failing to adopt a participatory approach to the forage introduction.

These failures are the main reasons why new forage ideas end up on paper in many parts of the developing world. Research and development organizations that are interested in scaling up the adoption of forage technologies (that would boost the milk production rate of cattle) in Africa must be willing to participate fully in the implementation processes. In dealing with dairy farmers in Africa therefore, researchers should stop taking the roles of facilitators and/or observers, and are encouraged to take active part in the implementation process (ILRI, 2015). They must ensure the sustainability of introduced measures through the establishment of strong partnerships between farmers, private and public organizations, NGOs, community groups, farmer schools and local churches. This participatory approach, however, should not be based solely on scientific enquiry but also on site-specific social factors. They hold a lot of potential to positively affect the rate of forage technology adoption in SSA.

3.2 Interviews and farm visits

3.2.1 Forage production

Forage production is the main focus of the project and played a major role in the discussions. Farmers distinguished both quality and quantity issues. In the dry season, farmers noted the low quality of the available fodder sources if no high quality fodder was conserved. The lack of rainfall also leads to a shortage of forage quantities. Farmers have to walk long distances to fetch fodder from sites with a reasonable vegetation cover. Such sites could be along roads, hedges or riverbanks. Some farmers even feed banana stems to their livestock. The biomass of such sources was reported to be rather low. The long distance between farmstead and fodder collection areas leads to many hours spent on fodder collection. In the rainy season, farmers appreciate having high quality forage grown close to the farmstead. The short distance to the cowsheds reduces the time of fodder collection that can be better used on crop production. The need to fetch fodder from other sources is reduced. Farmers are aware of the higher quality of improved forage varieties, but stress the low availability of planting material. Very few farmers conserve forage harvested at the end of the rain season. Even the ones that were conserving forage (e.g. hay, silage) saw it rather as an experiment than as a reliable source of livestock feed during the dry season. Farmers mentioned changes in rainfall patterns over the past years (e.g. a delayed start of rainy season or lower amount of rainfall). Such changes had a negative influence on cash crop yields. Livestock was seen (by some farmers) as a stabilizing source of income. In general, forage production on slopes, both on the fields and on the field boundaries, was seen as a good way to control soil erosion. Farmers interviewed were familiar with soil erosion problems, which were reported as a main trigger for the uptake of forage production. The economic benefits from higher quality and more stable fodder supply are seen as a by-product of erosion control.

3.2.2 Livestock production

Livestock production was discussed during the talks with the farmers. Farmers requested support in getting better cattle breeds from the local government, donors or other project organizers with the assumption that such hybrids were thought to have a higher milk yield when being fed the same amount of fodder as local breeds. However, farmers also knew that the feed quality and quantity they fed their cattle was often not sufficient. Extension officers tried to encourage farmers to first reach optimal feed levels with the existing breeds before asking for better livestock material. In general, there was very diverse knowledge about the optimal feeding quality and quantity of livestock. While some farmers underlined the importance of an adjusted feed ration for each part of the lactation, others barely fed their animals enough to reach their basic needs, and far below what was needed to get the appropriate levels of milk production. Some farmers added supplements, while others fed only inferior high-fiber shrubs or leaves. Furthermore, the farmers mentioned the supply of sufficient water for the livestock as another challenge. As water often had to be carried over a considerable distance from a well to the sheds, cows often did not receive sufficient water for optimal milk production. Provision of drinking water to cows was variable – it was sometimes provided twice a day, and often not at all, and hardly ever as required. The farmers' knowledge of the water needs of cattle and its link to milk production was often limited. The topic of reproduction was echoed by many farmers and was discussed at length. Farmers complained of difficulties in getting experts to visit their farms to carry out AI. The experts had to cover a too large area and might not arrive on time for a successful insemination. Also, the farmers reported that recognizing a cow being in heat was difficult, so they often did not call the AI expert at the right time; this was coupled with the lack of cooling facilities for semen. Farmers suggested that more successful reproduction rates could be achieved by training one farmer as an AI expert in each village or by keeping one bull by each village. However, there were trust issues and shared investment in terms of the training of one person or the purchase of a bull were problematic. Farmers reported bad experiences when money was entrusted to just one person in the past to purchase improved breeds of cattle (and the person left the village with the money and did not return). One observation during the visits was the bad condition of the cowsheds. Cows were often left standing on wet, soft soil mixed with dung. The roofs were sometimes absent so that cows were not sufficiently protected from the elements. Ropes used to keep the cows in place were at times too short and restricted the cows from even moving their heads. Questions from the interviewers around knowledge of what effects these conditions had on milk yields were often not seen as relevant. Marketing issues played a considerable role in the life of milk producing farmers. The prices mentioned by the farmers varied depending on the way the milk was marketed. Some farmers sold directly to end consumers and therefore got a higher price compared to farmers who sold their milk to a collector. The transportation of milk to selling points was time consuming both for direct and intermediate marketing. Immediate cooling of the milk was not possible for all the farmers interviewed.

3.2.3 Organizational issues

Discussion with the farmers on organizational issues revealed the influence of the innovation platform (IP) chairmen, village officers, and extension officers. While the IP chairmen play a proactive role in the promotion of forage production, knowledge distribution, and the provision of planting material, the village officers were considered only as "not interfering", but not supportive of the actions of the farmers. The role of the extension officers depended on their personal engagement. The ones in charge at the time of the interviews were seen as supportive and highly engaged. As mentioned earlier under the topic of reproduction, trust around shared investments was low (e.g. financing the training of an AI expert, delegation to a person to buy improved livestock, or the shared costs of keeping a bull). Additionally, some farmers were reluctant to become members of the IPs, because they did not trust in the benefits of shared learning and organization among farmers.

3.2.4 Summary from interviews and farm visits

In summary, the interviews unveiled triggering, sustaining, and inhibiting forces toward further adaptation and adoption of forage technologies from individual farmers' perspectives. While the triggering factors were related to shortage of feed and soil conservation problems, the expected economic advantages were not as dominant in farmers' responses. The reasons for sustaining the practices of growing improved forages were the: year-round availability of fodder, increased fodder demand (due to higher livestock numbers) and accumulated benefits (e.g. increased animal numbers and forage yields). Soil conservation issues were mentioned less often, in contrast to their dominance as triggering factors. According to the farmers, further up scaling needed more support in terms of: animal breeding, provision of sufficient planting materials, and the expansion of the program to other farmers beyond the innovation platform. The variation in the importance of triggering factors (especially land conservation) and sustaining factors (e.g. constant availability of fodder) is an important lesson learned from this survey.

3.3 QATo-FT multi stakeholder learning and assessment workshop

3.3.1 Adoption potential

The QATo-FT assessment for the two villages in Lushoto (Mbuzii and Ubiri) revealed a high but irregular influence of the various institutional thematic categories on the adoption potential of improved forages. The following section highlights those categories revealed by the workshop participants as exerting a positive influence on adoption potential as well as those identified as exerting a much lower or weaker influence on adoption potential of improved forage technologies in Lushoto.

The first positive category is the "community's perception towards forage technology". It was assessed as exerting a strong supporting influence on adoption potential, especially in the case of Mbuzii with an RT Score of 100% (see Figure 2).

This assessment implies that so far, ongoing forage project activities were viewed positively and did not interfere with the economic activities of non-adopters in the region. While non-adopters were obviously not as close to the innovation as adopters, they respected the decision of those who chose to adopt the technology and their daily economic activities were not negatively affected because they had not adopted the technology. Adopters and non-adopters therefore were able to live side by side in the same community, which gives potential for a future scaling up possibility once non-adopters start observing the benefits enjoyed by adopters as a result of their new practice. In addition, the promoting organizations for improved forages in the area (i.e. TALIRI Tanga), and the extension workers, have identified and are working closely with village leaders of the community and they accept, recognize and do not interfere with their activities. Although young farmers were basically absent from the scene, the few that we met were willing to

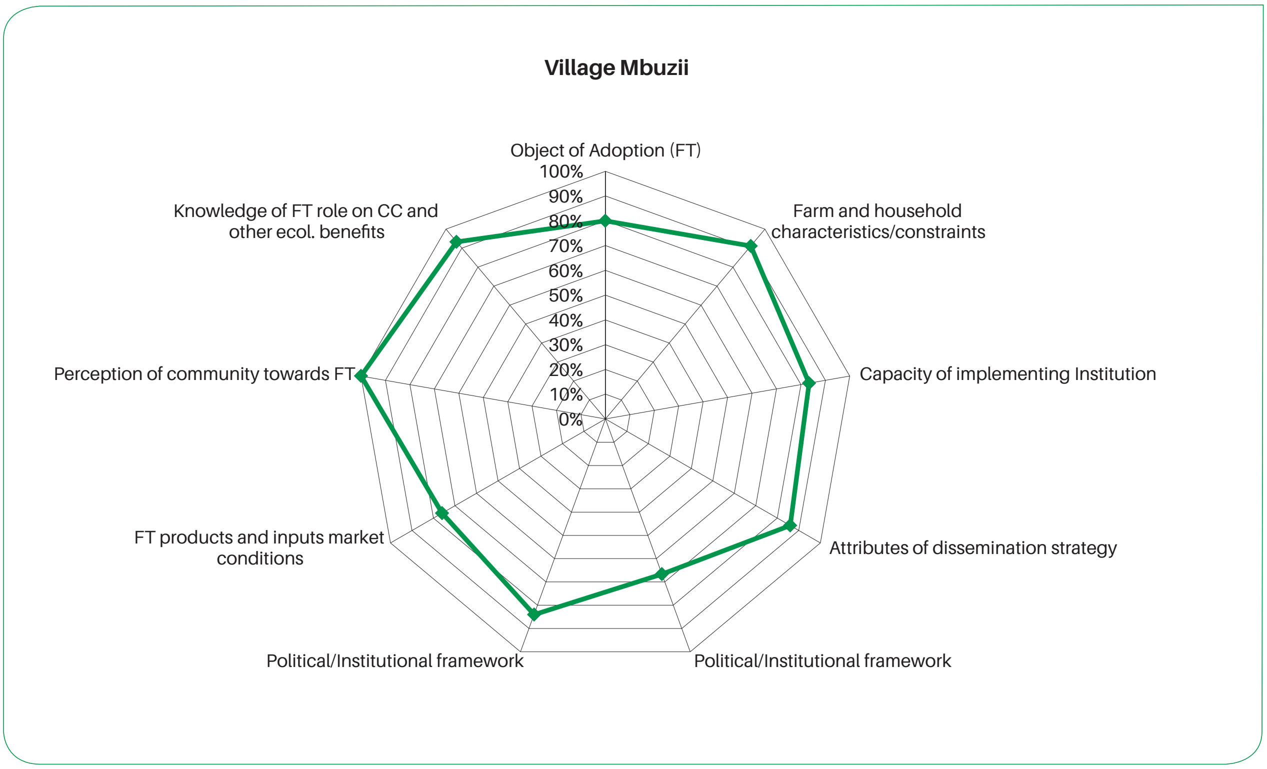


Figure 2: Thematic influence on adoption potential for Mbuzii-Lushoto

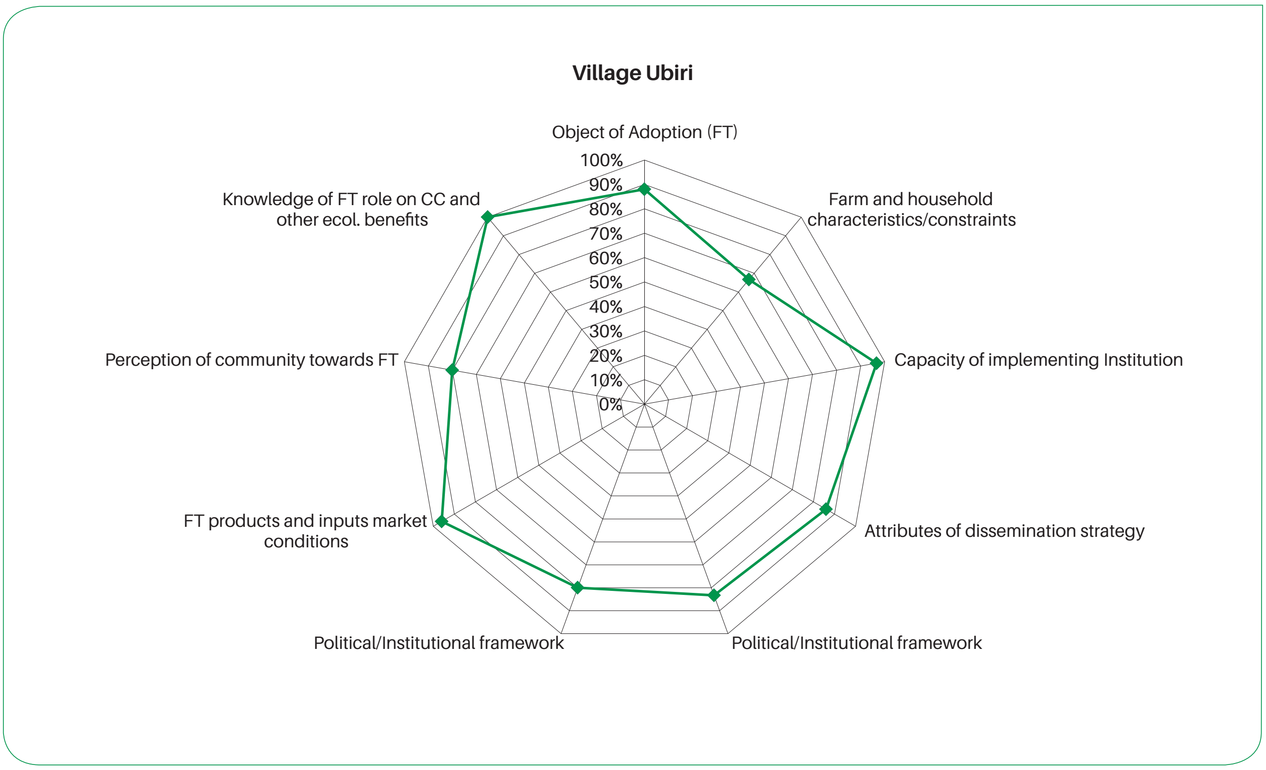


Figure 3: Thematic influence on adoption potential for Ubiri-Lushoto

participate in forage technology project activities and acknowledged that improved forage technology practices did create employment opportunities for them although livestock farming in this area was predominantly an activity for the elderly (age 40 and above). A good example is a young extension worker in one of the villages visited who was actively engaged in the promotion of this technology. The target group of farmers, who mostly are members of the Innovation platforms (IP), were self-reliant and could contribute either financially and/or physically to the promotion of the technology, though issues of trust amongst them hindered investment in shared ventures. Their decision as individuals or as a group to adopting improved forages was accepted by the entire community (and even led to some earning nicknames such as 'mzee wa hay' in Swahili which means an expert in haymaking or 'abzogani' meaning extension worker). This is a result of the exceptional skills of these farmers in managing improved forages. Their progress in adopting improved forages was partly because they were already engaged in entrepreneurial activities and had experience of general farm management before the introduction of improved forages.

The "role of improved forages on soil conservation and other ecological benefits" was assessed as exerting a strong positive influence on adoption potential especially for Ubiri village (score 100%). The role of forages in controlling soil erosion was well known to most farmers in Lushoto. Crop farmers had planted forages in contours or as hedges around their farms. As the main priority for such farmers was crop production, initially, the output from these forages within or around their fields was handed over to the livestock farmers in the village. However it was not long until these crop farmers realized the extra benefit that could come their way once they diversified their production (i.e. engaged in livestock production in addition to crop production). This has led to many farmers adopting the cultivation of improved forages not just for soil protection but for use as cattle feed as well. Such a mixed farming system is working quite well in Lushoto especially as "zero grazing" is the main livestock practice there. In this way, forages and crop residues from the contours and after harvest respectively are cut-and-carried home for feeding the animals, especially in the dry season when there is a shortage of forage from public feeding areas.

In summary, the results of the QATo-FT workshop revealed that in the case of Mbuzii (Figure 2), i) the receptive nature of the community towards the technology (RT 100%), ii) the expectations of improved forages on ecological benefits (93%), had a strong positive influence on the farmers' adoption potential for improved forages for this case. In the case of Ubiri: i) the expectations of improved forges on ecological benefits (100%), ii) role of promoting institutions (97%) and iii) products and input market conditions around livestock production and improved forages (96%) positively influenced the adoption potential for that village (Figure 3). The categories that exerted a much weaker influence on the adoption potential for the two villages were: i) the political and institutional framework at regional level (67%), ii) products and input markets conditions (76%) for Mbuzii (Figure 2); and iv) farm/household characteristics (68%) for Ubiri (Figure 3).

The overall adoption potential of improved forages for Lushoto area was rated high but with internal variations when viewed at village level. For example, Ubiri village had a slight edge over Mbuzii in terms of adoption potential. Promoting organizations must consider this internal variation in adoption potential and this should be reflected in the way their future promotional efforts are designed for the region.

3.3.2 Specific driving and inhibiting factors

According to the QATo-FT assessment scale, statements being assessed are listed on a scale of 0–5 (following the Likert-scale) indicating the legitimacy (strength) of the suggested statement with respect to their influence on the adoption potential for the case study area, where

- 0 = Not sure, has no positive effect on adoption likelihood (even negative)
- 1 = Strongly disagree, has limited positive effect on adoption
- 2 = Disagree
- 3 = Partly agree
- 4 = Agree
- 5 = Strongly agree, has maximum positive influence on adoption likelihood

N = if you think the statement is not applicable in this case or appropriate.

The QATo-FT workshop participants for Mbuzii and Ubiri did the following ranking which revealed the critically hindering and hindering factors for adoption potential in the two villages (Table 3) in any promotional effort to boost the adoption of the innovation beyond the present state in Lushoto (and for detailed information on the supporting factors see Annex 3 and 4).

In summary, across both villages, the QATo-FT assessment showed the critical hindering factors for the effective adoption potential in Lushoto to be the: i) communication channels used in transferring messages to potential adopters; ii) system of administration practiced in the region which was less decentralized for timely solutions to farmer's needs; iii) the indifference of local level governance structures to issues of forages technology; and iv) accessibility challenges for extension officers' which affected effective dissemination campaign activities. These findings tally with those from field observations and the literature review part of this report, as highlighted above.

Table 3: Critical and normal hindering factors for improved forages technologies in Lushoto

Critical hindering factors for adoption potential (participants strongly disagree with statement)[8]	
Mbuzii	**Ubiri**
The promoting organization promotes FT through the mass media, such as radio, TV or newspapers	The promoting organization promotes FT through the mass media, such as radio, TV or newspapers
There exist decentralized structures within the administration that allow locally adapted and timely solutions to farmers' problems	The settlement pattern allows extension officers easy access to farmers for promotional purposes
There is a local government with a strong leadership that commits itself to development objectives	
Normal hindering factors for adoption potential (participants disagree with statement)[9]	
Mbuzii	**Ubiri**
Household labor is usually sufficient to implement FT	Most farmers have knowledge of FT or traditional/ indigenous knowledge similar to FT
The local government promotes FT adoption through extension programs	Young farmers are willing to participate in FT project activities and FT practice creates employment opportunities for them

8. Critical hindering factors, ranked 1 on a scale of 1-5 i.e. the participants strongly disagreed with the assumption, which implies the aspect had a limited positive effect on adoption for the region.
9. Hindering factors, ranked 2 on a scale of 1-5 i.e. the participants disagree with the assumption, which implies the aspect has limited positive effect on adoption potential for the region.

4 Conclusions and recommendations

The adoption rate of improved forages in Lushoto is still in the early stages following classical diffusion theory. The farmer interviews unveiled triggering, sustaining, and inhibiting forces in adoption and further adaptation of forage technologies from individual farmers' perspectives. While the triggering factors were related to the shortage of feed and soil conservation problems, the potential economic advantages were not as dominant in the farmers' responses as expected. Farmers reported the reasons for sustaining the practices of growing improved forages as the year-round availability of fodder, increased fodder demand and accumulated benefits (e.g. increased animal numbers and forage yields). According to farmers, further up scaling needed more support in terms of animal breeding, provision of sufficient planting materials, and the expansion of the program to other farmers beyond the innovation platforms.

The rate at which a forage technology may be adopted by farmers depends on seven categories of factors: i) the characteristic attributes of the technology as an object of adoption (i.e. its adaptability, trialability, resistance of the cultivars, complexity to cultivate, relative economic advantage); ii) the capacity of promoting institutions, iii) market forces (i.e. whether or not there is a ready market with easy access and adequate transportation facilities and if the farmers aim to maximize profits); iv) the household characteristics (i.e. if the farmers are rich/poor, literate, young/old, female/male); and v) the institutional factors at the local and regional levels (i.e. do farmers receive government support, information, have access to credit and are R&D organizations readily available to assist?), vi) the general perception of the community of the technology; and vii) the knowledge of the impact of improved forages on soil conservation and other ecological benefits.

Following the QATo-FT (Qualitative participatory expert-based Assessment Tool for Forage Technology adoption) assessment, and based on the above-mentioned categories, the overall adoption potential for the Lushoto region was assessed as high. The following factors all exerted a positive influence on adoption potential: the general receptive nature of the community towards the technology; the expectations of improved forages on ecological benefits; and the role of promoting institutions. Factors exerting a weaker influence included the political and institutional framework at regional level, and products and input markets conditions for forage and overall livestock farming. Most important barriers to adoption were related to the whole farming system and the wider environment. The opportunity cost for labor was low due to lack of off-farm income possibilities, hence making it favorable for farmers to collect fodder from distant places instead of saving labor through growing forages closer to the homestead. Further, several other livestock management factors confounded potential gains in milk production through improved forages: current breeds were often not sufficiently high yielding to respond to improved feeding; providing water to zero grazing animals was not always achievable for labor-constrained farms; many farmers let forages overgrow for use in times of scarcity (dry season) which led to lower-than-necessary forage being fed to animals; sufficient planting material and extension advice on forage management and harvesting was not always available; milk prices were low and would not be increased if the volume of milk production did not increase (the collection center was operating at < 50% capacity).

This study calls for the following recommendations to improve the adoption levels for improved forages in Lushoto:

Knowledge transfer:

- A wide sensitization and education of local farmers on the short and long-term benefits of introduced forage technologies for general livestock production, increased milk yield, and soil conservation, alongside other ecological benefits.

Administrative issues:

- Local authorities should ensure the existence of decentralized structures within the administration, which allow for locally adapted and timely solutions to farmers' problems. They should allocate a budget for extension officers for farmer sensitization
- Forming and strengthening solid partnerships between local governments, farmers, NGOs, service providers, extension officers and other beneficial networks around the practice of improved forages beyond the present existing innovation platforms in the region
- The need to organize for easy access to basic resources such as water at community level to serve the farmers especially in dry seasons, and to improve education on the importance of sufficient water for animals, and its consequence on milk production.

Forages in Tanzania: making trade-offs
Photo credit: Georgina Smith / CIAT

Economic issues:

- Local authorities to work on easing smallholder farmers' access to farm loans, which could help them to acquire the basic facilities needed for maintaining decent living conditions for their livestock, temporal handling of milk between the farm and delivery sources, and improving their livestock breeds
- Improving off-farm income possibilities to reduce pressure on land use as the only income source
- Creating access to existing markets to encourage the mass production of milk from farmers, which will trigger their adoption of improved forages e.g. establishing more local collection centers endowed with small milk cooling facilities with the possibility of direct pick up at the farm gate to increase the farmers' profit margin.

Agronomic issues:

- An assessment of new, improved forage technologies' resilience and resistance to local and possible changing climatic factors of the region
- Careful consideration of the provision of crossbred cows which is a continuous demand of the farmers in the region e.g. organizing issues of availability and accessibility to AI services, alongside the lessons of optimal feeding
- A need to improve the issues of accessibility to seeds or planting material for potential adopter farmers who have become convinced of the effects of feeding improved forages on their milk yield levels. Easy accessibility to planting materials should not be limited to members of the innovation platforms but should be open to interested non-members.

Based on our findings, the aforementioned aspects hold the key to motivating small-scale dairy farmers to take up productive farm actions such as improved forage technologies in Lushoto and beyond. The performance of existing heads of cattle would improve, milk yields increase, and farmers' income levels enhanced. This could improve nutrition and eventually contribute to poverty alleviation.

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6 Annex

Annex 1: Overall thematic institutional influence on forage adoption potential for Mbuzii village (QAT-FT assessment)

	Thematic area (A....I)	Maximum possible points	Total points achieved	Percentage achieved (Points achieved/total points)
A	Object of adoption (FT) (ObjofAdoptFarmVillLev)	25	20	80%
B	Farm and household characteristics/ constraints (FarmHHcharac)	45	41	91%
C	Capacity of implementing Institution (CapacityofImpInstVillRegLev)	30	25	83%
D	Attributes of dissemination strategy (AttrOfDissemStraVillRegLev)	50	43	86%
E	Political/Institutional framework (PolInstRegLev)	30	20	67%
F	Political/Institutional framework (PolInstVillLev)	25	21	84%
G	FT products and inputs market conditions (MarkCondVillRegLev)	25	19	76%
H	Perception of community towards FT (PercepCommVillRegLev)	30	30	100%
I	Knowledge of FT role on climate change and other ecological benefits (FTClimateEE)	15	14	93%
	Total	**275**	**233**	**85%**

Annex 2: Overall thematic institutional influence on forge adoption potential for Ubiri village (QAT-FT assessment)

	Thematic area (A....I)	Maximum possible points	Total points achieved	Percentage achieved (Points achieved/total points)
A	Object of adoption (FT) (ObjofAdoptFarmVillLev)	25	22	88%
B	Farm and household characteristics/ constraints (FarmHHcharac)	45	30	67%
C	Capacity of implementing Institution (CapacityofImpInstVillRegLev)	30	29	97%
D	Attributes of dissemination strategy (AttrOfDissemStraVillRegLev)	50	43	86%
E	Political/Institutional framework (PolInstRegLev)	30	25	83%
F	Political/Institutional framework (PolInstVillLev)	25	20	80%
G	FT products and inputs market conditions (MarkCondVillRegLev)	25	24	96%
H	Perception of community towards FT (PercepCommVillRegLev)	30	24	80%
I	Knowledge of FT role on climate change and other ecological benefits (FTClimateEE)	15	15	100%
	Total	**275**	**232**	**84%**

Annex 3: Overall supporting forces to forage adoption potential Mbuzii village - Lushoto

ID	Supporting factors to FT adoption for Mbuzii village
A1	Not more than two trainings are needed for proper understanding of FT by farmers
A4	FT can be tried out on a small plot of the farmers' fields, partially adopted and extended in stages.
B1	Average farmers own sufficient financial resources to cover costs of FT.
B2	Majority of farmers have knowledge of FT or traditional/indigenous knowledge similar to FT.
B4	Farmers have access to FT inputs (seedlings).
B7	Economic risk a result of implementing FT is low for farmers.
B8	Introduction of FT leads to improvement of social status of farmers.
B9	The introduction of FT practice does not increase the pressure on natural resources (e.g. conflicts with pastoralist and farmers).
C1	The promoting institution has a clear vision and there is a common strategy to achieve stated objectives.
C2	The promoting organization has well-trained staff (technical and management).
C5	The leadership of the organization has a good reputation among the farmers.
D2	There is a clear and realistic time frame for dissemination of activities including an exit strategy.
D3	Objectives and indicators regarding outputs are defined and data is frequently collected for monitoring and evaluation (M&E).
D6	The information on FT is provided in an understandable way for each target group.
D7	A shared development vision and trust exists between the organization and the farmers, including a reliable feedback mechanism.
D8	The promoting organization supports farmers to become independent from the implementing agency.
D10	The organization initially equips farmers only with absolute necessary set of (technical) inputs and does not provide any monetary hand-outs to the farmers.
E1	There is no social, political or ethnic tension in the FT project region.
E6	Farmers are free to organize themselves in interest groups of their choice.
F2	There are informal local organizations that are willing to support dissemination of FT.
F3	The local rules/customs do not hinder the introduction of FT practice.
F4	Regulations concerning private and communal land rights are clearly formulated and effectively implemented.
F5	The settlement pattern allows extension officers easy access to farmers for promotional purposes.
G1	Local market structures exist to absorb the increased production based on FT (e.g. increased milk quantities).
G5	There are quality implementation control structures for FT and farmers can implement them.
H1	Project activities do not interfere with economic activities of non-adopters.
H2	The promoting organization has identified and contacted village leaders of the community and they accept and support activities.
H3	Young farmers are willing to participate in FT project activities and FT practice creates employment opportunities for them.
H4	The target group is self-reliant and able to contribute either financially and/or physically for the promotion of FT.
H5	The decision of individuals to adopt FT is accepted and respected by the entire community.
H6	Members of the community are already engaged in entrepreneurial activities and have experience in general farm management.
I1	There is sufficient knowledge or awareness of the environmental benefits of introduced FT over local feeding sources.
I3	First benefits of FT practice are witnessed within a short-term period.

Annex 4: Overall supporting forces to forage adoption potential Ubiri village - Lushoto

ID	Supporting factors to FT adoption for Ubiri village
ID	Supporting factors to FT adoption for Ubiri village
A3	Output of FT is easily observed through increased yields in the short term.
A4	FT can be tried out on a small plot of the farmers' fields, partially adopted and extended in stages.
A5	FT fits into the existing farming system.
B9	The introduction of FT practice does not increase the pressure on natural resources (e.g. conflicts with pastoralist and farmers).
C1	The promoting institution has a clear vision and there is a common strategy to achieve stated objectives.
C2	The promoting organization has well-trained staff (technical and management).
C3	The leadership of the organization has a good reputation among the farmers.
C5	The promoting organization has worked in the area before.
C6	The organization is able to collaborate with relevant partners and networks (donors, policy makers and researchers).
D1	The promoting agency uses already existing information channels such as self-help groups, schools, etc.
D2	FT champions (facilitators) are selected that act as diffusion leaders of FT.
D4	The promoting agency uses already existing information channels such as self-help groups, schools, etc.
D5	FT champions (facilitators) are selected that act as diffusion leaders of FT.
D6	The information on FT is provided in an understandable way for each target group.
D7	A shared development vision and trust exists between the organization and the farmers, including a reliable feedback mechanism.
D8	The promoting organization supports farmers to become independent from the implementing agency.
E1	There is no social, political or ethnic tension in the FT project region.
E6	Farmers are free to organize themselves in interest groups of their choice.
F1	There is a local government with a strong leadership that commits itself to development objectives.
F3	The local rules/customs do not hinder the introduction of FT practice.
F4	Regulations concerning private and communal land rights are clearly formulated and effectively implemented.
G2	Market facilities for FT are easy to access for farmers and at affordable cost at all times of the year.
G3	Other service providers or manufacturers around the region benefit from the introduction and adoption of FT farmers.
G4	The necessary infrastructure such as access to farm-to-market roads and planting material is available to target group.
G5	There are quality implementation control structures for FT and farmers can implement them.
H1	Project activities do not interfere with economic activities of non-adopters.
H5	The decision of individuals to adopt FT is accepted and respected by the entire community.
H6	Members of the community are already engaged in entrepreneurial activities and have experience in general farm management.

Annex 5: QATo-FT workshop participants from Mbuzii village

No.	Profession	Committee/responsibility	Affiliation
1	Farmer	Chairman	Innovation platform
2	Farmer	Secretary	Innovation platform
3	Farmer	Breed committee	Innovation platform
4	Farmer	Education committee	Innovation platform
5	Farmer	Forage committee	Innovation platform
6	Farmer	Breed committee	Innovation platform
7	Farmer	Shed committee	Innovation platform
8	Farmer	Advisor	Innovation platform
9	Farmer	Farmer	Innovation platform
10	Farmer	Village chairman	Village council
11	Extensionist	Extension officer	Mbuzii village

Annex 6: QATo-FT workshop participants from Ubiri village

No.	Profession	Committee	Affiliation
1	Farmer	Chairman	Innovation platform
2	Farmer	Ass. Chairman	Innovation platform
3	Farmer	Shed committee	Innovation platform
4	Farmer	Chairman (Shed committee)	Innovation platform
5	Farmer	Secretary/Breed committee	Innovation platform
6	Farmer	Chairman (Breeds committee)	Innovation platform
7	Farmer	Chairman (Milk price committee)	Innovation platform
8	Farmer	Milk price committee	Innovation platform
9	Farmer	Village executive officer	Innovation platform
10	Farmer	Farmer	Innovation platform
11	Farmer	Farmer	Innovation platform
12	Farmer	Milk collector (middleman)	Innovation platform
13	Officer	Ward education coordinator	Village council
14	Officer	Ward executive officer	Village council

Annex 7: QATo-FT workshop participants – researchers, practitioners, policy officers and facilitators

No.	Name	Organization	Responsibility
1	Beatus Nzogela	CIAT-Tanzania	Researcher
2	Hycenth Tim Ndah	ZALF-Müncheberg	Researcher and facilitator of workshop
3	Johannes Schuler	ZALF-Müncheberg	Researcher and facilitator of workshop
4	Walter Mangesho	TALIRI-TANGA	Practitioner/Researcher
5	Richard Mollel	TALIRI-TANGA	Practitioner/Researcher
6	Rose Loina	TALIRI-TANGA	Practitioner/Researcher
7	Birthe Paul	CIAT-Nairobi	Researcher/Researcher
8	Mama Msoka	Livestock district officer	Policy officer
9	Venance Kengwa	CIAT-Arusha	Field technician

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