Wageningen University

MSc Economics of Development

Farmers' Constraints vis-á-vis the Adoption of Improved Bean Varieties and Seeds in Hai District, Tanzania

Internship Report

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Abstract

Common bean (Phaseolus vulgaris L.) is the most important grain legume crop in Tanzania. In 2008, 75% of the smallholder farmers were estimated to depend on bean cultivation for daily subsistence. However, low yields due to insufficient soil fertility and vulnerability to pests and diseases are major constraints to increased food security and improved livelihoods of farmers in Northern Tanzania. Sokoine University of Agriculture and other organizations introduced several improved bean varieties over the last decades in order to increase yields. Furthermore, N2Africa distributed improved bean seeds in Northern Tanzania since its activities started. Therefore, this study analyses the constraints to the adoption of improved bean varieties and seeds in Northern Tanzania. The four main objectives are: (i) conducting a market survey in Arusha and Moshi to obtain information on the different bean varieties sold, (ii) gathering data on the crops grown in the different agro-ecological zones of Kilimanjaro in Hai District, (iii) determining the constraints farmers face vis-à-vis the adoption of improved bean varieties and seeds, and (iv) classifying farmers into different categories of adopters. The beans sold most frequently on the markets are the improved varieties Soya Njano and Rose Coco as well as the older variety Soya Kijivu, while the majority of farmers in Hai District cultivate Soya Njano. That means that farmers adopt improved bean varieties, having noticed their advantages over conventional varieties. However, when it comes to adopting improved bean seeds, farmers are confronted with wide unavailability of these. Even though seeds of Soya Njano and other improved varieties are demanded, there is no supply chain in place. This means farmers are forced to use grain leftovers from the previous season to grow improved varieties. Due to non-existent rejuvenation, bean yields decline by 5-10% per year, leaving farmers with ever lower harvests. A comparison with the maize seeds planted by farmers shows that only few of them are real peasants, as the majority of farmers use hybrid maize seeds, meaning they have to rebuy seeds every season. Also, 60% of the farmers can be classified as modern farmers given their use of improved agricultural practices including innovative fertilizers and herbicides among others. These smallholders are most likely to purchase improved bean seeds as soon as they become available. It is therefore crucial to match the demand for and the supply of improved bean seeds in order to increase nutrition security and enhance farmers' livelihoods.

Table of Contents

1. Introduction

1.1. Background

This research-focused internship was done with N2Africa (Phase II) in cooperation with the International Institute for Tropical Agriculture (IITA). N2Africa, implemented by the IITA and led by Wageningen University and Research Centre, pursues one main goal: putting nitrogen fixation at work for smallholder farmers in Africa. N2Africa is active in 11 African countries, including the DR Congo, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda and Zimbabwe. Activities in Tanzania started in 2013.

To address the problems of food and nutrition insecurity, and to increase the incomes of rural households, productivity of smallholder farmers in Tanzania has to increase. A key component of improving agricultural productivity and therefore achieving food and nutrition security is the diversification and intensification of farming systems. In this regard, legume crops play a major role as they are able to capture nitrogen from the air and fix it in the soils, which enriches exhausted soils and stimulates productivity of crops grown in rotation. Additionally, the protein-rich grain directly addresses the food and nutrition needs of rural households and provides an additional source of income. Lastly, the crop residuals of those grain legumes can be used as high-quality feed for livestock and organic mulch. (N2Africa, 2013a; Shiferaw et al., 2008).

Bean (Phaseolus vulgaris L.) is the most important grain legume crop grown in Tanzania (Hillocks et al., 2006). Most of the bean production in Tanzania is done by smallholder famers for their own consumption, as beans provide an important source of dietary protein and carbohydrate to complement their diet (Okigbo, 1977 in Giller and Amijee, 1998, Hillocks et al., 2006). In 2008 it was estimated that about 75% of smallholder farmers depend on beans for daily subsistence. Due to their lower cost per calorie compared to maize, beans are a strategic crop to eradicate poverty and food insecurity in Tanzania (CIAT, 2008). Beans are cultivated all over the country. However, due to their intolerance to long periods without rainfall, the main areas of production are situated in middle and high altitudes, where rainfall is more reliable and temperatures more moderate. Therefore, beans are mostly grown in the Northern region, especially around Arusha, the Southern Highlands and The Great Lakes region in the West (Hillocks et al., 2006). This report focuses on the Northern region, especially around Arusha, Moshi and Hai, which is offering great potential for cultivating common bean (N2Africa, 2014).

1.2. Problem Statement

In 2006, Tanzania was the second largest producer of dry beans in Sub-Saharan Africa (after Kenya) and one of the 20 largest producers worldwide. Still, in 2006, average bean yields were only as high as 500kg/ha, even though Tanzania is theoretically capable of producing 1500 up to 3000kg/ha given reliable irrigation, the use of improved varieties and good crop and land management (Hillocks et al., 2006). There are several reasons for low yields by most smallholder farmers, such as "poor seed quality, poor performance of the local landraces, mainly due to their susceptibility to pests and diseases, low soil fertility, drought and poor crop management […]" (Hillocks et al., 2006: 216). Particularly in the Northern Region soils lack nitrogen, potassium and phosphorus, which is mainly due to continuous farming and insufficient or non-existent replacement of nutrients. Also, monoculture and soil erosion play a vital role regarding the steadily decreasing soil fertility. The availability of certified/improved seeds and associated technologies like fertilizer therefore have significant potential to increase bean yields (N2Africa, 2013b).

Besides the unavailability of fertilizer, good bean seeds and additional inputs, there are other constraints that hinder the farmers to adopt new technologies and increase yields. Research on adoption has already been done on different regions in Sub-Saharan Africa. A recently published report by Andrew Farrow *"Review of conditioning factors and constraints to legume adoption, and their management in Phase 2 of N2Africa"* (2014) covers likely adoption constraints in Ethiopia, Tanzania and Uganda. During the phase of literature research before the actual fieldwork, this list of factors derived from Farrow's report was complemented by additional constraints farmers face when willing to adopt new technologies (Appendix 1).

For the last two and a half decades, Sokoine University of Agriculture in collaboration with other organizations released five improved varieties, namely Lyamungo 85, Lyamungo 90, Selian 94, Selian 97 and Jesca (CIAT, 2008) in Tanzania. This report wants to clarify whether farmers in Hai District actually adopt these promoted and improved varieties and buy their seeds and the reasons for not doing so.

1.3. Objectives and Research Questions

The overall objective of this research was to gain detailed information the beans grown and sold in the Northern region of Tanzania and to investigate the constraints and opportunities farmers face when adopting improved bean varieties and seeds. These translate into the following specific research questions:

I. Which beans are sold at markets in Arusha, Moshi and Hai? Which varieties are most preferred by consumers (and why)? What are the prices per kilogram for the three most preferred varieties?

II. What do farmers grow in the different agro-ecological zones? Which beans are grown in Hai District? What are the most popular bean varieties grown?

III. What constraints do farmers face when it comes to farming in general, and growing beans specifically? What are the major constraints? What constraints do farmers encounter regarding the adoption of improved bean seeds?

IV. Do farmers already use improved seeds for other crops? What does that mean regarding their willingness to adopt improved seeds? Can farmers be classified into different categories of adopters? If yes, what are the characteristics of modern farmers?

The above research questions will be answered with the help of the below objectives:

I. Conduct market surveys in Arusha and Moshi in order to obtain information on the different bean varieties being sold.

II. Gather data on the crops grown in the different agro-ecological zones of Kilimanjaro in Hai district close to Moshi.

III. Determine the constraints that farmers experience vis-à-vis the adoption of improved bean seeds.

IV. Classify farmers into different categories of adopters and evaluate their characteristics.

2. Theoretical Framework

Figure 2.1 depicts a generic approach that borrows some elements from Roger's (1983) "Diffusion-of-Innovations Theory" and is expanded by additional categories of constraints from Andrew Farrow (2014) and the author. The model helps to understand farmer's decision making in adopting new technologies. It reads from the right, starting with the potential relative advantage of a technology. We speak of 'relative advantage' because the advantage only exists in comparison with technologies that are currently used. These advantages are potential, as they are only experienced when the technology is properly understood and applied by the farmer.

As can be seen below, technologies with a substantial relative advantage will in principle be adopted automatically by smallholder farmers as depicted by the arrow to the right box 'Adoption of new technology'. Part of the smallholders adopting a new technology may be influenced by other farmers. By copying their behavior they do not need to be in contact with the original source of the technology like a research institute itself and are still able to adopt a new technology. This process is called diffusion and is an important factor when it comes to whether farmers adopt a new technology or not.

However, the diffusion process may be hindered by other constraining factors faced by the farmers, such as their own characteristics and situation, but also their surroundings. These constraints make a good understanding and application of the new technology more difficult or even impossible and can be divided into three categories, namely farmer specific characteristics, institutional factors and environmental factors. Farmer-specific characteristics include age, gender, risk perception or attitude of the farmer, capacity to bear risks, capital, assets and labor endowment, knowledge and education, farm size, demographics, mimicking and imitation, and membership in a cooperative.

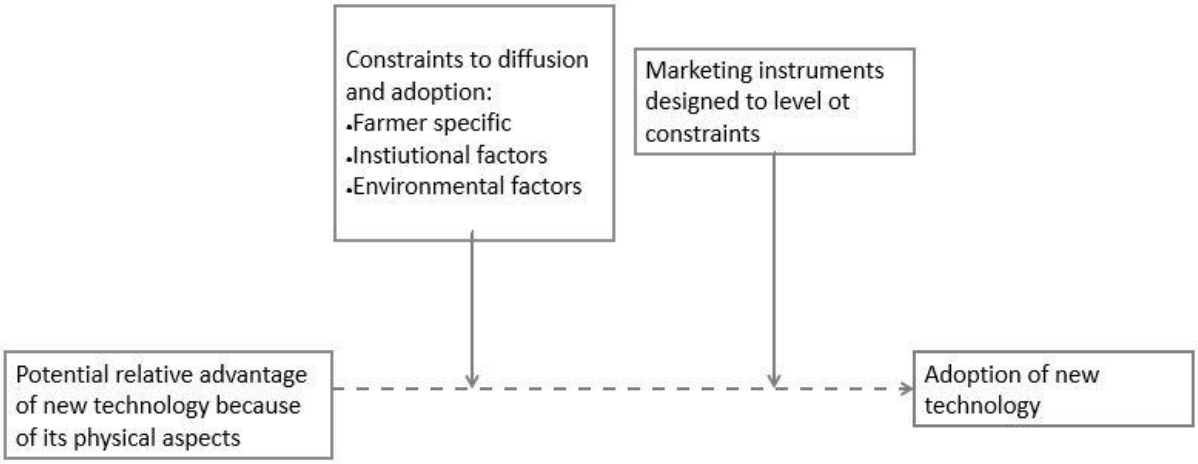

Figure 2.1: Conceptual framework for adoption strategy.

The institutional factors include availability of quality seeds, credit supply and access, market access, marketing system, and extension contact. Environmental factors inhabit the climatic conditions and the quality of the soil amongst others. Furthermore, the technology physical aspects that determine whether or not a new technology will be adopter are relative advantage, compatibility, complexity, trialability, and observability. As stressed by Rogers (1983) adoption will only take place if the new technology fulfills the requirements of the above mentioned characteristics.

Lastly, there are marketing instruments and strategies available to level these constraints.

3. Results

3.1. Research Question I

Which beans are sold at markets in Arusha, Moshi and Hai? Which varieties are most preferred by consumers (and why)? What are the prices per kilogram for the three most preferred varieties?

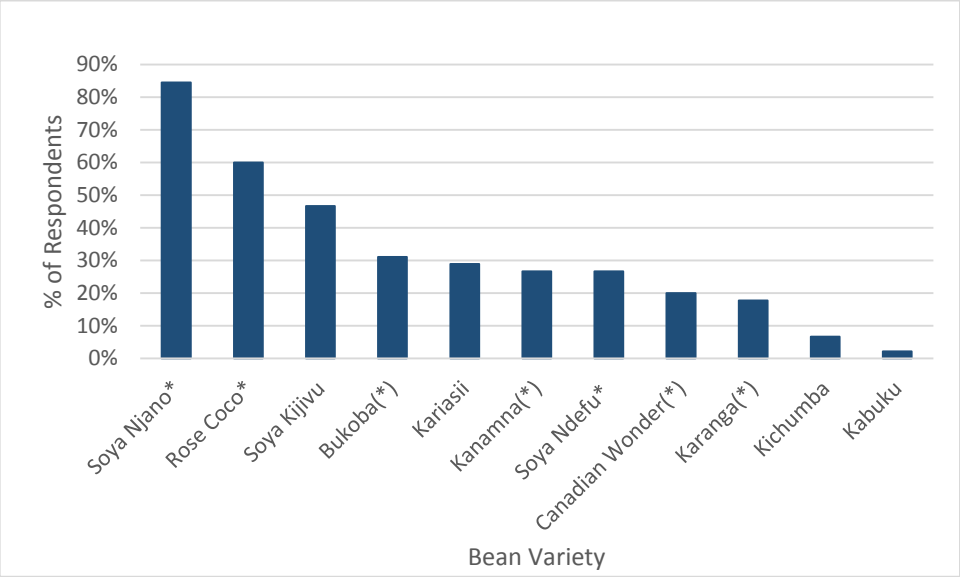

*Figure 3.1: Bean varieties sold in Arusha, Moshi and Hai. Beans marked with * are improved varieties, beans marked with (*) may be improved varieties, but this cannot be stated with certainty.*

Figure 3.1 shows the different beans sold on nine markets in Arusha, Moshi and Hai District. As mentioned earlier, 45 retailers were interviewed during the market survey. The varieties sold on the markets were Bukoba, Canadian Wonder, Kabuku, Kanamna, Karanga, Kariasii, Kishumba, Soya Kijivu, Soya Ndefu, Soya Njano and Rose Coco. As the beans do have different names depending on region, origin and meals they are used for, Appendix 2 gives a list of additional names the beans are known under. Another point worth mentioning is that Bukoba and Kanamna (Nganamna) seem to be two different beans, as said by the retailers interviewed, even though they look similar. In a report published by Farm Radio International (2015), who conducted a focus group discussion in Arumeru and Hai District, Bukoba and Kanamna are said to be the same bean, simply known under two distinct names. However, Bukoba and Kanamna will be treated as two different beans in this report. Readers should be aware that if they were treated as one bean variety, this would be the second-most sold variety.

In general, it is obvious that the three beans sold most often were Soya Njano, Soya Kijivu and Rose Coco. Soya Njano is an improved variety originating in Kenya, which is not yet registered in Tanzania. It was sold by 38 out of 45 respondents (84%). The reasons mentioned most often for not selling Soya Njano were the high costs of purchasing it, or the non-availability due to the time of the year. The selling price of one kilogram of Soya

Njano was 2088TZS on average while the survey was conducted, from February until April 2015 (Appendix 3A). During this time the selling price of Soya Njano varied between 1800TZS and 2500TZS, which is also the highest price that can be reached throughout the year. Most respondents sold Soya Njano for 2000TZS, 15 out of 38 (Figure 3.2). Soya Njano can also be sold at a price as low as 1000TZS, especially when there is oversupply because of the harvesting season, but the lowest price mentioned most often was 1500TZS. Additionally, the maximum price per kilogram of Soya Njano reached most often on the market is 2000TZS (Figure 3.3). Soya Njano was found to be the most preferred variety for several reasons. First of all, it cooks faster, secondly, it tastes sweeter and therefore better, and thirdly, it has less gas and is easier to digest than all other beans that are available.

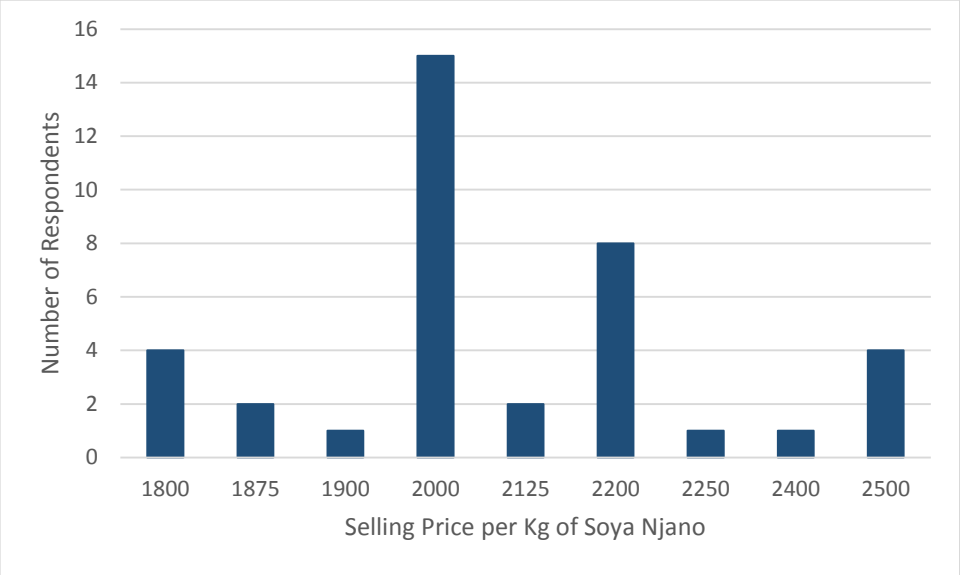

Figure 3.2: Selling prices per kg of Soya Njano in Tanzanian Shilling.

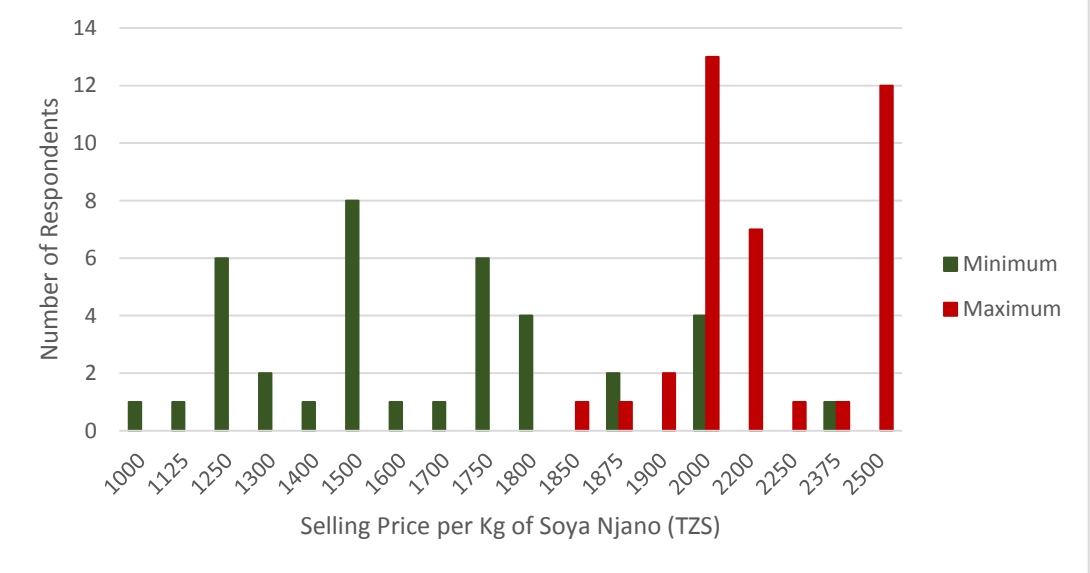

Figure 3.3: Minimum and maximum selling prices per kg of Soya Njano in Tanzanian Shilling.

Rose Coco, another improved variety promoted by the Tanzanian government and other organizations over the last years is a bean sold by 60% of the respondents, 27 out of 45 in numbers. It mostly consists of the different Lyamungo varieties 85 and 90. Rose Coco was sold at 1631TZS per kilogram on average during the survey time (Appendix 3B), with a maximum price of 2000TZS and a minimum price of 1200TZS between February and April. This shows that it was significantly cheaper than Soya Njano, which was 2088TZS on average. Most retailer sold rose Coco at a price of 1500TZS and 1750TZS per kilogram (Figure 3.4). The price of Rose Coco can decrease to 875TZS per kilogram, especially during harvesting season, and can rise to 2000TZS maximum. When at its minimum, most respondents sell Rose Coco at 1000TZS per kilogram, and when at its maximum for 1800TZS and 2000TZS per kilogram (Figure 3.5). Rose Coco is liked by customers because of its higher nutritional value compared to Soya Njano and its medical properties.

Figure 3.4: Selling prices per kg of Rose Coco in Tanzanian Shilling.

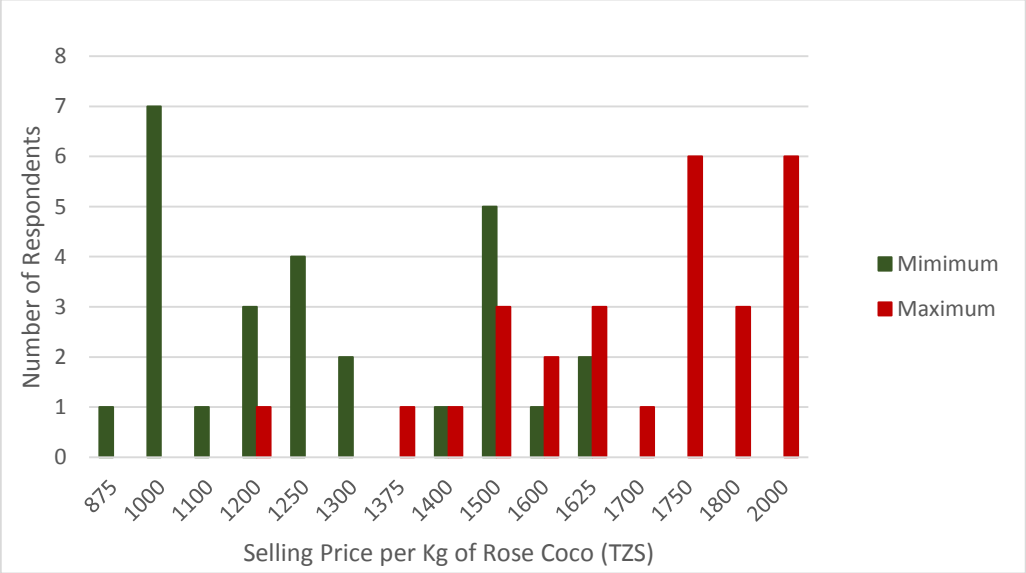

Figure 3.5: Minimum and maximum selling prices per kg of Rose Coco in Tanzanian Shilling.

Lastly, Soya Kijivu was sold third most by retailers in Arusha, Moshi and Hai, that is to say by 21 out of 45 retailers, resembling 47% of the respondents. The average selling price per kilogram of Soya Kijivu was 1968TZS (Appendix 3C). The price ranged between 1600TZS and 2500TZS during the time the survey was conducted. Most respondents sold Soya Kijivu for 2000TZS and 2200TZS (Figure 3.6). The lowest price throughout the year can be 1000TZS, while it can rise to 2500TZS when Soya Kijivu is scarce. The maximum prices for Soya Kijivu mentioned most frequently were 2000TZS and 2500TZS (Figure 3.7). Noticeably, the maximum prices for Soya Njano and Soya Kijivu are the same, each 2500TZS per kilogram. Also, Soya Njano and Soya Kijivu are both most often sold at their average prices of about 2000TZS, showing that these beans are similarly liked and demanded. Looking at the maximum prices for both beans reveals an analog picture. The maximum price for both beans mentioned most often is 2000TZS. However, Soya Njano and Soya Kijivu can both reach a price of 2500TZS when bean supply is low (Figure 3.3. and 3.7). This might be due to the fact that just like Soya Njano, Soya Kijivu is a bean that cooks faster and tastes sweeter than many other varieties.

In general, the maximum prices during the survey time are equal to the maximum prices that can be reached throughout a whole year for all three most preferred varieties, showing that the months February, March and April are a time of bean scarcity. Additionally, the last season was not a good one for beans, as mentioned by some retailers. These two facts may explain why the majority of retailers sold their beans at the highest price possible.

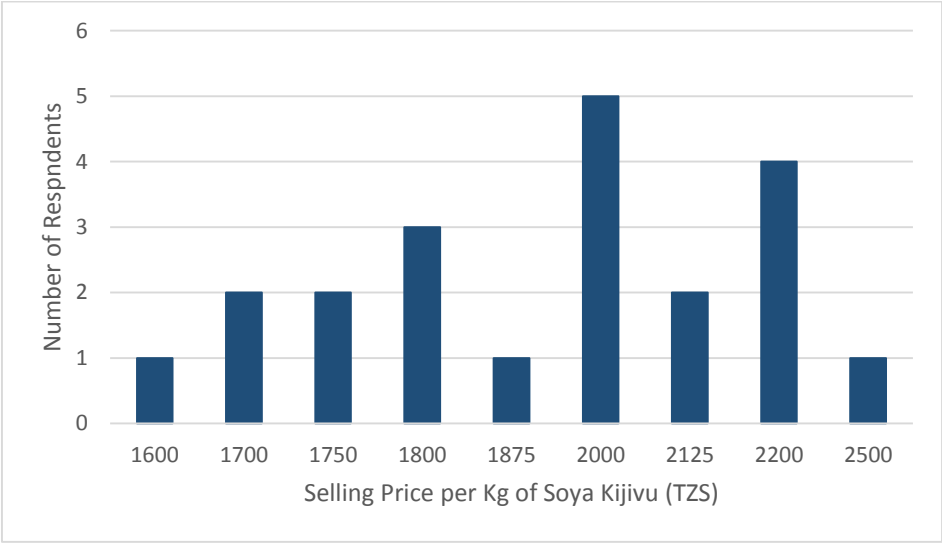

Figure 3.6: Selling prices per Kg of Soya Kijivu in Tanzanian Shilling.

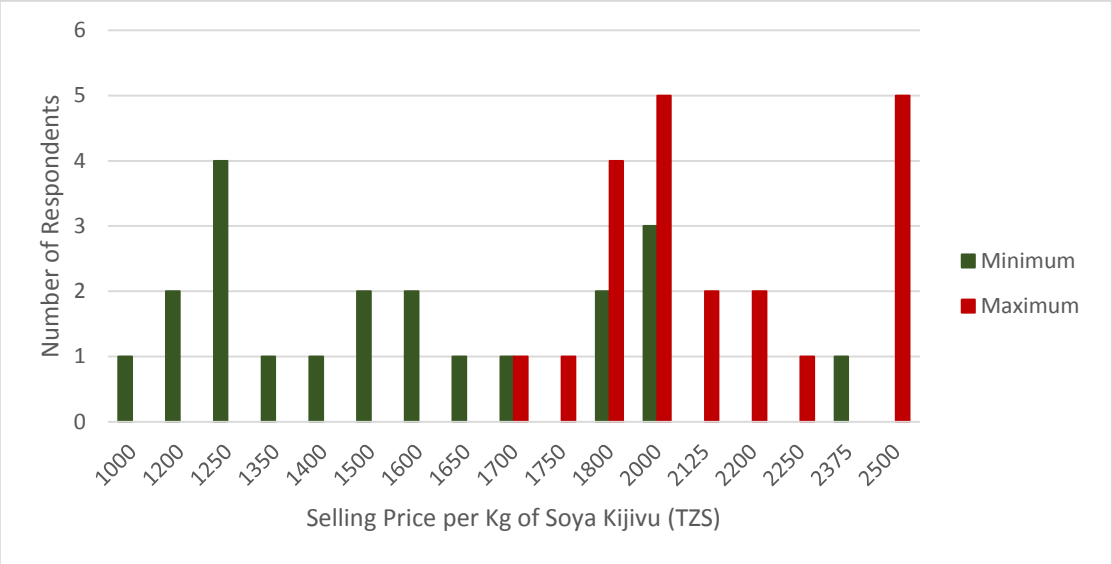

Figure 3.7: Minimum and maximum selling prices per kg of Soya Kijivu in Tanzanian Shilling.

3.2. Research Question II

What do farmers grow in the different agro-ecological zones? Where are the five most popular crops grown? Which beans are grown in Hai District? What are the three most popular bean varieties?

Farmers in Hai District grow several different crops throughout the year, depending on their agro-ecological zone. The five most popular crops grown were beans, maize, banana, coffee and sunflower (Table 3.1). Besides these crops, farmers also grow vegetables and rice.

Beans were grown by 96% of the interviewed farmers (127 times), a number showing that some farmers grow beans on multiple fields or more than one variety. It was expected that beans are mainly grown in the lower and the middle zone, since climatic conditions there fit their cultivation demands best. Surprisingly, 38% of the beans are still grown in the upper zone, while 62% are grown in the lower and the middle zone. However, total walking distance to the fields is highest for the upper zone, which might imply that farmers living on the slopes of Kilimanjaro possess plots in the lower and middle zone in order to cultivate beans (Appendix 4).

The second crop grown most often by almost all the respondents is maize with 122 times. Its distribution among the three agro-ecological zones shows a similar trend as the one for beans even though it is not as clear. 30% of maize are cultivated in the upper zone, while 70% are cultivated in the lower and middle zone. Also here a possible explanation might be given by the longer walking distance to the fields by farmers living in the upper zone. Thirdly, banana is grown 49 times and this time the cultivation distribution meets the expectations, as 80% of the bananas are grown in the upper zone. The same holds for coffee, which is grown 21 times by farmers in Hai. 90% of coffee are grown in the upper zone, while only 10% are grown in the

middle zone. Lastly, sunflower, the fifth most often crop grown is cultivated 15 times in the middle zone (60%) and the upper zone (40%) and mainly serves as a boundary to other fields.

Crop	Agro-ecological Zone			Total
	Low	Medium	High	
Amaranth	100%	0%	0%	1
Banana	**2%**	**18%**	**80%**	**49**
Beans	**31%**	**31%**	**38%**	**127**
Cabbage	50%	0%	50%	2
Cassawa	50%	50%	0%	2
Chinese Salad	0%	100%	0%	1
Cocoyam	100%	0%	0%	1
Coffee	**0%**	**10%**	**90%**	**21**
Cucumber	0%	0%	100%	1
Eggplant	50%	50%	0%	2
Groundnut	0%	100%	0%	1
Hoho	0%	100%	0%	1
Maize	**34%**	**36%**	**30%**	**122**
Millet	0%	100%	0%	1
Onion	100%	0%	0%	5
Rice	100%	0%	0%	8
Sunflower	**0%**	**60%**	**40%**	**15**
Sweet Pepper	0%	100%	0%	1
Sweet Potato	0%	100%	0%	1
Tomato	40%	0%	60%	5
Vegetables	0%	100%	0%	2
Total	28%	31%	42%	369

Table 3.1: Crops grown in different agro-ecological zones. Crops in bold letters were grown most often.

The beans grown most frequently in Hai District were Soya Njano with 90 out of 127 times or 90%, Bukoba with 15 times or 12% and Soya Kijivu and Kanamna with 6 times or 5% each (Table 3.2). In case Bukoba and Kanamna are the same bean known under different names, their number would add up to 21 times or 17%, which would mean they were grown even more often than Soya Kijivu. Sweden might also be known under the name of Bukoba or Kanamna, which would change the distribution again slightly. However, it becomes very clear that the improved bean Soya Njano is cultivated most often in Hai District, which shows that farmers prefer it for home consumption and produce the bean that is highly demanded by customers.

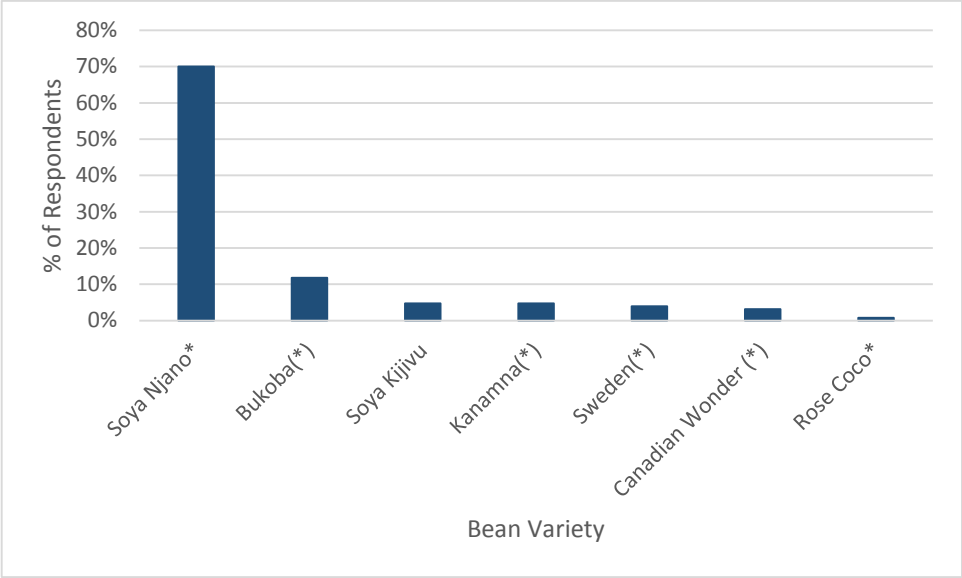

*Figure 3.8: Beans grown in Hai District. Beans marked with * are improved varieties, beans market with (*) may be improved varieties, but this cannot be stated with certainty.*

3.3. Research Question III

What constraints and opportunities do farmers face when it comes to farming in general, and growing beans specifically? What are the major constraints? What constraints do farmers encounter regarding the adoption of improved bean seeds?

Farmers in Hai District were faced with different production constraints on their farms, also depending on the agro-ecological zone they live in. Figure 3.9 presents all general production constraints farmers experienced, namely climate risk, seeds, pests and diseases, production means, costs and capital, agro inputs, availability, access, quality, markets and infrastructure and lack of knowledge.

The most important production constraint was 'Pests and Diseases', which was mentioned by 62% of the farmers. Even though the occurrence of pests and diseases is more or less evenly distributed among the different agro-ecological zones, one can see that the lower zone was affected slightly more often than the other zones, representing 35%. This might be due to insufficient rainfall, amongst others, which can increase the risk of pests and diseases.

The second-most often mentioned production constraint was 'Production Means, Costs and Capital'. This includes the availability of and costs for labor, the availability of tractors, capital constraints, especially when it comes to buying agricultural inputs on time, high production costs, and high prices for agricultural inputs, low production and poor soil quality. 'Production Means, Costs and Capital' is a constraint faced by 51% of the respondents and is equally experienced by all farmers regardless of the agro-ecological zone.

Thirdly, the climatic conditions, including drought, unreliable rainfall and snow are seen as a constraint for 44% of the respondents. Especially farmers in the middle and upper zone, 40% and 42% respectively, are faced with climatic conditions that impede the cultivation of crops in general. Only 19% of farmers in the lower zone experience a 'Climate Risk'. Especially colder temperatures and snow affect the middle and the upper zone, whereas the biggest issue in the lower zones is insufficient rainfall.

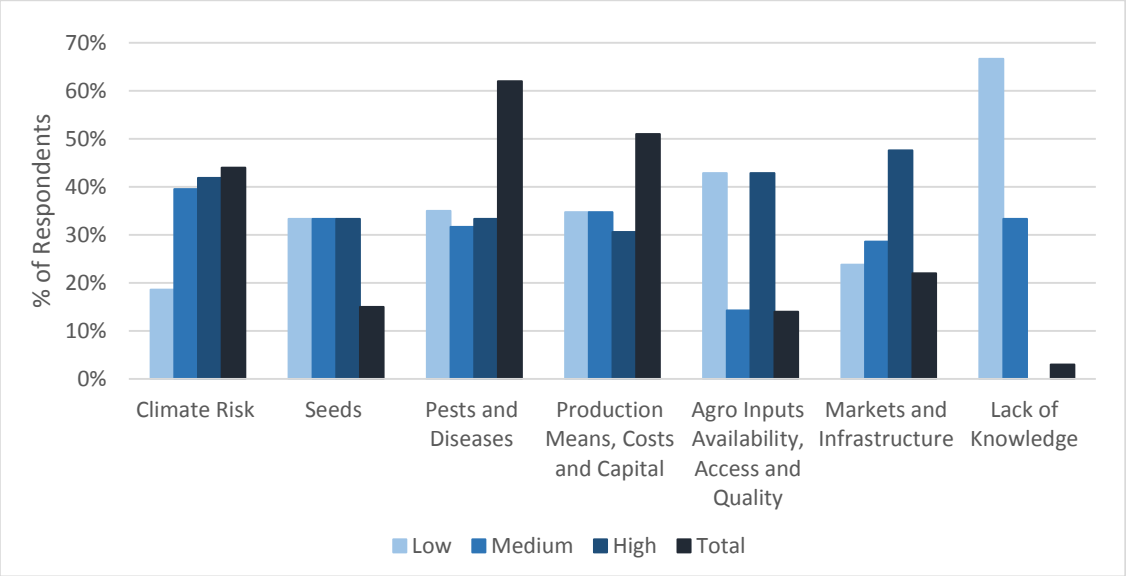

Figure 3.9: Production constraints on farm in total and per agro-ecological zone.

Besides general production constraints, famers were also faced with production constraints vis-á-vis the cultivation of beans specifically (Figure 3.10). As before, the most severe bean production constraint was 'Pests and Diseases', mentioned by 80% of the farmers. This time, the distribution is equal among the three agro-ecological zones, with 33% of all respondents having issues with pests and diseases in each zone.

In detail, 63 out of 97 respondents claimed they had problems with pests last season (2014), which resembles 65% of all farmers interviewed. The three most frequently experienced pests were caterpillars (41%), white flies (17%) and aphids (11%) (Table 3.2). Please note that the American bollworm, the army worm and the pod borer can also be counted as caterpillars (Infonet-Biovision, 2012).

Image 1: White flies. Source: Infonet-Biovision, 2012.

Image 2: Black bean aphids. Source: Infonet-Biovision, 2012.

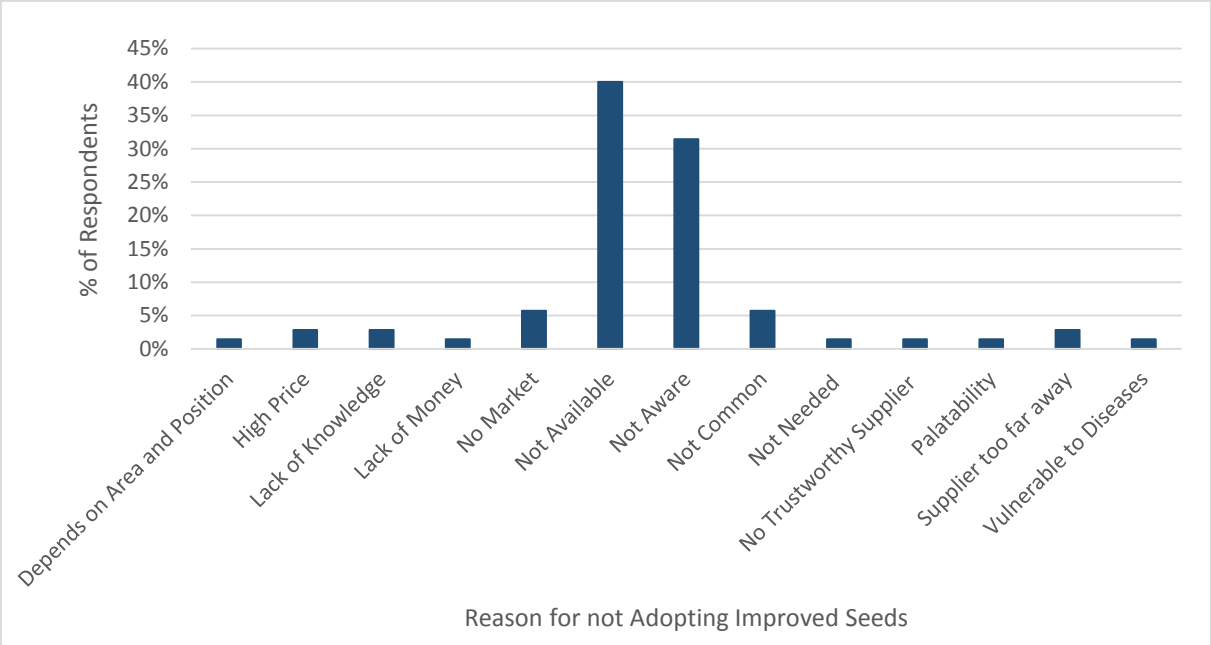

Figure 3.10: Bean production constraints on farm in total and per agro-ecological zone.

Pests last Season	Agro-ecological Zone			Total
	Low	Medium	High	
American Bollworm	0%	4%	4%	3%
Aphids	17%	8%	12%	11%
Army Worm	0%	8%	12%	8%
Beetles	0%	0%	8%	3%
Caterpillar	42%	16%	23%	24%
Cotton Bugs	8%	0%	0%	2%
Grasshopper	0%	8%	0%	3%
Insects	0%	8%	0%	3%
Kimamba	0%	0%	8%	3%
Mbilizi	0%	0%	4%	2%
Mite	8%	0%	0%	2%
Ootheca	0%	12%	4%	6%
Pod Borer	0%	4%	12%	6%
Stalk Borer	0%	4%	0%	2%
Tuta Absoluta	17%	4%	0%	5%
White Flies	8%	24%	15%	17%

Table 3.2: Pests on farm last season. Pests in bold letters were mentioned most often.

Other pests mentioned such as Kimamba and Mbilizi might fall under the category of another pest reported during the survey. However, no additional knowledge on these pests is available.

Furthermore, 31 of 97 farmers or 32% experienced diseases on beans last season (2014). The four diseases mentioned most often were yellow leaves before maturity (61%), bean rust (16%), blight (10%) and fungus (10%) (Table 3.3). That bean leaves turn yellow before the plant is mature can have several reasons as for example fusarium root rot, angular leaf spot (both a fungus) or powdery mildew (Infonet-Biovision, 2012). Therefore it may be that some farmers discovered the reason for the yellowing of leaves, namely a fungus, while others only mentioned the symptoms. However, these tables show that pests and diseases are a serious constraint to bean production that farmers have to deal with.

Diseases last Season	Frequency	Valid Percent
Blight	**3**	**10%**
Common mosaic virus	1	3%
Flower abortion	1	3%
Fungus	**3**	**10%**
Leaf Rust	**5**	**16%**
Soft Rot	1	3%
Yellow leaves before maturity	**19**	**61%**
Total	31	100%

Table 3.3: Diseases on farm last season. Diseases in bold letters were mentioned most often.

Image 3: Bean rust. Source: Infonet-Biovision, 2012.

Image 4: Common blight. Source: Infonet-Biovision, 2012.

'Climate Risk', meaning drought, cold and snow was the second-often reported bean production constraint. 37% percent of the respondents claimed climate to be a risk factor when it comes to bean production, especially lack of rainfall and temperatures below the acceptance level of beans, including snow. Here, the climate risk is equally distributed among the respondents of the different agro-ecological zones.

The third bean production constraint mentioned most frequently were 'Seeds', which does not only include the quality of bean seeds in general, but also the availability of quality and improved seeds as well as the high price of seeds (grains) during the planting season. 19% of all respondents experienced these problems.

As mentioned earlier, new technologies, in this case improved beans are especially fast adopted if they possess a clear relative advantage. However, there are factors that might hinder their adoption rate, which will be assessed in the following section. Table 3.11 shows the different reasons why farmers that cultivate beans do not use improved seeds. The most important and most often reported constraint to adopting improved bean seeds is their non-availability. 40% of 70 respondents said that they cannot buy improved bean seeds anywhere close to their homestead, if at all. Secondly, 31% were not even aware of improved bean seeds, which can be interpreted in two ways. Either farmers are not aware of a place to buy improved bean seeds, or they are not aware of an improved bean that is better than Soya Njano. Therefore, the issue seems to be non-availability of improved bean seeds for farmers who already adopted a new variety.

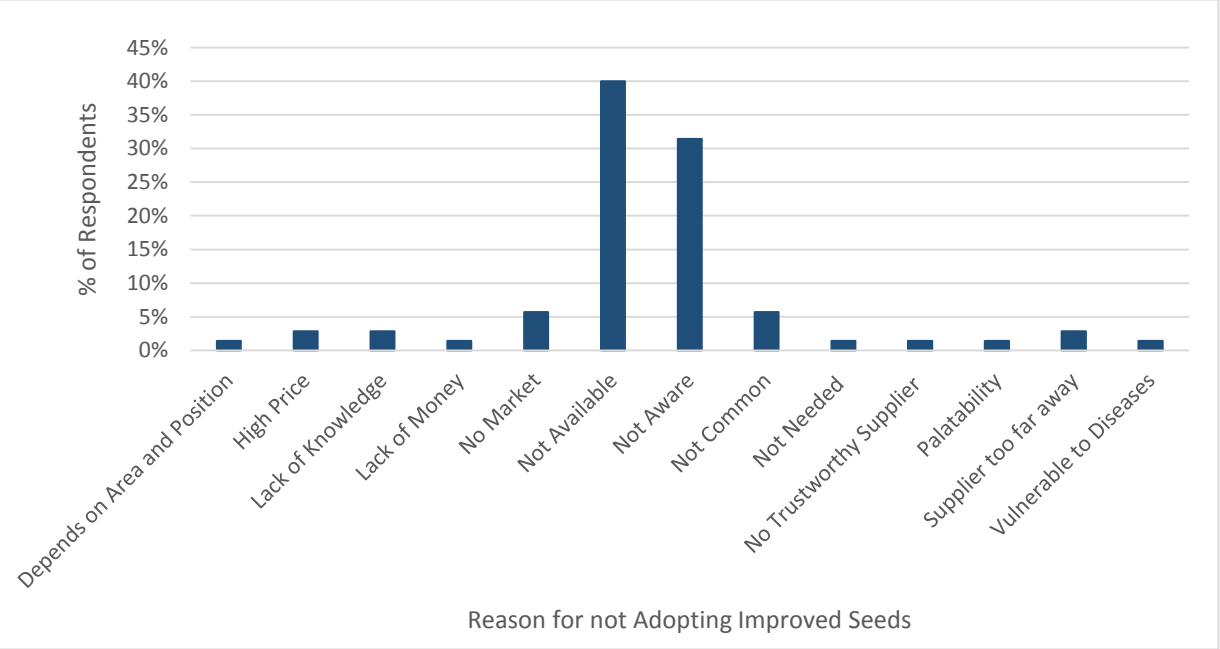

Figure 3.11: Constraints vis-á-vis the adoption of improved bean seeds.

3.4. Research Question IV

Do farmers already use improved seeds for other crops? What does that mean regarding their willingness to adopt improved seeds? Can farmers be classified into different categories of adopters? If yes, what are the characteristics of modern farmers?

In order to see whether farmers already use improved seeds for growing other crops, a comparison with maize will be made below. As can be seen in Figure 3.12, about 72% of all respondents used hybrid maize seeds while only 5% do not. When planting hybrid maize, farmers have to buy new seeds every season as hybrids are not self-pollinating. When also excluding the farmers that do not grow maize, 5%, the number of farmers using hybrids amongst those cultivating maize rises to 76%. This illustrates that only very few of the farmers were typical peasants, as the majority used hybrids from companies such as SeedCo and Dekalb.

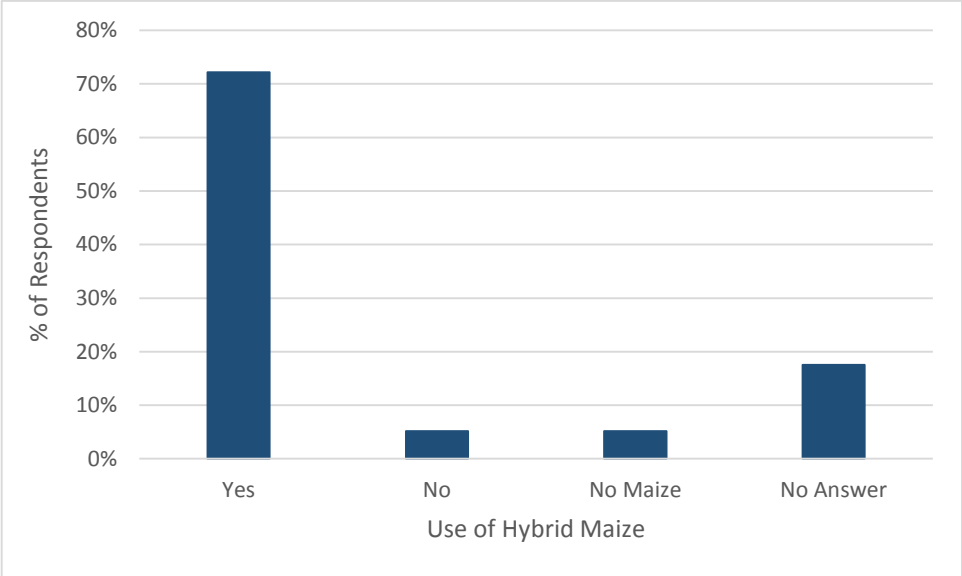

Figure 3.12: Usage of maize hybrids.

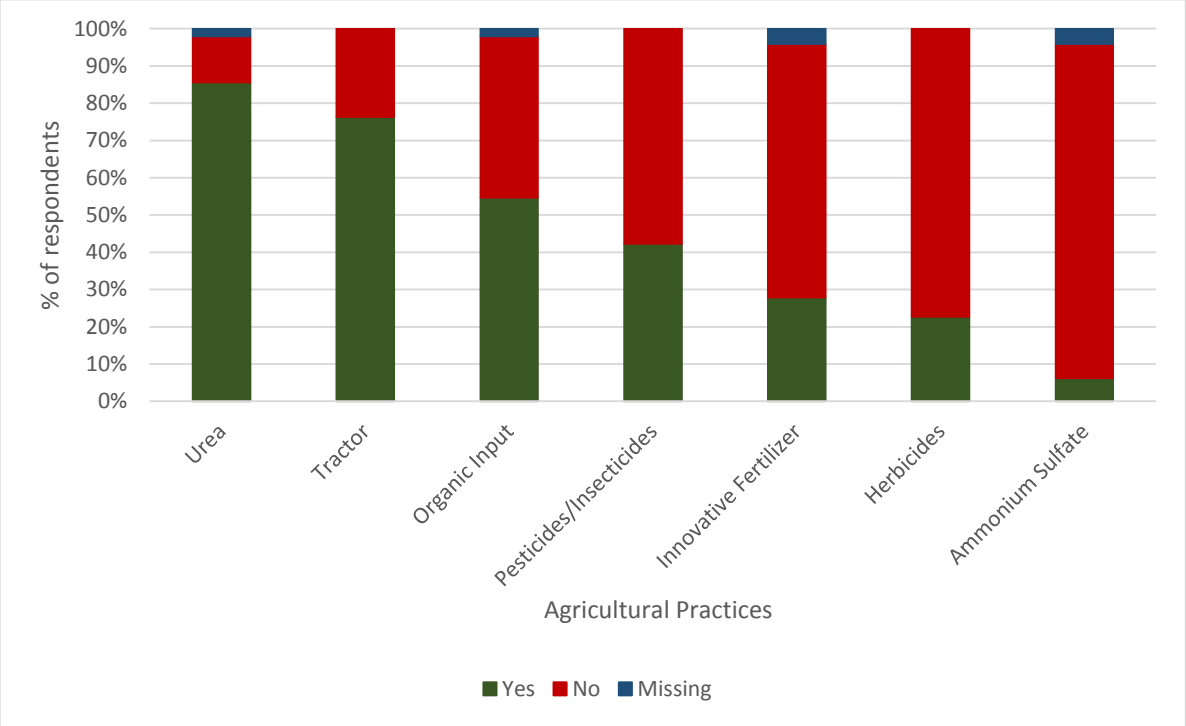

Figure 3.13: Agricultural practices for categorization of farmers.

Furthermore, farmers are classified into four categories of adopters with the help of the existing data (please see data management for process of categorization). The categories are: adopter, emerging adopter, lagging adopter and marginal adopter. In the following, adopters and emerging adopters are referred to as modern farmers and lagging and marginal adopters as traditional farmers. However, first of all Figure 3.13 depicts the factors that were used to categorize the farmers, namely the use of tractors, organic input, pesticides and insecticides, herbicides, common mineral NPK (Nitrogen – Phosphorus – Potassium) fertilizers like Urea and Ammonium Sulfate and innovative fertilizers such as DAP, CAN, and Booster. It can be seen that about 85% of the farmers applied Urea on their fields, a well-known nitrogen-release

fertilizer. Due to the fact that Urea is acid and soils already are acid, applying only Urea can also be a sign for not so good management. Fertilizers containing Phosphorus (P) and/or Potassium (K) therefore are superior to only applying Urea, as they do not only boost bean production but also improve soil fertility. Figure 3.13 shows that about 28% of the farmers applied innovative fertilizers such as CAN, DAP and Booster, illustrating that they are used a lot less than Urea. Lastly, herbicides, a labor-saving chemical to control weeds that requires knowledge on how to apply it and is money-intensive was applied by slightly more than 20% of the respondents.

		Agro-ecological Zone			Total
		Low	Medium	High	
Type of Adopter	Adopter	29%	25%	46%	28
	Emerging Adopter	29%	35%	35%	31
	Lagging Adopter	32%	43%	25%	28
	Marginal Adopter	60%	20%	20%	10
Total		33%	33%	34%	97

Table 3.4: Agro-ecological zone per type of adopter.

The categorization of the farmers into different types of adopters yielded 28 adopters, 31 emerging adopters, 28 lagging adopters and 10 marginal adopters. This already shows that the majority of farmers, about 60%, already adopted or about to adopt better and more modern agricultural practices. Table 3.4 presents the distribution of the different adopters among the agro-ecological zones. 46% of the adopters lived in the upper zone, while only 29% and 25% were situated in the lower and middle zone. A similar trend holds for the emerging adopters, of whom 35% lived in both, the middle and the upper zone. When looking at the marginal and the lagging adopters, a slightly different picture is drawn. The majority of marginal adopters lived in the middle zone, 43%, and 60% of the lagging adopters lived in the lower zone. In summary, adopters were mainly found in the upper agro-ecological zone while emerging adopters were mostly situated in the middle and upper zone. On the other hand, the majority of lagging adopters lived in the lower and medium zone, whereas most lagging adopters lived in the lower zone.

		Age Category Household Head				Total
		[20;35] Years	[36;45] Years	[46;55] Years	[>55] Years	
Type of Adopter	Adopter	4%	21%	39%	36%	28
	Emerging Adopter	6%	19%	39%	35%	31
	Lagging Adopter	11%	29%	29%	32%	28
	Marginal Adopter	0%	0%	56%	44%	9
Total		6%	21%	38%	35%	96

Table 3.5: Age category of household head per type of adopter.

Table 3.5 highlights that most of the modern farmers were aged between 46 and 55 years, 39%, or older than 55 years, 36%. Only 25% of the adopters were between 20 and 45 years old. The same holds for the emerging adopters, of wich 39% were aged between 46 and 55 years and 36% were aged above 55 years, while 25% were aged between 20 and 45 years. Looking at the distribution among the lagging adopters reveals that 29% of them were aged between 35 and 45 years and 46 and 55 years respectively, while 32% were older than 55 years. This means lagging adopters are very evenly distributed among these three age categories. In contrast, none of the marginal adopters were aged between 20 and 45 years, while 56% were between 46 and 55 years old and 44% were older than 55 years. It has to be noted that most household heads in the survey were older than 46 years. However, even the majority of adopters and emerging adopters were older than 46, it can also be seen that none of the lagging adopters was younger than 46.

		Gender of Household Head		
		Male	Female	Total
Type of Adopter	Adopter	29%	26%	29%
	Emerging Adopter	32%	32%	32%
	Lagging Adopter	28%	32%	29%
	Marginal Adopter	10%	11%	10%
Total		78	19	97

Table 3.6: Type of adopter per gender of household head.

Furthermore, Table 3.6 presents the type of adopter against the gender of the household head. 29% of the male and 26% of the female headed households were adopters. 32% of both, the male and female headed households were emerging adopters, while 28% and 32% of the male and female headed households were lagging adopters, respectively. Also the distribution of marginal adopters among male and female headed households was equal, with 10% and 11% respectively. Even though male headed households were slightly more often adopters and slightly less often lagging adopters, the distribution of the different adopter categories is almost similar for male and female headed households.

		Education Level of Household Head				
		None	Primary	Secondary	Post-Secondary	Total
Type of Adopter	Adopter	0%	74%	19%	7%	27
	Emerging Adopter	8%	77%	15%	0%	26
	Lagging Adopter	7%	86%	7%	0%	28
	Marginal Adopter	10%	80%	10%	0%	10
Total		5%	79%	13%	2%	91

Table 3.7: Education level of houehold head per type of adopter.

A first glance at Table 3.7 shows that all adopters, without exception, had at least completed primary education and that adopters are the only category with post-secondary education (7%

of adopters). Also, 19% and 15% of adopters had secondary education, respectively, while only 7% and 10% of lagging and marginal adopter had secondary education respectively. 10% of the marginal adopters had no education at all, while 7% of the lagging adopters and 8% of the emerging adopters had no education at all.

		Highest Education of Household Member				Total
		Primary	Secondary	Post-Secondary	University	
Type of Adopter	Adopter	19%	67%	4%	11%	27
	Emerging Adopter	15%	63%	7%	15%	27
	Lagging Adopter	50%	45%	5%	0%	22
	Marginal Adopter	22%	78%	0%	0%	9
Total		26%	61%	5%	8%	85

Table 3.8: Highest education level of household member per type of adopter.

A similar picture can be found when looking at Table 3.8. While none of the household members among the categories lagging and marginal adopter went to University, University was visited by 11%and 15% among the adopters and emerging adopters, respectively. Also, none of the household members of the marginal adopters had post-secondary education, while between 4% and 7% of the household members of the adopters, emerging adopters and lagging adopters had post-secondary education. From Table 3.7 and 3.8 it can be concluded that modern households tend to have better educated household heads and other household members.

		Size of all Fields				Total
		[<0.5] Ha	[0.5;1] Ha	[1;2] Ha	[>2] Ha	
Type of Adopter	Adopter	5%	37%	32%	38%	29%
	Emerging Adopter	19%	31%	44%	31%	32%
	Lagging Adopter	57%	29%	16%	13%	29%
	Marginal Adopter	19%	3%	8%	19%	10%
Total		21	35	25	16	97

Table 3.9: Type of adopter per size of all fields in ha.

As shown above, the majority of fields was between 0.5 and 1 ha, while the minority of fields was bigger than 2ha. 69% of the fields greater than 2ha were owned by adopters and emerging adopters, 38% and 31% respectively, while lagging and marginal adopters only owned 32% of these fields. A similar distribution can be found among the fields between 1 and 2 ha. While 76% of them were cultivated by adopters and emerging adopters, only 24% were owned by lagging and marginal adopters. Also, only 5% of the smallest fields were owned by adopters, whereas lagging adopters owned 57% of the smallest fields. This shows that the bigger fields were mainly owned by modern farmers, while the smaller plots were mostly cultivated by traditional farmers.

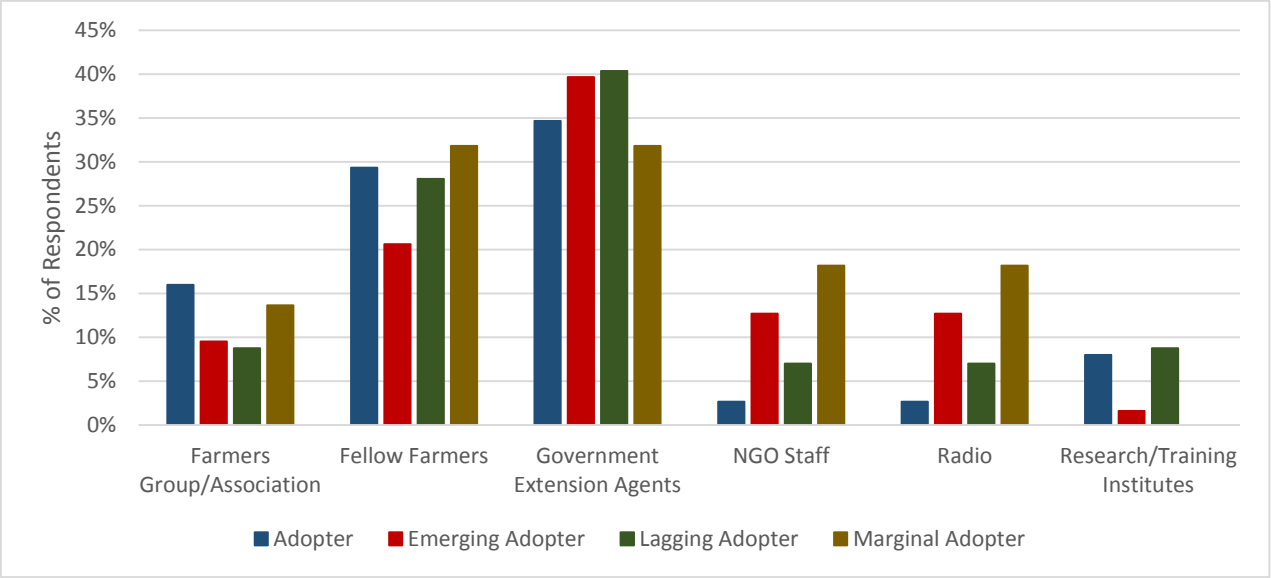

Figure 3.14: Information source on beans per type of adopter.

Lastly, Figure 3.14 depicts the source of information on beans per type of adopter. It shows that the three main sources of information on beans for the adopters were government extension agents (35%), fellow farmers (29%) and farmers groups and associations (16%). Emerging adopters, on the other hand, mainly received information on beans from government extension agents (40%), fellow farmers (21%), staff from non-governmental organizations (NGOs) (13%) and the radio (13%). The same holds true for the lagging adopters, whose main sources of information are equal to those of the emerging adopters. Marginal adopters mainly consulted government extension agents and fellow farmers (32%) as well as staff from NGOs and the radio (18%). Additional sources of information reported during the survey were seeds shops, inputs, newspapers, seminars and own experience. However, these were only mentioned by a few farmers and are therefore not shown in the figure above. In general, Figure 3.14 shows that government extension agents are a major source of information on how to grow beans. Also fellow farmers, mentioned by all types of adopters, are an important medium of spreading information. The only significant difference that can be seen between adopters and all other categories is that the former did not rank NGO staff as one of the mostly used sources of information, while the latter also received information from NGOs and the radio.

		Wealth Category			
		Poor	Medium	Wealthy	Total
Type of Adopter	Adopter	18%	54%	29%	28
	Emerging Adopter	29%	52%	19%	31
	Lagging Adopter	57%	32%	11%	28
	Marginal Adopter	60%	40%	0%	10
Total		37%	45%	18%	97

Table 3.10: Wealth category per type of adopter.

A cross-tabulation of the wealth category and the type of adopter yielded significant results. Table 3.9 illustrates that none of the marginal adopters was wealthy while 40% were medium and 60% were poor. Also, the majority of the adopters and the emerging adopters, 54% and 52% respectively, were medium. Compared to that, only 32% of the lagging adopters were medium, while 57% were poor. However, 11% of the lagging adopters were wealthy, a number that increases further when looking at the emerging adopters and the adopters. 19% of the emerging adopters and 29 of the adopters were wealthy. This clearly shows that wealthy households were mainly found among adopters and emerging adopters, while poor household were mostly constituted of lagging and marginal adopters.

4. Method

4.1. Study Area

The study was conducted in the Northern Region of Tanzania. The market survey was done in markets in and around Arusha, Moshi and Hai (Image 4.1).

Image 4.1: Map of Northern Tanzania showing the approximate location of the markets where market surveys were conducted. Source: Google Map, 2015.

The household survey was conducted amongst farmers in Hai district (Image 4.2).

Image 4.2: Hai district in Northern Tanzania. Source: Google Map, 2015.

Hai district is one out of six districts forming the Kilimanjaro region and lies between the latitudes 2°50' and 3°29' south to the equator and between longitudes 30°30' and 37°10' east of Greenwich. It entails an area of 1.011km² (approximately 101.100 ha) and is subdivided into three divisions, namely Lyamungo, Machame and Masama. It is further divided into 14 wards, 60 villages and 248 hamlets. In 2012, Hai district had a total population of 210.533 according to the National Population Census. About 108.000 are female, whereas about 102.000 are male. The average population density for the entire district is 130 people per km², however, in the upper zone more than 650 people inhabit one km². Land in Hai district is mainly used for farming activities and animal husbandry (Hai District Council). Table 4.1 presents the land use pattern in Hai district in detail.

Type of Land Use	Coverage (in ha)	Coverage (in %)
Potential Agricultural Area	46.506	46
Grazing Area	27.297	27
Forest Area	14.154	14
Mountain and Snow Area	13.143	13

Table 4.1: Land use pattern in Hai district. Source: Hai District Council.

Furthermore, Hai district has four main agro-ecological zones. The lowland zone lies below 900m above the sea level and receives about 500mm to 700mm of rainfall per year. Due to the climatic conditions in this zone, farmers mainly grow crops such as beans, maize, sunflower and rice. This is often complemented by keeping livestock, especially cattle, sheep and goats. The middle zone is located between 900m and 1.666m above sea level and annual rainfall varies between 700mm up to 1250mm. Besides growing the same cash and food crops that are cultivated in the lower zone, farmers are more like to produce milk in the middle zone.

The upper zone lies between 1.666m and 1.800m above the sea level and on the slopes of Kilimanjaro. The rainfall ranges from 1250mm to 1750mm per year, which makes this area especially well-suited for growing coffee and banana and keeping livestock. Lastly, the zone Mount Kilimanjaro peak lies 1,800m above the sea level. It covers approximately 27% of the area of Hai district and mainly encompasses uninhabited forest reserve and a National Park (Hai District Council).

4.2. Study Population and Data Collection

4.2.1. Market Survey

To collect information about the beans being sold at markets in Arusha, Moshi and Hai, three markets were chosen in each region as the primary sampling unit as can be seen in Table 4.2. Sampling was done for each region based on the likelihood of beans being sold in the different markets. Once the markets to visit were agreed on, five retailers (and where possible three wholesalers) were chosen randomly, representing the second sampling unit. The questionnaires (Appendix 5 and 6) asked for quantitative and qualitative information and were structured in five sections: (i) profile, (ii) general questions, (iii) purchases, (iv) sales and (v) storage. Questionnaires were discussed with local supervisors and translators before conducting the interviews and adjusted where necessary. The survey was carried out from February until April 2015 with the help of a colleague working for The World Vegetable Center (AVRDC) and two government officials from the Hai District Council who spoke the local dialect. In sum, 45 retailers and four wholesalers were interviewed during the survey.

Arusha	Hai	Moshi
Kilombero	Boma Ng'ombe	Himo
Mbauda	Kia	Mbuyuni
Tengeru	Kwa Sadala	Mwika

Table 4.2: Markets visited in Arusha, Moshi and Hai District.

In general, 77% of the respondents on the markets were female, while 23% were male. Most respondents had primary education (84%), while only 14% had secondary education. Also, male respondents were more often better educated than female respondents, which is shown by that fact that 60% of the male respondents had secondary education, whereas only 6% of the female respondents had secondary education. The majority of female respondent had primary education (91%) (Table 4.3). This supports the trend that men are often better educated than women.

		Gender of Respondent		
		Male	Female	Total
Education Level of Respondent	None	0%	3%	2%
	Primary	60%	91%	84%
	Secondary	40%	6%	14%
Total		10	34	44

Table 4.3: Gender and education level of respondent.

The majority of respondents was aged between 36 and 45 years, making up 36% of all retailers interviewed. 27% and 24% were aged between 20 and 35, and 46 and 5 years respectively, while only 13% of the respondents were older than 55 years. However, most of the male respondents were between 20 and 35 years old (55%), whereas most female respondents were aged between 36 and 45 years. Also, none of the male respondents was older than 55 years. Summing it up, the number for the first two age categories shows that 82% of the male respondents were between 20 and 45 years old, while only 56% of the female respondents were that age (Table 4.4). This indicated that, on average, male respondents tended to be younger than female respondents.

		Age Category of Respondent				
		[20;35] Years	[36;45] Years	[46;55] Years	[>55] Years	Total
Gender of Respondent	Male	55%	27%	18%	0%	11
	Female	18%	38%	26%	18%	34
Total		27%	36%	24%	13%	45

Table 4.4: Gender and age category of respondent (MS).

Lastly, the average experience in trading for all retailers interviewed was 15 years, with a minimum of one and a maximum of 40 years. Experience in trading beans was slightly lower, 10 years on average with a minimum of one and a maximum of 34 years (Table 4.5). This may be due to the fact that some retailers did not start with beans when becoming a retailer but with other crops and commodities.

	Minimum	Maximum	Mean	Std. Deviation
Experience in Trading (years)	1	40	15	10
Experience in Trading Beans (years)	1	34	10	9

Table 4.5: Experience in trading (beans).

The above explanations show that male as well as female respondents in different age categories and with different levels of experience in trading were interviewed, allowing generalization of results for markets in Arusha, Moshi and Hai.

4.2.2. Household Survey

To gather data about what farmers grow in the different agro-ecological zones of Hai district and what constraints they face vis-á-vis the adoption of improved bean seeds and associated technologies, two villages were chosen as the primary sampling unit in each of the three agro-ecological zones under consideration (Table 4.6). Afterwards, the Hai District Council in cooperation with the village extension officers chose 16 farmers in each village to be interviewed, being the second sampling unit. The questionnaire (Appendix 7) asked for quantitative and qualitative information and was divided into 13 sections: (i) general information, (ii) income and assets, (iii) livestock, (iv) labor, (v) land use, (vi) crop production, (vii) crop utilization, (viii) use of labor saving tools in bean cultivation, (iv) information access, (x) nutrition, (xi) N2Africa, (xii) problems and (xiii) sales. The questionnaire was discussed with local supervisor and adjusted where needed. The survey was carried out from March until April 2015 with enumerators from the Hai District Council who spoke the local dialect. The enumerators were trained prior to the field work to ensure a common understanding of the research aim and a uniform data set. In total, 97 interviews with farmers in Hai District were conducted. Also, GPS coordinated were collected in order to ensure that follow-up interviews are possible (Appendix 8).

Lower Zone	Middle Zone	Upper Zone
Kikavu Chini	Kimashuku	Kiselu
Kawaya	Kware	Orori

Table 4.6: Villages chosen in three agro-ecological zones in Hai District. Maps can be found under Appendix 9.

As can be seen below, 44 of the respondents were female and 52 (plus one respondent that did not mention his age) were mal. The majority of male and female interviewees was aged above 55, representing 33% of the sample, while only 10% of the respondents were aged between 20 and 35 years. Also, most male respondents were older than 55 years (40%9, while most female respondents were aged between 36 and 45 years (Table 4.7).

		Age Category Respondent				
		[20;35] Years	[36;45] Years	[46;55] Years	[>55] Years	Total
Gender of the Respondent	Male	6%	15%	38%	40%	52
	Female	16%	34%	25%	25%	44
Total		10%	24%	32%	33%	96

Table 4.7: Gender and age category of respondent (HS).

In total, 68 of the farmers interviewed were the head of the household, while 29 were not. In detail, 52 of the male respondents were the household head whereas only two were not. Compared to that, only 17 of the female respondents were the household head while 27 were not. This shows that households in the sample were mainly led by men, in this case 78 out of 97 households (Table 4.8).

		Gender of the Respondent		
		Male	Female	Total
If Respondent is Household Head	Yes	51	17	68
	No	2	27	29
Total		53	44	97

Table 4.8: Respondent household head and gender of respondent.

The survey included 36 poor, 44 medium and 17 wealthy households. The education level of the household head varied between no education and post-secondary, with the majority (79%) of the household heads having primary education and 2% having post-secondary education. Interestingly, none of the household heads of a wealthy family had no education, while 9% of the poor and 5% of the medium families had no education. Also, secondary education of household heads was highest among wealthy households that was the only group with post-secondary education as well. This also explains the low number of wealthy household heads having only primary education compared to poor and medium households, as they went to primary school more often. In total, 79% of the 91 interviewees answering this question (91) had primary education, while 13% had secondary education and 2% post-secondary education. None of the household heads went to University (Table 4.9).

		Wealth Category			
		Poor	Medium	Wealthy	Total
Education Level Household Head	None	9%	5%	0%	5%
	Primary	85%	82%	57%	79%
	Secondary	6%	14%	29%	13%
	Post-Secondary	0%	0%	14%	2%
Total		33	44	14	91
Highest Education of Household Member	Primary	27%	23%	31%	26%
	Secondary	67%	62%	50%	61%
	Post-Secondary	3%	5%	6%	5%
	University	3%	10%	13%	8%
Total		30	39	16	85
Gender Household Head	Male	35%	46%	19%	78
	Female	47%	42%	11%	19
Total		37%	45%	18%	97
Has Mobile Phone-Number	Yes	89%	89%	100%	91%
	No	11%	11%	0%	9%
Total		36	44	17	97

Table 4.9: Household characteristics.

As can be seen above, while only 6% and 14% of the poor and medium household heads had secondary education, secondary school was visited by 67% and 62% of one of the household

members. Secondly, none of the household heads of poor and wealthy families had post-secondary education, but 3% of the poor and 5% of the medium household had at least one family member with post-secondary education. Also, while only 29% of the household heads of wealthy families had secondary education, 50% of these households did send one member to secondary school. Lastly, all wealth categories had a family member going to University, with the wealthy households had most members with a University degree (Table 4.9). This shows that even though household heads may not always be well educated, there is a trend that households have at least one member with higher education.

Table 4.9 also illustrates how many male and female headed households were poor, medium and wealthy. It can be seen that 35% of the poor households were headed by a man, while 47 of the poor households were headed by a women. Male and female headed households were almost equally distributed among the medium households, with 46% and 42% respectively. However, whereas only 11% of the female headed households were wealthy, more or less twice as much of the male headed households were wealthy. In sum, male headed households were more often wealthy and less often poor than female headed households.

Lastly, the cellphone penetration for the different wealth categories is presented. All wealthy households had a cellphone, while 11% of the poor and medium household did not possess a cellphone. With 91% of the respondents having a cellphone, cellphone penetration is high (Table 4.9).

Thanks to a sample containing respondents from a range of different age, gender, education and wealth categories, the results of this research can be generalized to Hai District.

4.3. Data Management

The gathered data was analyzed using SPSS Software Version 23. First, the data was cleaned to remove incoherent information and data entry errors. A descriptive statistical analysis was done in order to capture the relevant information and answer the research questions.

Furthermore, farmers were categorized into four types of adopters, namely adopters, emerging adopters, lagging adopters and marginal adopters with the help of certain variables. These different variables for categorization were given a weight to demonstrate their importance concerning adoption of new technologies. Innovative fertilizers was given a weight of four, while the application of Urea was given a weight of three. Herbicides, pesticides/insecticides and organic input received a two, while the use of a tractor received a one. Ammonium Sulfate was given a weight of zero because of its similarity to and simultaneous application with Urea. Still, cases were also looked at individually, especially with regards to NPK fertilizer type usage.

5. Conclusion

The report set out to draw a picture of the current status of the adoption of improved bean varieties and seeds in agricultural production and its presence in the commercial markets in Northern Tanzania.

Soya Njano, an improved bean variety released in Kenya about five years ago, is the bean variety sold most often on the markets and is grown by 90% of the farmers. However, there seems to exist a huge gap between what is available on the market and local production. For example, Rose Coco, also known as Lyamungo 85 and 90 (often sold as mixed), ranks second among the most sold beans on the markets. In contrast, Rose Coco appears to be completely absent from the farmers' fields in the surveyed regions. A similar phenomenon is present with respect to Soya Ndefu (Jesca). While being sold at the market frequently, none of the farmers is cultivating it. Therefore it can be concluded that the beans found on the markets are not necessarily grown in the same region, but are often produced in other regions. Farmers pick the beans they want and like, in this case mainly Soya Njano, which can be attributed to the characteristics of Soya Njano, such as higher resistance to pests, diseases and climatic conditions as well as its better taste and shorter cooking time. As beans are mainly grown for home consumption, these factors play a major role in the decision-making process of farmers.

At this juncture, a point of caution with respect to the credibility of the results is warranted. There seems to be a significant challenge to accurately identify the beans. During the research and informal follow-up conversations, it was found that there is almost no expert from any of the NGOs, Government, and market actors (seed suppliers, wholesalers and retailers) in the region who can safely identify the beans, for example whether Kanamna and Bukoba are the same, and whether either one or even both correspond to an improved variety known under the scientific term of Selian05 or Selian06. Consequently, based on the assumption that Canadian Wonder is Selian 97, Karanga is Selian 94, and Bukoba/Kanamna/Nganamna/Sweden are the same or at least one of them is Selian 05 or 06, the picture of the situation concerning the adoption of improved bean varieties on the farms and markets would be even more positive.

As mentioned earlier, about 31% of the respondents stated that they are not aware of improved bean seeds, which may have two reasons. Either they are not aware of where to buy them, or they are not aware of a better variety than Soya Njano. To date, there is no clear case for another bean variety to be superior to Soya Njano. This shows that farmers are not ignorant of new and improved varieties, as Soya Njano (and probably also others) is (are) widely adopted. To the contrary, farmers know exactly what they want to grow and make sure they get it, even from other regions such as Kenya in the case of Soya Njano. The fact that 97% of the farmers are of the opinion that lack of knowledge is a not constraint to bean production supports the hypothesis that farmers understand the value of improved bean varieties and seeds, meaning that there is no need to tell them what they already know.

This radically shifts the nature of the problem, which would not be low yields due to the non-adoption of improved bean types; the low yields would then owe to the fact that farmers cannot buy improved seeds and instead use grain leftovers from harvest (bean grains). These leftovers, although genetically improved, would still deteriorate in yield potency over time and lead to a reduction in yield of 5-10% per year if not rejuvenated. Farmers are aware that improved seeds would benefit the production of beans, shown by the fact that 20% of the farmers view the unavailability of quality seeds as a constraint to the cultivation of beans. Additionally, other constraints such as climate risk, mentioned by almost 40%, as well as pests and diseases, mentioned by 80% of the respondents, would simultaneously be tackled with the usage of improved bean seeds because of their greater resistance compared to that of bean grains.

In summary, farmers already adopted improved bean varieties, especially Soya Njano from Kenya, but also others such as Rose Coco. The reason for not adopting improved bean seeds simply is owed to their unavailability, not to the lack of knowledge or awareness of farmers. Linking this back to the marketing instruments mentioned in the very beginning, it can be said that it has proven itself. Soya Njano, even though never promoted in Tanzania, became one of the most popular and widely adopted bean varieties in Northern Tanzania, which is due to its special traits. Therefore, the problem is not whether or not farmers actually adopt improved bean varieties, but whether or not improved bean seeds can be purchased. This means that constraints can be classified into three levels. Level one contains the characteristics and traits specific to the new technology, level two entails the constraints faced by the farmers, and level three asks whether the new technology is available. It becomes clear that if requirement one is not fulfilled, meaning the new technology is not superior to the one currently used, farmers are unlikely to adopt it. In the case of Soya Njano and other improved seeds, famers already know that their characteristics are advantageous to those of other varieties, which means they are willing to adopt them. Also all other constraints are overcome by the new technology, which is most likely because its relative advantage outweighs all constraints. However, the problem is that improved seeds are not available, meaning that farmers can only use bean grains for planting improved varieties so far.

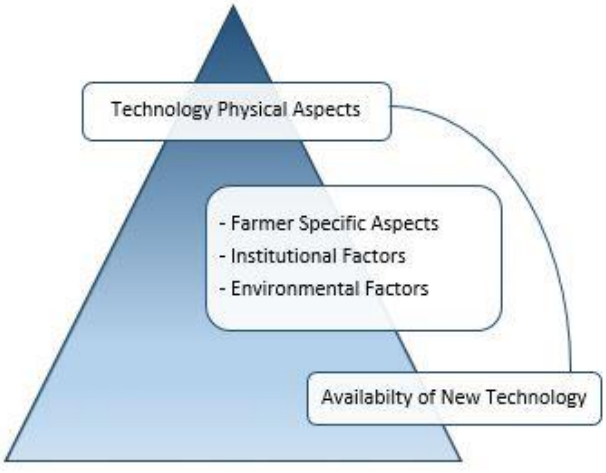

Figure 5.1: Levels of constraints for adoption.

The above conclusion is further supported by the observation that the majority of interviewed farmers already used improved hybrid seeds for maize, 76% of all respondents growing maize. This means that farmers have to purchase new seeds every season in order to be able to cultivate maize, since hybrids are not self-pollinating. Therefore, only few farmers are real peasants and it is likely that farmers are also willing to buy improved seeds for bean production if they were available.

Lastly, light was shed on some of the characteristics applying to modern farmers that already adopted improved agricultural practices and new technologies, as they are most likely to purchase improved bean seeds. First of all, adopters were mainly situated in the upper zone, emerging and marginal adopters in the upper and the middle zone, and lagging adopters in the lower zone. This might imply that greater distance to input and output markets, which can be assumed for farmers living in the upper zone, is not a big problem. Secondly, there is no clear trend regarding the age of the different types of adopters. However, none of the marginal adopters was between 20 and 45 years old, which might indicate that the likelihood of being a modern farmer decreases with age. The same holds true for the question whether modern farms are mainly headed by men or women. Even though male headed households were categorized as adopters slightly more often and as marginal adopters slightly less often than female headed households, it is impossible to draw a clear conclusion here. It seems as if the factor gender does not play a major role regarding the questions of whether farmers are adopting improved agricultural practices or not. However, it has to be noted that 78 of the household were headed by men, while only 19 were headed by women. Fourthly, it can be said that modern farmers, in this case adopters and emerging adopters, were generally better educated than lagging and marginal adopters. Next, modern farmers tend to have bigger plots than traditional farmers, while traditional farmers mainly cultivate smaller fields. Sixth, the sources of information on beans production were very similar among the different adopter categories, with government extension agents being the most frequently used source. The only difference between adopters and all other categories is that NGO staff and radio weried not among their top three information sources, they rely on farmers groups and associations instead. Also, while the majority of lagging and marginal adopters were found among the poor households, adopters and emerging adopters were mainly medium. Additionally, adopters were more often found among the wealthy compared to all other categories, which might mean that modern farmers are wealthier than traditional farmers on average. The question remains whether farmers are modern because they are wealthier than others or whether farmers are wealthier because they are modern.

In summary, modern farmers mainly living in the upper zones of Kilimanjaro tend to be better educated, wealthier, and cultivate bigger fields. Regarding their age, gender and source of information, no clear trend can be distinguished. However, these farmers might be more willing to buy improved bean seeds once available.

6. Recommendations

1. Capacities to generate data of satisfactory quality and credibility must be built. A first and very important step is that surveys and interviews are conducted by thoroughly trained and well-qualified individuals who display sufficient degrees in language proficiency (including translation) as well as in academic rigor and integrity.
2. A second major limitation of the research presented in this report which must be addressed is the building of capacities to accurately identify beans. The exchange and provision of data through a centralized platform funded by all NGOs would be an efficient and effective way to collect and offer crucial pieces of information. Further efforts to develop complex projects will be futile as long as the most basic data is absent or of poor quality.
3. One should also be mindful of the trade-offs between deep analysis and impact versus (geographic) coverage.
4. Additional research is necessary in order to receive more detailed information on the characteristics of modern farmers. This will help to predict the demand for improved bean seeds in the future and in other areas of production.
5. A crucial step towards the adoption of Soya Njano seeds is the certification of this bean variety in Tanzania. Furthermore, there is no need for better bean varieties but for wide availability of quality seeds in general. The priority should be to match the demand for and supply of improved bean seeds.

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8. Appendices

Appendix 1

Background Theory

1. Introduction

To address the problems of food and nutrition insecurity, and to increase the incomes of rural households, productivity of smallholder farmers in Sub-Saharan Africa has to increase. A key component of improving agricultural productivity and therefore achieving food and nutrition security is the diversification and intensification of farming systems. Regarding the diversification of farming systems, grain legumes play a key role, as they are able to capture the infinite resource of transforming atmospheric gas into protein. Not only does the protein-rich grain directly address the food and nutrition needs of rural households, but the crop residuals of those grain legumes also provide a high-quality feed for livestock. Additionally, these residuals add nitrogen to the soils, which enriches exhausted soils and stimulates productivity of crops grown in rotation. Lastly, as important cash crops, grain legumes also provide an additional source of income (N2Africa, 2013; Shiferaw et al., 2008).

However, in order to make rural farmers reap the benefits of grain legumes and nitrogen fixation, research is necessary to investigate why, when and how farmers adopt new technologies like the one put forward by N2Africa. Not only physical and technical aspects of farming, but also economic and social factors and risk attitude (Kebede et al., 1990) have to be known and understood to provide an enhancing and enabling environment for farmers to adopt grain legumes.

Research on adoption has already been done on different regions in Sub-Saharan Africa. A recently published report by Andrew Farrow The recent report *"Review of conditioning factors and constraints to legume adoption, and their management in Phase 2 of N2Africa"* (2014) covers the adoption constraints in Ethiopia, Tanzania and Uganda. The goal of this article, which will be guided by the above mentioned report, is to develop a conceptual framework regarding the factors that enhance or constrain the adoption of new technologies among African smallholders and to generate a more general view on farming systems. By using this framework as a guideline, further research on adoption can be done in Ethiopia, Uganda and Tanzania.

2. Adoption and Diffusion

Aggregate adoption behavior is characterized by two main processes, namely adoption and diffusion. Adoption is related to private utility mechanisms (Feder et al., 1985, Feder and Umali, 1993) and can be defined as "the choice to acquire and use a new invention or innovation" (Hall and Kahn, 2002: 1), whereas "diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system"

(Rogers, 1983: 5). As the messages that are exchanged between the research service and the potential user are concerned with a new idea, diffusion is considered a special type of communication. The newness of the communicated idea also implies that a certain degree of uncertainty is involved. Rogers defines uncertainty as "the degree to which a number of alternatives are perceived with respect to the occurrence of an event and the relative probability of these alternatives" (1983: 6). This lack of certainty is often represented by missing predictability, information and/or structure, whereby the exchange of information is considered one of the most powerful means of reducing uncertainty. This is why research and extension services have to reduce the difficulties of understanding the innovation as well as to clearly state the costs and benefits of the new technology because uncertainty is one of the major factors influencing the intention to adopt (Arts et al., 2011).

A study by Mahajan et al. (1990) on technology adoption makes a distinction between interpersonal communication and communication through mass media. In the Bass model illustrated below it ca be seen that technology adoption as a consequence of mass media is faster in the initial stage. However, the diffusion of an innovation mainly happens due to interpersonal communication (Figure 2.1). For both ways of communication transmission the rate of adoption decreases after a considerable period of time (Mahajan et al., 1990).

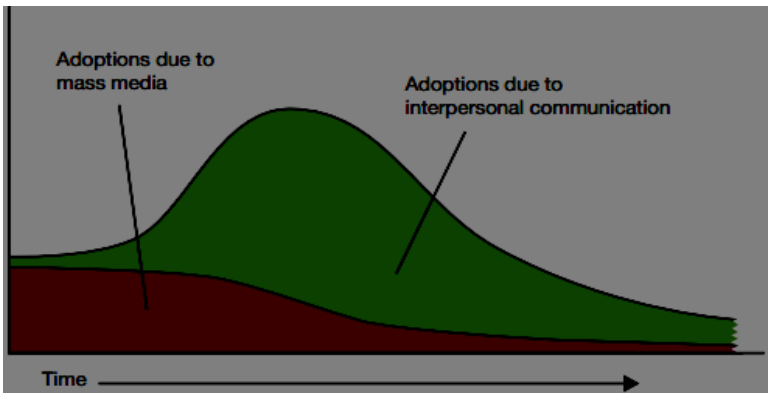

Figure 2.1: Bass forecasting model. Source: Mahajan et al., 1990.

Having said this, diffusion can be defined as "the process by which alteration occurs in the structure and function of a social system" (Rogers, 1983: 6). The invention, diffusion and lastly adoption or rejection of a new technology will consequently lead to some change in the social system.

As can be seen in Figure 2.2, innovations are progressively adopted by a certain group of potential users over time, leading to an S-curve. Inherent in this S-curve is a frequency distribution showing the number of adopters over time (Rogers, 1983). Herein five types of adopters can be identified: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%) and laggards (16%) (Rogers, 2003). A report by Taylor Nelson Sofres (TNS) (2012) about the attitudes of farmers in Malawi and Tanzania divided the farmers into slightly different groups, namely contented dependents, competent optimists, independents,

frustrated escapists, traditionalists, and trapped, whereby the contented dependents and the competent optimists are most open towards new ideas and technologies.

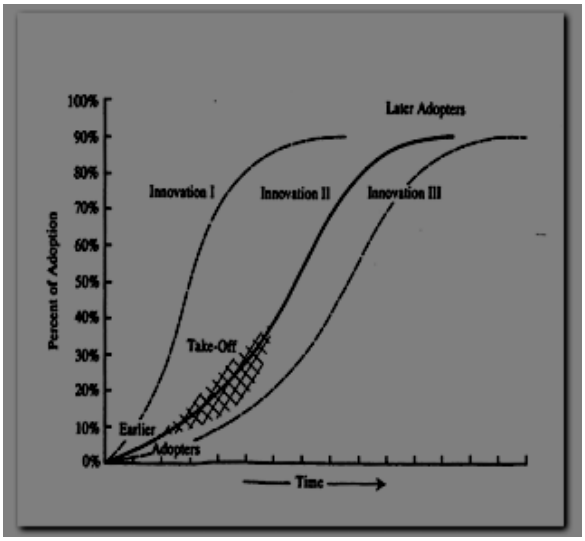

Figure 2.2: Innovation diffusion process. Rogers, 1983.

The innovation-decision process consists of 5 steps, which will be shortly explained in the following. At first a person has to become aware of a new technology and needs to have a basic understanding of how it functions (knowledge). Secondly, at the persuasion stage a potential user forms a favorable or unfavorable attitude towards the new technology (persuasion). Next, the potential user decides whether to adopt or reject the innovation with the help of certain activities such as experimentation and trial (decision). Fourthly, in case the new technology is not rejected the potential user becomes an adopter and puts the innovation into use (implementation). Lastly, the adopter seeks reinforcement for an adoption decision made earlier and might reverse the decision in favor of the new technology if conflicting information come into play or reuse the technology if satisfied (confirmation) (Rogers, 1983).

3. Theories on Technology Diffusion

In general one can distinguish three conceptual models that aim at explaining the decision-making process of farmers regarding the adoption of new technologies.

(i) The Innovation-Diffusion Model (or Transfer-of-Technology Model) is based on the initial work of Rogers 'Diffusion of Innovations' (1962). In this model, a technology is transferred from its source (e.g. research systems) via an agent-medium (e.g. extension service) to the final users (e.g. farmers), whereby the diffusion of the new technology is only dependent on the personal characteristics of the potential user (Negatu and Parikh, 1999). Therefore, it is assumed that “the technology is appropriate for use unless hindered by the lack of effective communication” (Negatu and Parikh, 1999: 208).

(ii) The Economic Constraint Model (or Factor Endowment Model) on the other hand assumes that the distribution of resources among the potential users located in the same region

determines the pattern of adoption (Hayami and Ruttan, 1971; Hayami and Ruttan, 1985 in Negatu and Parikh, 1999).

(iii) The Technology Characteristics – User's Context Model integrates those approaches which assume that "characteristics of [the] technology underlying users' agro-ecological, socio-economic and institutional contexts play the central role in the adoption decision and diffusion process" (Negatu and Parikh, 1999: 208). Therefore, this model includes an additional factor that might affect the adoption behavior and diffusion of the innovation, namely the perceptions of potential users about the technology and its characteristics (Negatu and Parikh, 1999).

4. Potential Constraints to Technology Adoption

Andrew Farrow reviewed several peer-reviewed journal articles and book chapters, as well as some gray literature and set up an initial list of possible constraints to the adoption and utilization of legume technologies. This list included 16 factors. Three additional factors were added after the assessment of the 16 factors. The three most commonly used constraints among the 53 articles under review were the biophysical relevance of the technology or practice (such as suitability for the agro-ecological zone, or response to a specific problem) followed by the effectiveness of the research and extension service, and access to capital/assets (or credit).

A review matrix was constructed by Andrew Farrow upon the above mentioned factors to make them country specific. From this review matrix, the following table can be extracted to find factors influencing the adoption of legume technologies in Ethiopia, Tanzania and Uganda respectively.

Ethiopia	Tanzania	Uganda
• Relevance of technology • Collective action • Land availability, quality or tenure • ARD system • Alternative technologies or livelihoods • Labour • Knowledge • Capital/Assets • Output market	• Seed, • Knowledge • Capital/Assets • Relevance of technology • ARD system • Education • Land availability, quality or tenure. • Alternative technologies or livelihoods • Labour • Collective action • Adaptability of technology.	• Labour • Capital assets • Relevance of technology • Adaptability of technology • Risk perceptions • Knowledge • Education • Collective action

Table 4.1: Constraints to adoption in Ethiopia, Tanzania and Uganda. Source, Farrow, 2014.

As can be seen in the above table, certain constraints are present in all three countries, such as *Labor, Knowledge, Collective action, Capital/Assets and Relevance of technology***.** Other factors that are deemed important will be included. In the following the different factors will be classified into three categories, namely farmer specific characteristics, institutional factors, and technology physical factors. It cannot be assumed that the list of factors below is sufficient and additions will be necessary and welcomed throughout the research.

The **farmer specific characteristics** include age, gender, risk perception or attitude of the farmer, capacity to bear risks, capital, assets and labor endowment, knowledge and education, farm size, demographics, mimicking and imitation, and membership in a cooperative.

Age. Previous studies have shown that the age of the farmer can positively or negatively affect his/her attitude towards new ideas and innovations, which may influence his/her adoption decisions. Polson and Spencer (1991) found that especially younger farmers have greater knowledge about new technologies and are more likely to take risks due to their longer planning horizons. Older farmers may be less willing to adopt new technologies as they are confident with their traditional farming methods. However, the may have gained more experience, resources, and authority providing them with the possibility to experiment with new technologies (Adesina and Zinnah, 1993; Kebede et al., 1990).

Gender. The gender of a farmer also affects the decision-making process regarding the adoption of a new technology. Female-headed households are often less likely to adopt a new idea, which may be due to several constraints they face, such as limited access to credit and extension services, and time constraints (Zeller et al., 1998).

Risk Perception. A study by Kebede et al. (1990) on technology adoption in Ethiopia found that the adoption of agricultural innovations is dependent on the risk attitude of farmers. It is hypothesized that farmers with higher risk aversion are less likely to change traditional practices and adopt new technologies (Kebede et al., 1990). This is supported by Fliegel and Kivlin who state that "since we are dealing here with innovations having direct economic significance for the acceptor, it is not surprising that innovations perceived as most rewarding and involving least risk and uncertainty should be accepted most rapidly" (1966: 248). Following from this, more risk averse a farmer is, the less likely he is to try new technologies, implying that least risky innovations will be adopted most.

Capacity to Bear Risks. Feder et al. (1985) found that the capacity to bear risks is an important determinant of whether a new technology is adopted or rejected. The higher the risk-bearing capacity of the household, the more likely the adoption and usage of the new technology. However, when the household's capacity to bear risks is fairly low, the preference for the traditional farming methods is often higher. As the ability to bear risks is mainly determined by the equity capital owned by the household (and access to credit), households with greater capital and asset endowments will adopt a new technology more often (Zeller et al., 1998).

Capital and Household Assets. A study by Shiferaw et al. (2008) on the adoption of improved pigeonpea varieties in Tanzania found that capital and household assets, among others, play

a crucial role in the decision-making process of farmers. This is highly related to the capacity to bear risks, as more affluent households are more likely to adopt a new technology due to the ability to cope with the risk inherent in the adoption of a new technology.

Labor. Labor availability is another important determinant of technology adoption, as the implementation of an innovation often goes hand in hand with the need for additional labor. Therefore, farmers with limited (access to) labor (markets) are usually less willing to adopt a new technology (Feder et al., 1985). As labor costs can go up to 80-90% of the production costs, capital constraints can induce labor constraints. This is especially true during the peak seasons of planting and harvesting when family labor is not sufficient (Zeller et al., 1998).

Education and Knowledge. The adoption of a new technology is further determined by the level of education of farmers (Kebede et al., 1990; Shiferaw et al., 2008) and their knowledge about the innovation (Shiferaw et al., 2008, Arts et al., 2011). Generally one can say that farmers with more schooling and information "will be better informed about the existence and general performance of different technologies, will make more accurate assessments of differences in farm-level performance, and will make more efficient adoption decisions" (Abdulai and Huffman, 2005: 651). Furthermore, education enhances the farmer's managerial skills, which also includes the more efficient use of additional inputs (Feder et al., 1985; Binam et al., 2004). Farmers that acquire more information and knowledge about the new technology through extension services or other channels are more likely to be early adopter than those receiving less information. Imperfect knowledge may lead to a strategic delay of adoption as non-adopters take advantage of the opportunity to costlessly observe their neighbors' experiments with the innovation, which may result in a higher rate of adoption if successful (Abdulai and Hufmann, 2005). This further undermines the importance of extension services and demonstration plots.

Farm Size. Studies by Polson and Spencer (1991), Shiferaw et al. (2008) and Yesuf and Köhlin (2009) show that farm size has a positive relationship with the adoption behavior of farmers. Farmers with larger farms may be more willing to devote part of their land to the experimentation with a new technology.

Demographics. The demographic characteristics, including the quality of soils, erosion and agro-ecological zone, of a farmer are also factors that have to be taken into account when analyzing the decision-making behavior of farmers (Negatu and Parikh, 1999). Whether or not a new technology will be adopted highly depends on whether it fits the requirements and conditions of the region it is brought to. Andrew Farrow (2014) drew the same conclusion from his evaluation of a bunch of articles, stating that biophysical relevance is one of the most important aspects regarding technology adoption.

Mimicking and Imitation. Binet and Richford (2008) provide evidence that mimicking behavior and imitation are major factors related to the diffusion and adoption of a new technology. As mentioned above, especially less wealthy farmers may observe the experiments of their more affluent neighbors in order to assess the profitability of the new technology for themselves.

Rogers undermines this theory by stating that “imitation by potential adopters of their near-peers who have previously adopted a new idea” (1983: 293) is the heart of the diffusion process. Farmers mainly depend on the communicated experience with the new technology that resemble subjective evaluations and flow through interpersonal networks (Rogers, 1983).

Perception of the New Technology. A study by Adesina and Zinnah (1993) shows that the farmer's perception of the technology-specific characteristics are a significantly influence the decision-making process of farmers.

Membership in a Cooperative. A study by Abebaw and Haile (2013) on the influence of cooperatives on technology adoption in Ethiopia suggests that membership in a cooperation may have a positive influence on the farmer decision-making. This may be due to the fact that those cooperatives do not only provide improved farm inputs and loans, but also market the products of its members.

Production Decisions. It is further hypothesized that the question of whether farmers produce solely for the household or (also) the market affects the decision-making process. Polson and Spencer (1991) found that farmers producing a surplus for the market are more likely to adopt new technologies. Therefore, whether farmers adopt a new idea or not is highly dependent on their needs, wants and household decisions.

The **institutional factors** include availability of quality seeds, credit supply and access, market access, marketing system, and extension contact.

Availability of Quality Seeds. The local availability of quality seeds and the farmers' ability to access this input is crucial with regard to the decision-making process of farmers (Shiferaw et al., 2008). Furthermore, the source of seeds has to be trusted by farmers to make them plant the new seeds. The non-existence of trustworthy local seed suppliers may dramatically hamper adoption.

Credit Supply and Access. Credit supply and access are crucial factors when it comes to the adoption of innovations (Shiferaw et al., 2008; Zeller et al., 1998). However, it is not clear what kind of credit is actually needed for legumes. Due to the risk of crop failure or severe yield reduction the interest rate for credits mostly is too high and not affordable for farmers. Therefore, credit often only works for short-time trade, to hire labor during peak seasons, for drought resistant cash crops such as sesame and sorghum or for irrigated agriculture. Grain legumes, on the other hand, hardly appear as a focus for credit, which means that in some cases farmers need to finance their investments, at least partly, with their own equity (Abdula and Huffman, 2005). In other cases, farmers can use their land, cows or even a crop as collateral to finance the adoption of a new technology (Abdulai and Huffman, 2005). To sum it up, a credit constraint might not affect farmers' adoption of new technologies as long as it can be displaced by a different source of finance, such as savings or sufficient arm income. Therefore, the focus should rather be on the potential income generation of a farm than simply on credit constraints.

Access to Markets. Another factor determining the rate of adoption of new technologies is the access to input and output markets (Negatu and Parikh, 1999; Feder et al., 1985; Abdulai and Huffman, 2005). Market distance in agriculture is defined as "the distance to the point of sale of the farm output, notably a market center where buyers congregate" (Schalkwyk, 2012: 97). In case of greater distance to the market it becomes more difficult for the farmer to sell his/her products as several logistical problems arise. Among others, the availability of transportation, high transport costs (Schalkwyk, 2012) and time constraints might hinder farmers to engage in selling and buying activities at central markets.

Therefore, farmers that are based in areas further away from markets are more likely to have no market access, especially if they lack the necessary means to reach the selling point with their produce (Schalkwyk, 2012). This in turn can reduce the expected profitability of an innovation as the greater distance to the center can reflect a barrier to "professional support and more limited and costly access to complementary inputs" (Abdulai and Huffman, 2005: 652). Furthermore, the costs of marketing products (under poor refrigeration) increases with distance to a major center and there is only limited information about marketing outlets available. Also, the screening, bargaining with and monitoring trading partners that are located further away becomes more costly and difficult (Abdulai and Huffman, 2055). Those factors may lead to less adoption. Lastly, limited access to input markets may weaken the availability of complementary inputs that are necessary for technology adoption, such as fertilizers, water and storage facilities (Feder et al., 1985).

However, as stated by Edward Baars, the costs of land and labor are likely to be lower in areas located further away from market centers and the availability of land may be more favorable. The costs of transportation are often only a small percentage of the total production costs as trucks deliver many non-agricultural products to the farms and need a back-load in order to be efficient.

Marketing System. According to Fafchamps (2004) markets can be distinguished into primary, secondary and tertiary markets. Undeveloped markets as can be seen in Ghana can be classified as a tertiary markets, intermediate markets such as the one present in Kenya as secondary markets, and well developed markets such as in Zimbabwe as primary markets. This has to be taken into account as information exchange in primary markets functions better and smoother than in secondary or tertiary markets, possibly strengthening and supporting the process of adoption and diffusion. Different markets systems can be broadly depicted to certain countries but are also likely to vary within different countries and regions.

Due to the more efficient communication and exchange of information in primary markets, technology adoption and diffusion are more likely to happen there. It is hypothesized that the early adopters are closer to or part of a primary markets whereas laggards are part of secondary or tertiary markets. This means that the market system in which potential users are located may increase or decrease the rate of adoption due to different levels of information transfer.

Extension Contact. In order to decide whether to adopt a new technology or not, farmers need information about the intrinsic characteristics of the innovation. Therefore, contact with extension agents is necessary to gain information about the new technology and to understand the usage and benefits of it, preferably with the help of demonstrations (Negatu and Parikh, 1999; Abdulai and Huffman, 2005), which can stimulate adoption (Polson and Spencer, 1991).

The **technology physical aspects** include relative advantage, compatibility, complexity, trialability, and observability. As stressed by Rogers (1983) adoption will only take place if the new technology fulfills the requirements of the above mentioned characteristics.

Relative Advantage. The degree to which a new technology is perceived as superior in comparison to the traditional one, which might not only be measured in economic terms, but also in terms of satisfaction and convenience, I called relative advantage. As explained by the Technology Characteristics – User's Context Model, the 'objective' advantage of a new technology is mostly not the component that is most important, instead it matters whether the individual user perceives the innovation as useful and advantageous. Furthermore, communicating the benefits of the new technology with regard to the needs and lifestyles of the potential adopter might increase the rate of adoption (Arts et al., 2011, Rogers, 1983).

Compatibility. In case a new technology fits the existing values and norms of a social system, experiences and needs of farmers, and the natural environment, compatibility is present. Arts et al. (2011) support the finding by stating that compatibility is one of the most influential characteristics of the innovation that affect the intention to use or not to use the innovation. Therefore, special care should be taken in explaining who benefits from the new technology and why (Rogers, 1983).

Complexity. Complexity refers to the perception of difficulty of usage and understanding of the new technology. Obviously, technologies that are understood easily will be adopted quicker than those more complicated (Rogers, 1983). If successful technology adoption requires new skills and competencies due to its complexity, which is very time-consuming or costly, implementation may be slow (Rosenberg, 1972).

Trialability. Trialability is concerned with the possibilities of experimenting with a new technology on a limited basis. It can be assumed that innovations that are not divisible will be adopted more slowly than those that can be experimented with before the actual adoption (Rogers, 1983). This is mainly due to the fact that trying a new technology reduces the degree of uncertainty as a process of learning by doing takes place (Fliegel and Kivlin, 1966).

Observability. Lastly, observability captures the degree to which the outcome and results of a specific technology are visible for those not using the innovation. The better the results can be observed, the more confident are potential users about the benefits of adopting the new technology, which positively influences their decision-making behavior (Rogers, 1983). Demonstration plots can be one way to make the benefits of the new technology visible to potential adopters.

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Appendix 2

Name Used in Report	Additional Names	Scientific Names
Bukoba(*)	Biskuti	Selian05 or Selian06?
Canadian Wonder(*)	Kanada, Canada	Selian 97?
Kabuku		
Kanamna(*)	Mrondo, Nganamna, (Bukoba), (Sweden)	Selian05 or Selian06?
Karanga(*)		Selian 94?
Kariasii		
Kishumba	Masai Red	
Soya Kijivu		
Soya Ndefu*	Combat, Iringa, Military Soya	Jesca
Soya Njano*		KATB1 (Kenya, Katumani)
Rose Coco*	Nyayo	Lyamungo

*Beans marked with * are improved varieties, beans market with (*) might be improved varieties.*

Appendix 3

A.

	Minimum	Maximum	Mean	Std. Deviation
Price per Kg of Soya Njano	1800	2500	2088	200
Minimum Price per Kg of Soya Njano	1000	2375	1599	299
Maximum Price per Kg of Soya Njano	1850	2500	2199	235

B.

	Minimum	Maximum	Mean	Std. Deviation
Price per Kg of Rose Coco	1200	2000	1631	180
Minimum Price per Kg of Rose Coco	875	1625	1256	228
Maximum Price per Kg of Rose Coco	1200	2000	1709	214

C.

	Minimum	Maximum	Mean	Std. Deviation
Price per Kg of Soya Kijivu	1600	2500	1968	226
Minimum Price per Kg of Soya Kijivu	1000	2375	1556	348
Maximum Price per Kg of Soya Kijivu	1700	2500	2098	277

Appendix 4

	Minimum	Maximum	Mean	Std. Deviation
Walking Distance to Fields in Lower Zone	1	126	41,57	38,494
Walking Distance to Fields in Middle Zone	1	360	70,50	95,269
Walking Distance to Fields in Upper Zone	1	601	164,42	128,139

Appendix 5

Market Survey N2Africa Project

Retailer Questionnaire

Name of the interviewer: _____

Date: _____ /_____ /2015

Survey Start Time: _____

Survey End Time: _____

Country: _____ Region: _____

District: _____ Village: _____

Market: _____

Introduction

Introduce yourself and the N2Africa project. Explain the purpose of the survey and assure the interviewee(s) of the confidentiality. Please check if the interviewee(s) has/have any questions at this time.

Part A. Profile of Retailer

A.1. Name of the respondent: _____

A.2. Sex of respondent: Male ___ /Female ___ Age: ____

A.3. Mobile: _____

A.4. Education level of respondent: _____ (years)

A.5. Total experience in trading: _____ (years)

A.6. How long are you a beans retailer? _____ (years)

A.7. How many beans retailers did you know when you started your business? _____

A.8. How many beans retailers do you know now? _____

A.9. How many of the beans retailers you know are female? _____

A.10. Why did you become a beans retailer? _____

Part B. General Questions

B.1. What do you sell?

_____

_____

_____

_____

B.2. What bean types do you sell?

_____

_____

_____

B.3. How relatively important are beans compared to other products you sell?

_____

_____

_____

_____

Part C. Purchases

C.1. Details of Purchases of Beans (currently in stock)

No.	Bean	Quantity purchase (Unit)	Unit Name	Kg per Unit	Quantity Purchase (Kg)	Price paid	Date of Purchase (dd/mm/yy)	Source of Purchase	Min/Max Price	Seasonality
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

C.2. How do you get the beans to our store?

_____

_____

_____

C.3. Why do you purchase/sell these beans?

_____

_____

_____

_____

C.4. Besides the beans you mentioned above, are there other beans you purchase throughout the year (bean, quantity price, and source)?

_____

_____

_____

_____

C.5. Why do you not purchase them at the moment?

_____

_____

_____

_____

Part D. Sales

D.1. Details of Sales of Beans

No.	Bean	Current Price/Unit	Min price/Unit	Max price/Unit	Unit Name	Kg/Unit	Current Price/Kg	Min Price/Kg	Max price/kg
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

D.2. Do your costumers demand other beans besides the ones you offer?

_____

_____

D.3. Where else do you sell your beans?

_____

_____

_____

D.4. What percentage of beans do you sell from the total purchase? How much do you lose due to sorting the beans?

_____

_____

_____

Part E. Storage

E.1. Do you encounter any storage problems? If yes, which?

_____

_____

_____

E.2. What measures do you take to control for these storage problems?

_____

_____

_____

E.3. Do you experience any other quality related issues that influence the price?

_____

_____

_____

Part F. Payment

F.1. How do you pay for your purchases?

_____

_____

_____

F.2. How do your customers pay?

_____

_____

_____

Thank you!

Appendix 6

Market Survey N2Africa Project

Wholesaler Questionnaire

Name of the interviewer: _____

Date: _____ /_____ /2015

Survey Start Time: _____

Survey End Time: _____

Country: _____ Region: _____

District: _____ Village: _____

Market: _____

Store Name: _____

Introduction

Introduce yourself and the N2Africa project. Explain the purpose of the survey and assure the interviewee(s) of the confidentiality. Please check if the interviewee(s) has/have any questions at this time.

Part A. Profile of Wholesaler

A.1. Name of the respondent: _____

A.2. Sex of respondent: Male ___ /Female ___ Age: ____

A.3. Mobile: _____

A.4. Education level of respondent: _____ (years)

A.5. Total experience in trading: _____ (years)

A.6. How long are you a beans wholesaler? _____ (years)

A.7. How many beans wholesalers did you know when you started your business? ___

A.8. How many beans wholesalers do you know now? _____

A.9. How many of the beans wholesalers you know are female? _____

A.10. Why did you become a beans wholesaler? _____

Part B. General Questions

B.1. What do you sell?

_____

_____

_____

_____

B.2. What bean types do you sell?

_____

_____

_____

_____

B.3. How relatively important are beans compared to other products you sell?

_____

_____

_____

_____

Part C. Purchases

C.1. Details of Purchases of Beans (currently in stock)

No.	Bean	Quantity purchase (Unit)	Unit Name	Kg per Unit	Quantity Purchase (Kg)	Price paid	Date of Purchase (dd/mm/yy)	Source of Purchase	Min/Max Price	Seasonality
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										

C.2. How do you get the beans to your store?

_____

_____

_____

C.3. Why do you purchase/sell these beans?

_____

_____

_____

C.4. Besides the beans you mentioned above, are there other beans you purchase throughout the year (bean, quantity price, and source)?

_____

_____

_____

C.5. Why do you not purchase them at the moment?

_____

_____

_____

Part D. Sales

D.1. Details of Sales of Beans

No.	Bean	Current Price/Unit	min price/Unit	Max price/Unit	Unit Name	Kg/Unit	Current Price/Kg	Min Price/Kg	Max price/kg
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

D.2. Do your costumers demand other beans besides the ones you offer?

_____

_____

D.3. What kind of customers do you sell your beans to?

_____

_____

_____

D.4. Do you also sell to customers from outside Arusha/ Moshi /Hai? If yes, where?

_____

_____

_____

D.5. How do your customers get your beans?

_____

_____

_____

D.6. What percentage of beans do you sell from the total purchase?

_____

_____

_____

Part E. Storage

E.1. Do you encounter any storage problems? If yes, which?

_____

_____

_____

E.2. What measures do you take to control for these storage problems?

_____

_____

_____

E.3. Do you experience any other quality related issues that influence the price?

_____

_____

_____

Part F. Payments

F.1. How do you pay for your purchases?

_____

_____

_____

F.2. How do your customers pay?

_____

_____

_____

Thank you!

Appendix 7

Household Survey N2Africa Project

Hai District, Tanzania

Name of the interviewer: _____

Name of the person filling the form: _____

Date of interview: _____/_____/2015

Country: _____ Region: _____

District: _____ Ward: _____

Village: _____

GPS coordinates homestead (decimal degrees):

Latitude (North/South): _____ Longitude (East/West):_____ Altitude: _____ (meter)

Introduction

Introduce yourself and the N2Africa project. Explain the purpose of the survey and assure the interviewee of the confidentiality. Please check if the farmer has any questions at this time.

Part A: General Information

A.1. Name of the farmer: _____

A.2. Sex of the farmer: Male ___ /Female ___ Age: _____

A.3. Phone number of farmer or contact person: _____

A.4. Farm ID: _____ (please assign unique farm ID)

A.5. Is farmer head of the household: Yes ___ / No ___

A.6. If no, head of household is Male ___ /Female ___; Age _____ years

A.7. Member of the household: Total number of people in the household: _____

Age	**No. of females**	**No. of males**
0 – 16 years		
17 – 35 years		
35-60 years		

A.8. What is the education level of the person with the highest education in the household, and the education level of the households head (in years)?

Schooling level	**Within household**	**Household head**
1. Primary		
2. Secondary		
3. Post-secondary		
4. University		
5. Other, specify:		

Part B. Income and Assets

B.1. Importance of agriculture in the household. Please provide an estimate of the relative importance of different sources of income by dividing the total income into different portions. Write 0 if type of income does not apply.

	What are the main sources of ***cash*** income in the household? (please tick)	General estimate of proportion of total income (in %, total equals 100%)
Cropping		
Livestock		
Casual labour		
Trade		
Other business		
Salaried job		
Pension		
Remittances		
Other, specify:		

B.2. What are the three most valuable goods or assets in your household?

1._____

2._____

3._____

B3. Does your household possess any of the items mentioned below? Please tick.

Item		Item	
Bicycle		Tractor	
Motorbike		Plough	
Car		Ox cart/ donkey cart	
Cell phone		Tap (piped) water	
Radio		Private well	
Television		Electricity	
Fridge		Solar Power	
Sofa		Generator	
House with tiled roof and/or cement/ brick walls		Other, specify:	
Iron sheet roof		Other, specify:	

B4. Apart from living what are your major expenses and how much do you spend on them?

Category	**Expense (%)**
Labour	
Farm inputs	
Transport	
Loans	
Others, specify:	

B.5. Estimated wealth category of household based on interviewer's perception?

Very poor: _____Poor: _____ Medium: _____Wealthy: _____

Part C. Livestock

C.1. Number of valuable livestock species owned of by the household

Local Dairy cows (no.): _____ Improved Dairy cows (no.): _____

Draught cattle (no.): _____ Fattening cattle (no.): _____

Sheep (no.): _____ Goats (no.): _____

Pigs (no.): _____ Chicken (no.): _____

Other valuable livestock, type: _____ no: _____

type: _____ no: _____

C.2. How did the availability of feed for ruminant livestock vary over the previous year? *(on a scale of 0-10, where 10 = excess feed available, 5= adequate feed available and 0=no feed available)*

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Feed availability												

C.3. How much did the various feeds contribute to the diet of the animals (ruminant livestock) throughout the previous year? Proportion of nutrition derived from different sources. **The different sources must add to 10!**

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Crop residues (e.g.rice straw, maize stover)												
Legume crop residues from legume crops, specify legumes:												
Green forage (e.g. roadside weeds, cut fodder crops)												
Grazing												
Concentrates (e.g. Wheat bran, grains, oilseed cakes)												
Others, specify:												
Others, specify:												
Must add to 10	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*	*10*

C.4. Was the previous year a:

Good year_____; Average year_____; Bad year_____

Part D. Labour

D.1. Do you hire labour from outside the household to work in your fields? Tick what best describes your situation.

1. Yes, permanently (i.e. every year, throughout the cropping season)	
2. Yes, regularly (e.g. at peak periods during the cropping season)	
3. Yes, sometimes (e.g. not every season or peak period, only if money allows)	
4. No, never	

D.2. Last year (season 2014), did you hire labour from outside the household to work in your fields?

D.3. Did you or your household members work on other people's fields for food or cash (as hired labour) last year (season 2014)?

D.4. Was there any period in the year 2014 when activities on your own fields were delayed because:

	1. You and/or your family members had to work on other people's fields first? (Tick activity which was delayed)	2. You could not hire enough people to work on your fields? (Tick activity which was delayed)
Land preparation		
Sowing		
Weeding		
Harvest		
Other		

Part E. Land Use

E.1. Draw a sketch map of the farm indicating the fields:

E.2. 11. How much arable land do you have available for crop farming (incl. fallow land)?

Area: _____ Unit: _____

E.3. Did you leave any land fallow during the previous cropping season (2014)?

If yes, how long is a field typically left fallow between crops (seasons): _____

E.4. What are the two most common crop rotation sequences on your farm? (Refer to the sketch map drawn with the farmer for the field no.)

Field no.	**Season**		
	2011-2012	**2012-2013**	**2013-2014**

Part F. Crop Production

F.1. Please fill the table below for the three main arable crops grown on the farm in the current or most recent season (exclude small vegetable gardens). In case three major crops do not include beans, include major bean as fourth crop.

Field	Size (indicate ha, acre or m^2)	Distance of this field from the homestead (walking distance in minutes)	Crop(s) grown (if intercropped, mention all crops and indicate relative shares, e.g. 80% maize / 20% beans)	Indicate variety/ies (ensure variety names for all legumes are noted).	Mineral fertiliser applied? (If yes, specify type)	Organic inputs applied (e.g. compost/manure)? (Tick if yes)	Inoculant applied? (Tick if yes)	Total harvest from this field (give unit, e.g. in kg)	Who manages this field (husband, wife, both husband and wife, other (please specify))	Who decides about the harvest/ sales of the crop from this plot? (husband, wife, both, other (please specify))
1										
2										
3										
4										

F.2. For your 3 most important crops, how much do you harvest (per area of land) in a normal year (if 3 major crops do not include beans, add bean as fourth crop)?

Crop 1: _____ amount: _____ unit: _____areal of land: _____unit

Crop 2: _____ amount: _____ unit: _____areal of land: _____unit

Crop 3: _____ amount: _____ unit: _____areal of land: _____unit

Crop 4: _____ amount: _____ unit: _____areal of land: _____unit

F.3. What proportion of your total bean produce is used for home consumption and what proportion for sale? Tick what best describes your situation.

1. All produce used for home consumption	
2. Most produce used for home consumption, small part used for sale	
3. Half of produce used for home consumption, half of produce used for sale	
4. Small part used for home consumption, most produce used for sale	
inut5. No produce used for home consumption, all produce used for sale	

F.4. What proportion of the three major beans grown is use for home consumption and what proportion for sale? Please indicate on axis below.

Bean 1: _____

All sale ----------half/half---------- All consumption

Bean 2: _____

All sale ----------half/half---------- All consumption

Bean 3: _____

All sale ----------half/half---------- All consumption

F.5. What do you consider to be the major production constraints for your farm?

_____

_____

_____

_____

Part G. Crop Utilisation

G.1. Use of ***crops***

Indicate for each crop the total production from last season for the entire farm and the amounts for sale, kept in the household for food, for payment/food of hired labour, and the amount kept for seed. The table refers to the division of crop production directly after harvest. *Make sure that the sum of the different amounts equals total production as mentioned in part F.*

Non-bean crops	Total production at the farm Indicate units, e.g. kg, 50 kg bags. Total production should correspond with the yields given in section F.	Amount for sale	Amount for food in the household	Amount used as payment/ food for hired labour	Amount kept as seed	Amount given away as gifts, for funerals, church, etc.
Beans						

G.4. Use of ***crop residues***

How do you use crop residues? Give the percentage used to feed livestock, mulched, burnt, etc. Make sure the total equals 100%.

Non-bean crops	Fed to livestock	Mulched (left in field)	Burnt	Sold	Other, specify:
Beans					

Part H. Use of Labor Saving Tools in Bean Cultivation

H.1. Do you use any labour-saving technologies or tools in the cultivation of beans (e.g. tractor, herbicide, processing machine, etc.)?

If yes, which tool(s) do you use?

Specify tool	**Specify activity where the tool is used for (e.g. ploughing, planting, processing)**	**Tool(s) used by men, women, both?**

Part I. Information Access

I.1. What are your main sources of information on beans (rank the three most important sources of information).

1. Government extension agents (development agents, district experts) _____
2. Research/Training Institutes _____
3. NGO Staff _____
4. Farmers Group/Association _____
5. Fellow Farmers _____
6. Radio _____
7. TV _____
8. Newspaper _____
9. Mobile Phones _____
10. Others, please specify: _____

I.2. What kind of information on beans do you normally seek (tick)?

1. Inputs (seed, varieties, fertilisers, inoculants) ___
2. Agronomy (planting time, spacing, disease and pest control) ___
3. Post-harvest handling and processing (storage, product value addition) ___
4. Marketing (where markets are, prices, quality required) ___
5. Other, specify: ___

I.3. What would you like to learn more about concerning beans?

_____

_____

_____

_____

_____

I.4. What are the key challenges that you face in bean cultivation?

_____

_____

_____

Part J. Nutrition

J.1. In a normal year (not a drought year for instance), are there any months in which you struggle to find sufficient food to feed everyone in the household?

If yes, in which months of the year do you struggle to find sufficient food?

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Tick the months when you struggle												

J.2. In a normal year, in which months does the food consumed in the household **mainly** come from your own farm and which months mainly from other sources?

	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec
Tick the months when food comes from your own farm												
Tick the months when food comes from other sources												

J.3. Do you eat grain legumes and/or legume leaves in your household?

Y___ / N___

If yes, how often do you eat grain legumes and legume leaves in your household (which kinds, number of days per week, main or side dish (e.g. as snack))? In case beans are not mentioned, specifically ask for beans!

	Which grain legume?	**Number of days per week**		**How eaten? Main or side dish?**
		Peak season	Low season	
1.				
2.				
3.				
4.				
	Which legume leaves?			
1.				
2.				

Part K. N2Africa

K.1. Did you ever work with N2Africa?

Yes ___ / No ___ If no, skip part K and go to part L

K.2. Did you participate in N2Africa demonstrations in previous season(s)?

Yes ___ / No ___

K.3. Did you fill the field book in previous season(s)? Yes ___ / No ___

If yes, which season(s)? _____ Old farm ID (lok up later): _____

K.4. Did you receive the N2Africa package? Yes ___ / No ___

If yes, which package? _____

K.5. Did you plant the bean(s) that you received? Yes ___ / No ___

K.6. Did you use all the improved inputs for this bean? Yes ___ / No ___

In case you did not plant the bean(s) or did not use the inputs, what did you do?

_____

_____

K.7. What was the reason for not planting the bean(s) or using the input?

_____

_____

K.8. Were the technologies offered in the N2Africa package new to you or did you already use some of the technologies before? Please tick what was new.

Part of package	**Tick if new**
Bean species	
Bean variety	
Use of mineral fertilizer on this bean	
Inoculant	
Other, specify:	

K.9. Which input do you use?

_____

_____

_____

K.10. Are there any other inputs you would like to use? Yes ___ / No ___

If yes, what other inputs? _____

K.11. What is the reason for not using these inputs?

_____

_____

Part L. Problems

L.1. Problems experienced during the growing season on the (N2Africa) field?
Please tick whether the problems listed in the table were absent / mild / moderate / severe, also record other problems that occurred and differentiate between N2Africa fields and other fields.

Problem	**Absent**	**Mild**	**Moderate**	**Severe**	**Field**
Drought					
Water logging					
Storm / hail					
Pests					
Weeds					
Disease					
Other, specify:					

L.2. If weed/pest/disease problems were reported, please provide the following information (if known):

Type of weeds: _____

Type of pest: _____

Type of disease: _____

Part M. Sales

M.1. Please indicate what beans the farmer sells, at what prices and quantities, and whether the season of the ear determines which beans are grown and at what prices they are sold.

No.	Bean	Quantity sold in Kg	min price/Unit	Max price/Unit	Unit Name	Kg/Unit	Min Price/Kg	Max price/kg	Seasonality
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									

M.2. Where do you sell your bean produce?

_____

_____

_____

M.3. How does your bean produce get to the market?

_____

_____

_____

In case farmer transports beans to the market by him/herself, ask for mode of transport, costs, and for person selling the beans at the market.

_____

_____

_____

In case beans are collected from the farm by a collector, ask the following questions:

M.4. Do different collectors collect different beans or does one collector collect all beans you produce?

_____

_____

_____

M.5. Do you always sell your beans to the same collector(s)? Yes ___ / No ___

M.6. Are the prices that the collectors pay for your beans fixed or negotiable?

_____

_____

_____

M.7. Do you know at what prices other farmers sell their beans to the collectors?

_____

_____

_____

M.8. Are you involved in the collective marketing of beans?

If yes, which bean(s) and explain the marketing system?

_____

_____

_____

M.9. Do you process your bans before selling them? Yes ___ / No ___

If yes, which bean(s) and how do you process them?

_____

_____

_____

M.10. How many times a year and when do you sell your beans?

_____

_____

_____

M.11. Does your profit vary with the time of the year when you sell your beans?

_____

_____

_____

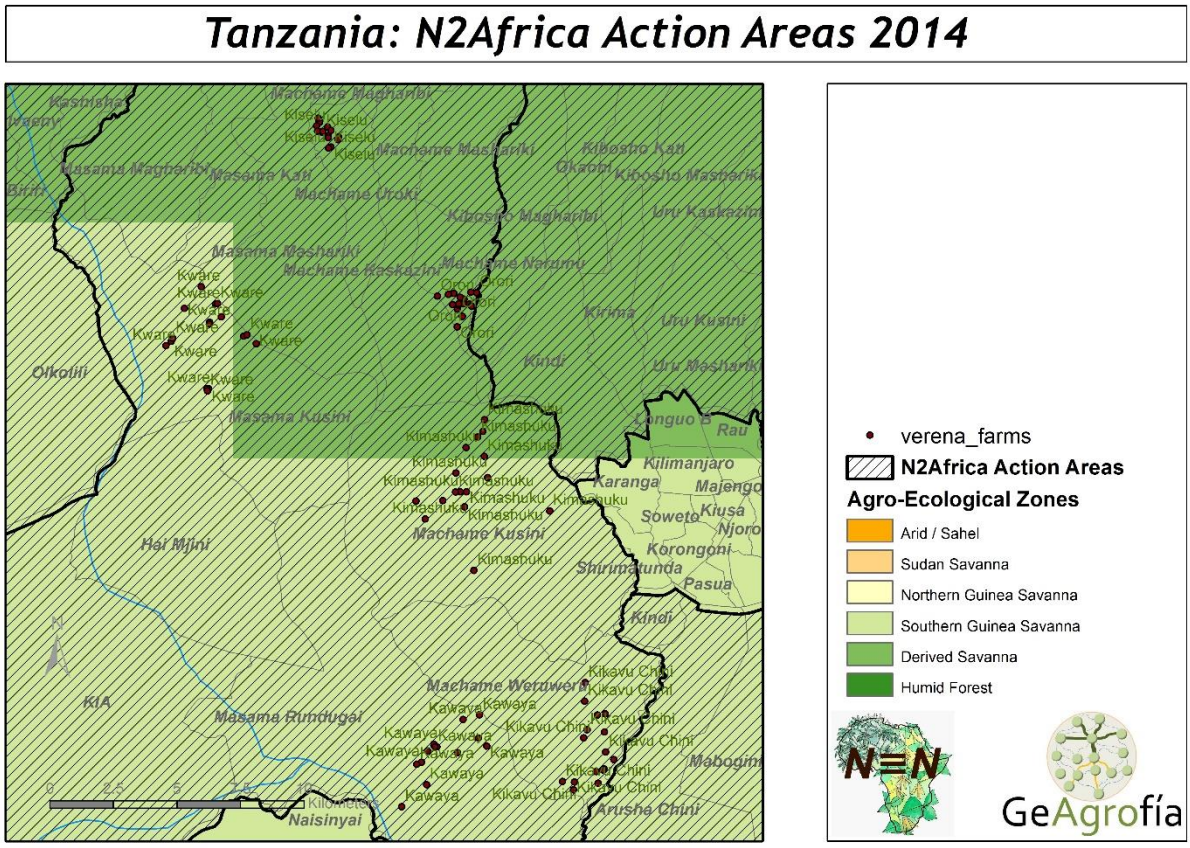
M.12. How would you like to improve the market value of your bean produce?

_____

_____

_____

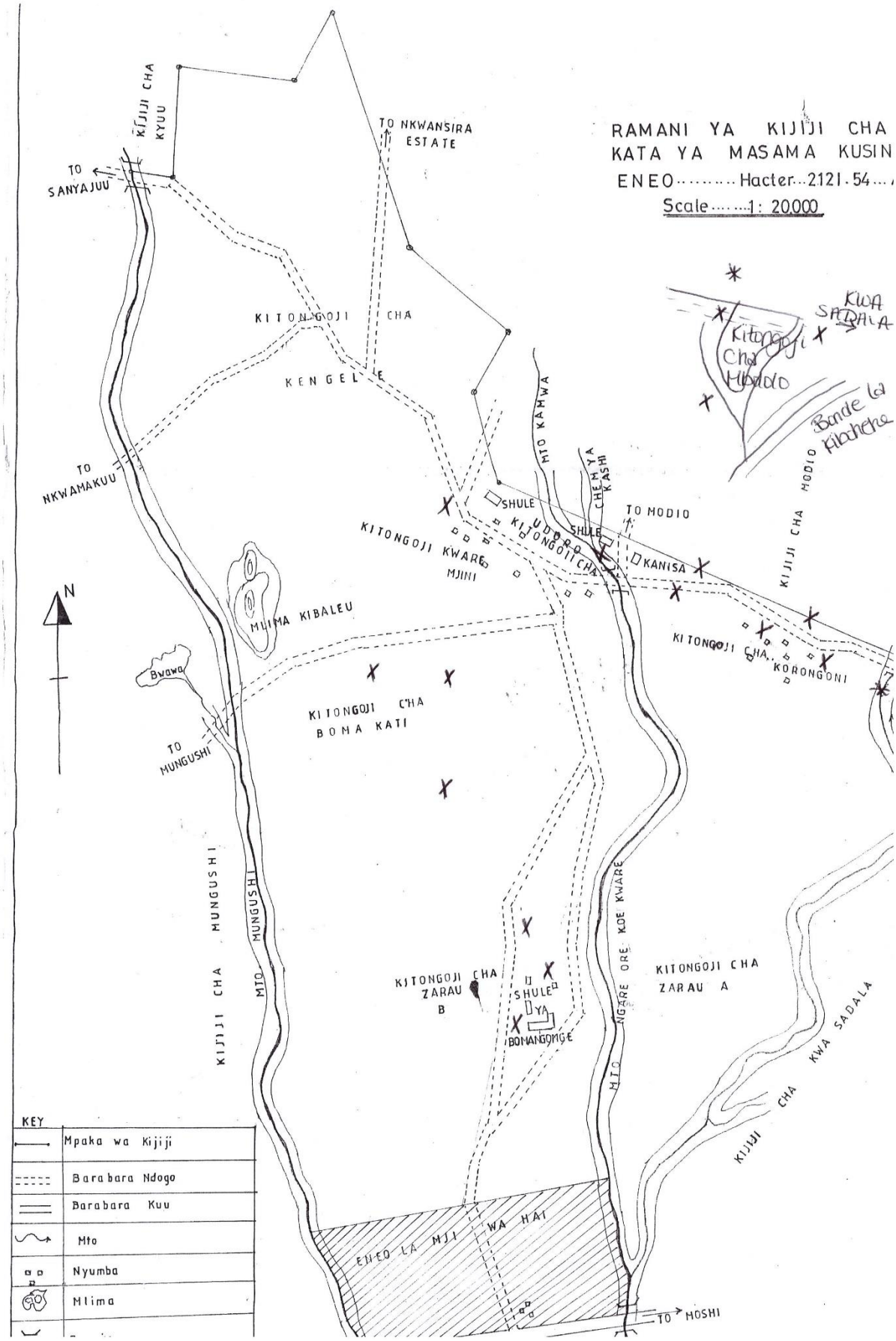
Appendix 8


Tanzania: N2Africa Action Areas 2014
verena_farms
N2Africa Action Areas
Agro-Ecological Zones
Arid / Sahel
Sudan Savanna
Northern Guinea Savanna
Southern Guinea Savanna
Derived Savanna
Humid Forest
GeAgrofía
Machame Magharibi
Machame Mashariki
Machame Uroki
Machame Kaskazini
Machame Narumu
Machame Kusini
Machame Wetuwero
Masama Magharibi
Masama Mashariki
Masama Kati
Masama Kusini
Masama Rindugai
Kibosho Kati
Kibosho Magharibi
Kirima
Uru Kusini
Uru Mashariki
Kiruri
Kiseriu
Kware
Kimashuku
Kikavu Chini
Kawaya
Hai Mjini
Kilimanjaro
Karanga
Majengo
Soweto
Kiusa
Njoro
Korongoni
Shirimatunda
Pasua
Kinoi
Mabogini
Arusha Chini
Naisinyai
Olkolili
KIA
Kilometers

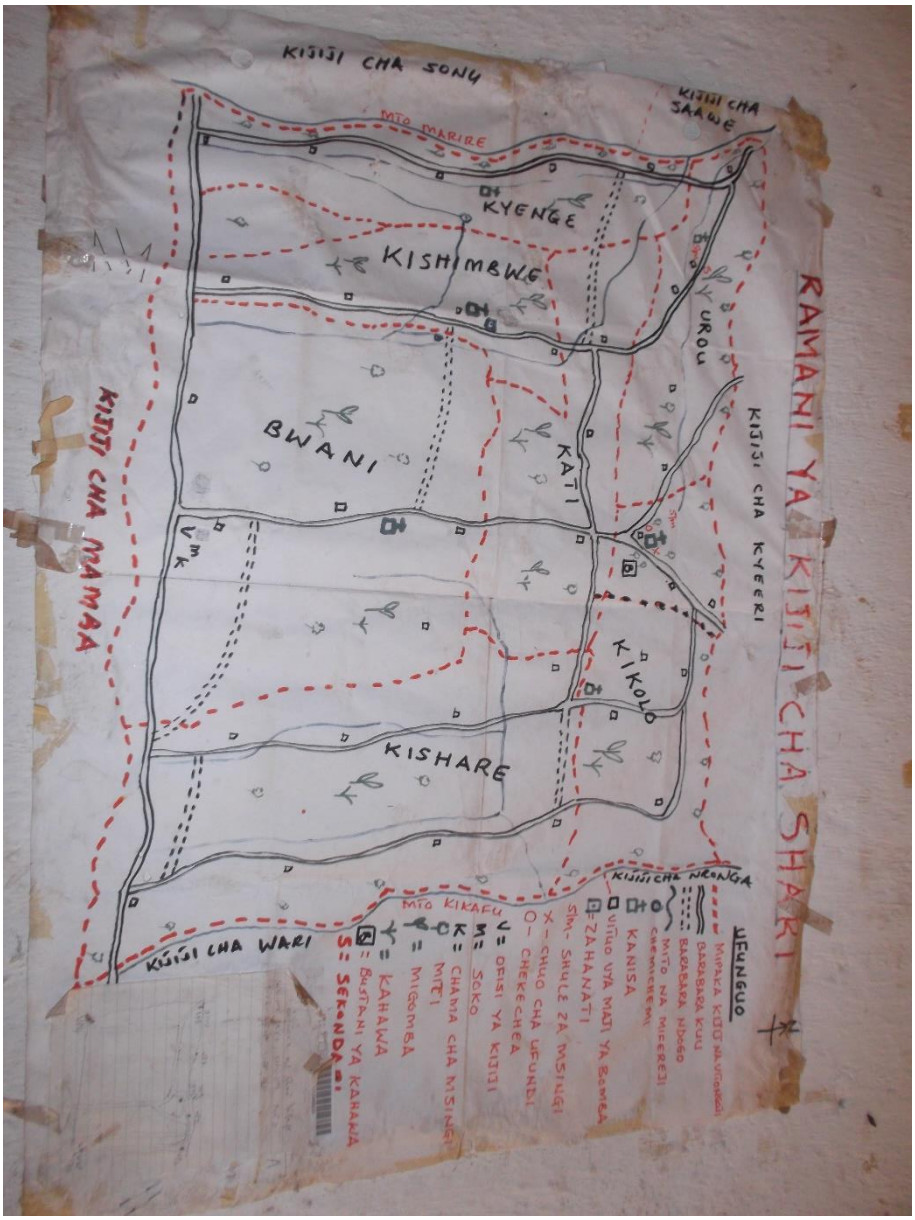
Appendix 9

A. Kikavu Chini Village

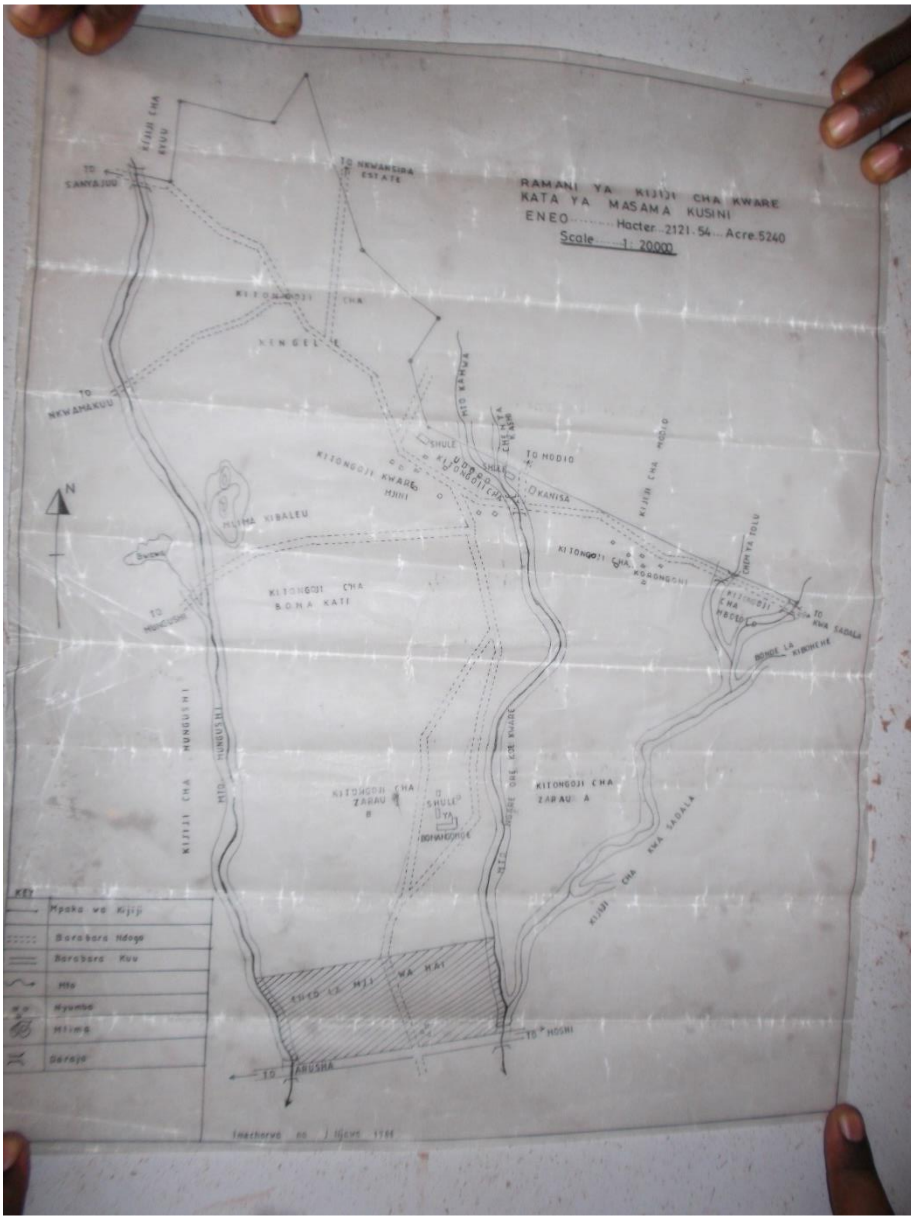
B. Kimashuku Village



C. Kiselu Village



D. Kware Village



E. Orori Village