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Climate Change Mitigation in Tanzania: Agricultural Production Systems in Njombe

Work Report from a Study in a High Altitude Farming Area

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Preface

In Tanzania, agriculture, including forestry, livestock and fisheries, is the main source of livelihood for more than 83% of the poor who live and work on the land. Agriculture is almost entirely driven by smallholder farmers still depending on the hand hoe, traditional rain-fed agriculture, and animal husbandry practices. It is characterized by limited access to and participation in input and output markets, extension services; access to knowledge, information and financial services. Women account for more than 70% of the agricultural production especially food crops, and they play an important role in the efforts to transform Tanzanian agriculture. Productivity of agriculture remains low compared to Asia and Latin America. Frequent droughts and unreliable rainfall patterns aggravate food and livelihood insecurity for the majority of the rural population and the urban poor. If agriculture becomes more productive, pressure on forest resources may decrease. Studies to compare different farming systems, both traditional and more innovative or productive ones, with respect to profitability for farmers and food production efficiency are highly needed.

Another challenge of the 21st century is climate change. The accumulation of greenhouse gases (GHG) such as carbon dioxide (CO_2) in the atmosphere promotes global warming (IPCC 2007). The burning of fossil fuels is estimated to contribute to about 80% of the GHG emissions while land use and land cover changes, especially deforestation and degradation of forests, contribute to the rest (Stern 2007). Tanzania is endowed with different ecosystems and a variety of ecosystem services. The vulnerability of these services and to what extent they will be impacted by climate change is not well known.

Currently two Norwegian-initiated and financed programs are undertaken in Tanzania: i) Enhancing Pro-poor Innovations in Natural Resources and Agricultural Value Chains (EPINAV) and ii) Climate change Impacts, Adaptation and Mitigation (CCIAM). The objective of EPINAV is to address up-scaling of proven technologies and promote adaptation of agriculture and natural resources to the effects of climate change. The work in CCIAM focuses on promoting natural forest conservation, afforestation, reforestation and better agricultural practices for improved livelihoods related to the “Reduced Emissions from Deforestations and Forest Degradation (REDD)” initiative. Studies on how the different ecosystems and associated ecosystem services will be impacted by climate change are also undertaken.

This report is written to describe the current farming situation in Njombe, one of the study areas for the two programs above. Through collaboration between farmer groups, Sokoine University of Agriculture (SUA) and Norwegian University of Life Sciences (UMB), on farm-research for sustainable production systems has been undertaken over a decade in Njombe. The report will be a basis for studies of changes in the farming systems both with respect to profitability to farmers in the area and their effects on GHG emissions. Similar studies are also planned for other parts of Tanzania.

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1 Introduction

1.1 Background and purpose

Njombe, which is a region in a high-altitude farming area located in the Southern Highlands of south-western Tanzania, is situated along the main road running from Dar es Salaam at the coast in the east to Zambia and Malawi in the west and southwest. Njombe Town, which is the regional centre, is located about 700 km from the commercial capital of Dar es Salaam, and about 100 km from Lake Malawi in the southwest.

Tea estates and forests plantations are important for the Njombe region. The tea is processed locally for international markets. The region also has significant timber plantations and supplies timber and electricity poles to other parts of Tanzania as well as to neighbouring countries. Njombe is also an important region for gaming. The largest game reserve is the Mapanga-Kipengere Game reserve. The reserve covers an area of 1,574 square kilometres. The reserve is also an important water catchment area to several rivers that feed into the Great Ruaha River.

Most people in Njombe are employed in subsistence farming and livestock keeping. The main agricultural activities in the area are cultivation of food crops, especially maize and Irish potatoes. The Njombe region is one of Tanzania's largest producers of Irish potatoes, maize and partly also beans. Maize and Irish potatoes are both cultivated for household use and sale. Livestock keeping, mainly dairy cattle; is also common in Njombe. The largest populations are still the traditional local breeds. However, exotic breeds are gaining in importance in the region. The milk is both used for home consumption and sale. The herds are small, and milk yield per cow is generally low. Farmers are able to carry the milk, eventually using a bicycle, to a collection point from where it is delivered to the dairy factory in Njombe town. Most farmers also keep a few hens mainly for home consumption, and some keep a few pigs or local East African goats for meat and manure. On marginal agricultural land, pasture areas and land previously not utilized by farmers, planting of fast-growing tree species, mainly pine and eucalyptus for sale is also common.

The purpose of the study is to describe and examine the productivity of different farming systems in the Njombe area. Studies of opportunities and pathways for agriculture growth will also be discussed as well as farm level limitations to growth. In particular, challenges related to climate change and farm level mitigating measures such as tree planting, and intensification of agriculture by improving animal or crop yields will be dealt with.

1.2 Study area

The study was undertaken in three villages; Magoda, Kichiwa and Ibumila. Magoda is located 15 kilometres away from the main centre of Njombe town, while Kichiwa and Ibumila are located about 49 and 43 km, to the northwest of Njombe Town (Figure 1).

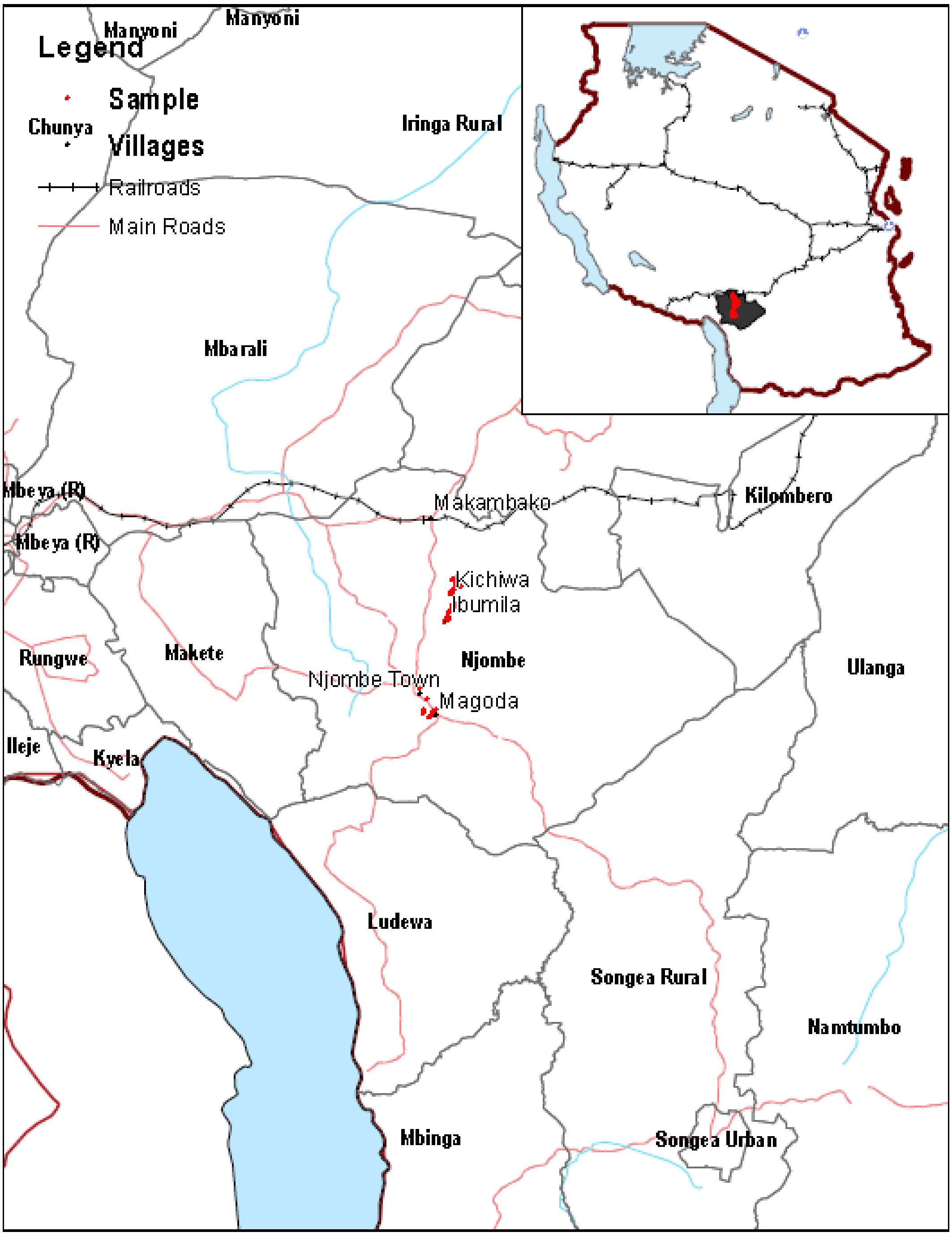

Fig. 1. Map of the study area with the Kichiwa, Ibumila, and Magoda villages

1.3 General sample characteristics

Pre-study, village meetings were held at each of the three study sites. The farmers who attended the meetings were first informed about the purpose of the study. Afterwards, in collaboration with local authorities and village leaders, 20 households from each village were selected for detailed household interviews. In the selection of farmers for the interviews, inclusion of a variety of production systems was emphasised.

Due to this procedure, involving selection of voluntary households for interviews, the material may not be representative for the farming systems in the area or in the three villages. The sample may, however, represent farmers interested in farming and farm development in the area, i.e. active farmers where the head of the household has the main responsibilities for sustaining a rather large household. Such farmers might be the early adopters of new technologies, a target group for agricultural interventions, and of particular importance for promoting agricultural growth in the area.

The interviews were carried out in June 2012. All in all, 60 interviews took place in 19 days; 4-5 interviews per day. The head of each household was interviewed, and the total sample consists of 60 households, that is 20 households from each of the three villages; Magoda, Kichiwa and Ibumila. In total there were 26 male and 34 female respondents (table 1).

Table 1: Characteristics of the respondents, education level

Respondents	No formal education	Primary level (7 yrs)	Secondary level (O-level)	Sum
Male	0	23	3	26
Female	6	28	0	34

Out of the 26 male headed households, three household heads had completed secondary O-level education whereas the other 23 had primary education, only (table 1). As for the female headed households, six had no formal education and 28 had completed primary level education. The average age of the respondents was 48 and 42.5 years for male and female farmers, respectively. The average household size was 5.1 persons.

1.4 Agricultural and forest land

Average farm area, defined as the area that the farmers are currently cultivating, was 1.0 ha in the three villages. The size of the agricultural land does not differ significantly between the three villages, ranging from 0.8 ha in Magoda, 0.9 ha in Ibumila, to 1.2 ha in Kichiwa (table 2). However, in Kichiwa one large farm was 10.1 ha. Excluding this farm, the average farm size was 0.73 ha in Kichiwa. In Magoda and Ibumila, the largest farms were 2 and 2.4 ha, respectively.

Table 2: Average farm size, cultivated area and forest land

Village	Cultivated area, ha (Min, Max)	Farm forest, ha (Min, Max)
Magoda	0.8 (0.1 – 2) (N=20)	1.5 (0.4-2.8) (N=9)
Kichiwa	1.2 (0.1 – 10.1) (N=20)	2.1 (0.1-10.1) (N=16)
Ibumila	0.9 (0.1- 2.4) (N=20)	8.3 (0.4-53.4) (N=19)
Overall average	*1.0 (0.1-10.1) (N=60)*	*4.5 (0.1-53.4) (N=44)*

In the table, forest is defined as the area where pine, eucalyptus or black wattle is planted. The average forest size for Magoda, Kichiwa and Ibumila was 1.5, 2.1 and 8.3 ha, respectively, with an overall average of 4.5 ha per household. The size of the farm forests was highest in Ibumila and the largest forest (53.4 ha) was also located in Ibumila. However, when excluding this plot average forest size was still 6.9 ha.

The agricultural area is very fragmented. The average number of plots per household for the agricultural land was 2.7. The walking distance from the household to a farming area plot is, on average, 18 minutes one way (table 3).

Table 3: Characteristics of the farming area in the three Njombe villages (Min and Max)

Farm characteristics	Magoda (N=20)	Kichiwa (N=20)	Ibumila (N=20)	Average (N=60)
Plots per household	2.4 (2-3)	2.7 (1-3)	2.9 (1-3)	2.7
Cultivated area per plot, ha	0.8 (0.1-2.8)	1.2 (0.1-10)	0.9 (0.1-3.2)	0.9
Crops per plot	1.7 (1-3)	1.9 (1-4)	1.9 (1-4)	1.8
Walking distance, minutes	23 (0-90)	15 (1-90)	17 (1-120)	18

Plots per household do not differ significantly among the three villages. The average size of a plot is around is 0.9 ha. Regarding the number of crops per plot the average was 1.7 crops in Magoda and 1.9 in the Kichiwa and Ibumila village. Households often plant more than one crop per period, on average 1.8, within the same plot. Looking at the minimum and maximum values will give us a broader picture of the agricultural system. Farmers in Magoda planted up to 3 crops per plot whilst those in Kichiwa and Ibumila plant up to 4 crops per plot.

In table 4 below, the same overview is presented for the farm forest area.

Table 4: Characteristics of the forest land in the three Njombe villages (Min-Max)

Farm characteristics	Magoda (N=9)	Kichiwa (N=16)	Ibumila (N=19)	Average (N=44)
Plots per household	1.4 (1-2)	2.1 (1-3)	1.6 (1-3)	1.7
Tree species per plot	1 (1)	1.4 (1-3)	1.2 (1-3)	1.2
Walking distance, minutes	47 (3-120)	26 (1-120)	17 (3-120)	39

Farmers with woodlots are found in all the three villages. In Magoda less than half (45%) of the villagers are planting trees whilst 16 out of 20 households in Kichiwa (80%) and 19 out of 20 in Ibumila (95%) are planting trees. Farmers in the sample from Kichiwa and Ibumila have 2.1 and 1.6 plots with trees per household compared to 1.4 in Magoda. Farmers in the sample from Magoda also have only one tree species and have a longer walking distance to their tree plots.

2 Farming activities

The farming activities in the area can be divided into four main groups; 1) Cultivation of different kinds of vegetables, food and feed crops, for sale, home-consumption, or for animal feed 2) Growing fruit, multipurpose trees and pasture[1] for sale, self-sufficiency or for animal feed, 3) Planting trees for timber and 4) Livestock keeping for sale or self-sufficiency. Much activity is due to feeding the animals forage crops, and pasture as well as the leaves

[1] The pasture system is a kind of zero grazing (cut and carry system) where the grass is cut and brought to the animals each day. We use the term pasture for this activity throughout the report.

and branches of fodder trees, crop residues or residues from processing of oil, including also feeding with purchased concentrate feedstuff.

2.1 Cultivation of vegetables, food and feed crops

The average distribution of the different food and feed crops in the farming households is shown in table 5. All crops were not cultivated by every farmer and only farms with the crop in question were included when calculating the averages. Crops can be grown in the same field once, twice or three times per year. Here, we have recorded annual area.

Protein rich vegetable crops like beans and sunflowers are not commonly grown in Magoda. In fact, no beans were cultivated by the farmers in the sample from Magoda, and only one household was cultivating sunflower (0.2 ha annually). In Kichiwa, four households were cultivating beans (12.9 ha in total) and three households had sunflower (4.3 ha in total). In Ibumila, two households produced beans (2.4 ha in total) and one household had sunflower (0.4 ha). Farmers usually use the sunflower to extract oil for cooking, and leave the protein rich cakes for the animals. Sunflower oil is also an important source of fat for humans and also rich in polyunsaturated fatty acids which are beneficial for human health.

Only minimal cultivation of Chinese cabbage and tomatoes were observed in the villages. Only one household were cultivating Chinese cabbage (0.2 ha in Magoda) and one household stated to cultivate tomatoes (0.6 ha in Kichiwa). Chinese cabbage and tomatoes may both be important sources for fibre and vitamins. There may, however, be some vegetables not included in this study such as carrots, cultivated in small plots in a home garden (kitchen garden) and used entirely for home consumption by the household. We did not inquire about kitchen gardens in the households.

Table 5: Average size of crop area, annual ha per farm according to village

Village	Protein crops		Vegetables*		Carbohydrates*			
	Beans, N-fixing	Sun-flower	Ch. cab.	Toma-toes	Maize	Irish potatoes	Sweet potato	Wheat
Magoda	-	0.2 (N=1)	0.2	-	0.9 (N=20)	0.9(N=17)	-	2.4
Kichiwa	3.2(N=4)	1.4 (N=3)	-	0.6	1.3 (N=20)	1.1(N=10)	0.8	-
Ibumila	1.2(N=2)	0.4(N=1)	-	-	0.9 (N=20)	1.4 (N=7)	-	-
Average	*2.6(N=6)*	*1(N=5)*	*0.2*	*0.6*	*1.0 (N=60)*	*1.3(N=34)*	*0.8*	*2.4*

*N=1 for Chinese cabbage, tomatoes, sweet potatoes and wheat.

The most common crops cultivated in the area are maize and Irish potatoes. All farmers sampled in the three villages grow maize (N=60) and a majority also cultivated Irish potatoes (N=34) for home-consumption and sale. Total area for all the tree villages was 102.5 ha of maize and 43 ha of Irish potatoes. Average plot size is 1 ha for maize and the average maize area per household is 1.7 ha annually. The number of times a crop can be harvested will depend on the local conditions, maize typically takes six months from seeding to harvest while Irish potatoes take around four months.

Sweet potatoes and wheat are less common, only one farmer in Magoda produced wheat (2.4 ha) and one farmer in Kichiwa grew sweet potatoes (0.8 ha).

2.2 Growing fruit, multipurpose trees and pasture

The area used for fruit trees did not differ significantly among the villages (table 6). The most common fruits were guava and bananas. The total number of fruit gardens in the Magoda sample was 14, they were owned by 11 farmers, and the average size of the gardens was 0.6 ha. For the Kichiwa village sample, there were eight fruit gardens owned by seven farmers. Average size of the holdings was 0.6 ha. In Ibumila, there were only five individual farmers who owned six fruit gardens with an average size of 0.5 ha. Fruits are cultivated mainly for sale, but some of the produce is also for home consumption while leftovers and crop residues are used as feed, especially for pigs.

Cultivation of pasture was uncommon until a few years ago when it was introduced by researchers from SUA[2]. Today it is quite common, and 47 of the 60 interviewed farming households (78%) reported they cultivated such pastures. The most common pasture species found are Napier grass and *Pennisetum spp*. Most pasture plots are utilized with 3-4 harvests per 12 months. Hence, plots set aside for pasture and for fodder trees are more or less to be considered as permanent grass- and forest lands, although pastures can be on a rotational basis. Cultivation of pastures are for most farmers done by transplanting[3] whereby farmers collect grass from communal lands and plant this onto their own plots. This can make establishment of pastures quite labour-intensive, but on the other hand there are no other input costs involved in such pasture cultivation. The transplanting is only necessary before the first rotation and after that only when repairing damaged or thinned parts of the grass sward.

Table 6: Average area of fruit, transplanted pasture or fodder trees for animal feeding, ha.

Village	Fruit trees	Pasture	Fodder trees
Magoda	0.6 (N=11)	0.6 (N= 12)	-
Kichiwa	0.6 (N=7)	1.2 (N= 17)	0.4 (N= 2)
Ibumila	0.5 (N=5)	0.8 (N= 18)	0.6 (N= 9)
Overall average	0.6 (N=23)	0.9 (N=47)	0.5 (N=11)

The fodder trees, sometimes called multipurpose trees, are species such as *Leucaena Leocephala*, *Calliandra spp* and Mulberry. They are cultivated primarily for animal feeds. This was not so common in the villages only 11 out of 60 households (18%) reported cultivation of fodder trees. None of the 20 households in Magoda and only 2 in Kichiva (10%) reported they had fodder trees. The farmers prune the fodder trees, and take off the leaves for drying. After 1-2 days in the sun they can be fed to the dairy cows as an important source of protein. The leaves can also be stored for feeding later. The leaves may also be an ingredient in concentrate mixture feedstuffs. The leaves can also be fed fresh together with the bark and thin branches. This system is particularly beneficial for goats. Most leaves of fodder trees are protein rich and the fodder trees may also provide nitrogen for the soil since they

[2] Introduced in the PANTIL (Program for Agricultural and Natural Resources Transformation for Improved Livelihoods), a collaborative program between SUA and UMB and Norwegian College of Veterinary Sciences (NVH), 2005-10.

[3] Vegetative reproduction (vegetative propagation, vegetative multiplication, vegetative cloning) is a form of asexual reproduction in plants. It is a process by which new plants arise without production of seeds or spores. It can occur naturally or be human-induced (horticulture).

have N-fixing bacteria in root noodles. A question is whether extended cultivation of fodder trees could be beneficial to the dairy farmers in Njombe.

The fodder or multipurpose trees have a range of additional benefits such as providing shade for the ground and animals as well as serving as windbreaks and for erosion control. Stems and branches provide timber and fuel-wood, while roots, leaves, flowers and bark may be used for medicinal purposes. In areas where the rainfall is low and/or irregular, grasses fed to animals may be low in both quantity and quality in the dry season, and more fodder trees could help to level out such irregularities. Fodder trees are permanent and can be used in both the rainy and dry seasons. Branches will re-sprout after pruning. They can be planted either in groups or scattered around the farm, and are particularly common near to the house and are used to shield crops vulnerable to wind damage.

In the households keeping dairy cows, a zero-grazing system is normally practised in which animals are kept inside a well-ventilated barn i.e. a cowshed with a holding-ground for the animals to exercise. In the rainy season farmers cut the grass and feed it fresh to the cattle. Some households also produce hay during the rainy season for use in the dry season. This requires cutting, drying and storing the hay at the farms. Definitely increasing haymaking in the rainy season should be considered to encounter a fodder deficit, which can easily occur in the dry season particularly if it is long lasting. Crops and/or residues from maize, Irish potatoes, fruits and sunflower are used for animal feeding. Although most farmers stated that they feed some of the crop residues to animals, only one household was able to quantify the amount. This was estimated to 3000 kg and was mainly from maize residues over a period of 12 months.

In contrast to dairy cows, the local cattle are generally not kept in a barn, but in a 'kraal'. They are thus grazing and not fed pasture or leaves from the fodder trees. However, they may pick up some crop residues in the fields if allowed. The local East African Goats are kept for meat only. The goats are often grazed and roam freely together with the local cattle and receive no supplementary feeding. They are kept inside a 'kraal' or tied up to a tree (tethering) when not freely grazing. Pigs are kept in 'kraals' while hens in general are free ranging in small flocks kept around the farm family house. For the households with larger flocks, hens are kept inside a shed with access to feed and water.

The protein from the sunflower is used by animals and they are also fed residues from sunflower oil processing. Sunflower oil cakes are also bought and used as protein source. Pigs are often fed leftovers from fruit production and 23 out of 60 households had fruit trees. Other crop residues are more commonly left at the field to be utilized by grazing animals. Residues left in the field provide shelter and moisture for the soil and such practice is considered an important element of conservation agriculture.

2.3 Forest production activities

Pine, Eucalyptus and Black Wattle are the common tree species planted in Njombe and bordering regions. Pine was the most commonly planted tree species in the sample. In Magoda all the forest area is used for Pine and the recorded average area of Pine corresponds with the average total forest areas in the village (table 2). The Magoda farmers still have less pine than the others. In Kichiwa and Ibumila, some farmers also grow Eucalyptus and Black Wattle (table 7).

Table 7: Average size of area with planted tree species, ha.

Village	Pine	Eucalyptus	Black wattle	Sum
Magoda	1.5 (N=9)	-	-	1.5 (N=9)
Kichiwa	2.4 (N=14)	1.8 (N=10)	2.1 (N=7)	2.1 (N=31)
Ibumila	10.9 (N=17)	2.1 (N=7)	1.2 (N=2)	8.3 (N=26)
Overall average	6.2 (N=40)	1.9 (N=17)	1.8 (N=9)	4.5 (N=66)

Both pine and eucalyptus are widely known as fast-growing tree species, which are mainly used for wood products such as transmission poles, construction material, doors and furniture products. Compared with the other two villages, farmers in the sample from Ibumila kept more forest, in particular pine and eucalyptus. The farmers from Kichiwa had the largest plots of the black wattle tree, which is used mainly for charcoal production.

The most common variety of Pine planted is the *Pinus patula*. Pine is vulnerable to fire and the risk of a devastating wildfire in the area should not be underestimated. In general the risk is lower or damage can be limited if smaller areas can be kept separate compared with large connected areas. Farmers with larger forests have also established fire lines around the property in order to reduce the risk of damage when a wildfire or accidental fire occurs. Corridors without vegetation between the plantings are also helpful. According to Evlagon *et al*., (2011) it is possible to lower the risk of wildfire by using goats to browse the under vegetation in pine stands, woody vegetation - dwarf shrubs, shrubs and re-growing native trees – vegetation that is generally avoided by sheep and cattle and so grows undisturbed, creating an ever-increasing fuel load. This opportunity has not been examined in the area.

2.4 Livestock activities

The average number of livestock in the villages was 2.9 dairy cattle, 6 local cattle, 3 meat goats, 2.9 pigs, and 28 chickens. Village breakdown is shown in table 8.

Table 8: Number of livestock animals in each village (Min, Max)

Village	Dairy cattle	Local cattle	Meat goats	Pigs	Poultry
Magoda	3.7 (1-9) (N=20)	13 (13) (N=1)	-	1.2 (1-2)(N=6)	9 (3-23)(N=13)
Kichiwa	2.1 (1-6)(N=20)	4.7 (3-9) (N=13)	3(1-5) (N=5)	5 (1-15) (N=5)	38 (6-305) (N=18)
Ibumila	2.9 (1-7)(N=20)	7.1 (2-15) (N=10)	-	3 (1-6) N=3)	31 (3-300) (N=19)
Average	2.9 (N=60)	6 (N=24)	3 (N=5)	2.9 (N=14)	28 (N=50)

This part of the Njombe region is a dairy area where there is a more urbanised market and a milk factory in Njombe Town. All farmers in the sample had dairy cows, but several had only one. The questionnaire does not capture specific data regarding the young cattle stock aged between six months to two years. At the most, 9 dairy cattle were found in one household (in Magoda). The largest herds of dairy cattle are found in Magoda, which is located nearest to Njombe town, 3.7 heads on an average. Kichiwa and Ibumila have a lower number of dairy cattle, 2.1 and 2.9 respectively. The dairy cattle mainly originate from Ayshire and Holstein cows brought into the area in the 1950s and 60s as well as more recent import of semen, mainly of the Holstein-Friesan breeds. In-breeding is a major problem for the dairy industry in the area, more widespread use of semen should be considered as it could counteract that and also increase the milk yields.

Farmers in Kichiwa and Ibumila on the other hand had a higher number of local cattle. In Magoda, only one farmer kept local cattle. The local cattle are grazing during day-time and kept in an enclosure during the night. Supplementary feeding is seldom practised for local cattle. Milk yield per cow is low for the local cows and they are only milked during the rainy season. Local cattle produce meat and are also commonly used by the pastoralist Masaai people. Pastoralists are quite common in Tanzania although less so in the Njombe area. Due to the reliance on grazing of the natural vegetation and a lack of supplementary feeding, there is a considerable risk of a feed deficit during the dry season for the local cattle in particular. In the rainy season there can be plenty of grazing area available and too few animals to utilize all of it. A key question is how many local cattle animals farmers should try to feed through the dry season. If the dry season becomes long lasting some of the cattle may die and that will have devastating effects on the economy. More animals can be fed if the dry season is short or if additional feed can be provided. Improved decision making regarding these issues is an area worth exploring.

In general there are very few local East African Goats in the area; only in Kichiwa a few flocks were found. The management system is similar to that of local cattle, but the goats are not milked. Pigs are common on farms in the area, but only 14 of the interviewed stated they kept pigs. Pigs are more common in Kichiwa, although pigs are found in all three villages. Average number of pigs was 1.2 in Magoda and 3 in Ibumila. In Kichiwa the average was 5 but excluding one farmer with 15 pigs the average in that village is close to the other villages. Pigs are kept in similar constructions as the dairy cattle; simple wooden structures or sheds.

In all villages most farmers have poultry animals, in total 50 of the 60 households and nearly all farmers in the Kichiwa and Ibumila villages, kept poultry animals. Nearly all farmers in Kichiwa and Ibumila villages had a larger number of broiler chicken compared to Magoda. Some farmers seem to have specialized somewhat in egg and broiler production keeping flocks with more than 300 poultries. The farmers with larger flocks may have constructed special chicken-houses with food and water stations as well as lighting. As for other farmers most keep a few hens which are generally allowed to go anywhere on the farm.

3 Crop inputs and yields

3.1 Use of inputs according to crops

In table 9 inputs for the different crops in a rotation, from land preparation to harvest and transport to the market are presented. It was difficult to find reliable information on the use of purchased inputs like seeds, fertilizers and herbicides in the different cropping systems, in particular for crops that are cultivated by a few farmers only.

Table 9: Average use of inputs for different crops

Input	Protein crops		Vegetables	Carbohydrates	
	Beans, N-fixing	Sunflower	Tomatoes	Maize	Irish potatoes
Plot size, ha	2.6 (N=6)	1.0 (N=5)	0.6 (N=1)	1.0 (N=100)	1.1 (N=39)
Seeds, kg	84 (N=6)	4.9 (N=4)	0.1 (N=1)	14 (N=100)	679.5 (N=39)
Manure, kg	210 (N=1)	221 (N=3)	1000 (N=1)	2118 (N=53)	48 (N=2)
Urea, kg	25 (N=1)	-	-	63 (N=90)	49 (N=24)
DAP*, kg	36 (N=4)	12 (N=2)	100 (N=1)	66 (N=38)	72 (N=35)
CAN**, kg	-	-	-	25 (N=6)	37 (N=10)
Pesticide, ml	433 (N=3)	-	300 (N=1)	203 (N=97)	122 (N=10)
Fungicide, kg	1 (N=1)	-	5 (N=1)	0.4 (N=1)	16.3 (N=29)

*Di-Ammonium Phosphate **Calcium Ammonium Nitrate

The use of seeds reflects plot size and seed weight, but seem in general to be low compared to European standards. Manure is used on all crops but in small amounts, clearly the use of manure seems to be economized. Urea is regularly supplied for the maize (on 90 out of 100 plots) and Irish potatoes (on 24 out of 39 plots) and a few farmers also used CAN for these crops. One farmer also used small amounts of urea for beans which should take up N from the air. DAP is used on all crops, for Irish potatoes DAP was used on nearly all (35) out of 39 plots, and for maize it was used on 38 out of 100 plots. Pesticides were used for all crops apart from sunflower. Pesticides were used on nearly all maize plots. Fungicides are commonly used on Irish potatoes, by 29 out of 39 farmers (74%), likely against the *Phytophthora infestans* fungi, while not much fungicides were applied for maize.

One farmer reported cultivation of Chinese cabbage using 0.1 kg of seeds and 125 kg of manure on 0.2 ha of land. Sweet potatoes were only grown on one farm also, but the farmer was unable to specify any use of inputs. One farmer also reported production of wheat using 60 kg of seeds and 5 kg of DAP on 2.4 ha of land. Compared to European standards the amount of seeds was very low for wheat.

Among the farmers who planted fruit trees, the average number planted per farm was 58 trees (table 10). All farmers used manure but only one reported use of pesticide and fungicide on the fruit trees.

Table 10: Crop production and inputs – fruit, pasture and fodder trees (Min, Max)

Input	Fruit trees	Pasture	Fodder trees
Plot size, ha	0.6 (N=28)	0.9 (N=53)	0.6 (N=11)
Amount of seeds, kg	18 (N=2)	32 (N=36)	-
Amount of seedlings, no	58 (3-200)(N=26)	-	276 (50-1200) (N=11)
Manure, kg	1 776 (N=28)	1 757 (N=43)	826 (N=11)
Urea, kg	-	23 (N=19)	-
DAP, kg	-	114 (N=5)	-
Pesticide, ml	200 (N=1)	350 (N=1)	-
Fungicide, kg	0.1 (N=1)	-	-

The values for pasture in table 10 may give a wrong picture of the amount of seed needed due to the fact that for 22 out of 53 plots (42%) the farmers stated that they saved seeds by more or less transplanting. These farmers could not state how much seeds they needed to plant any amount of pasture. We have not recorded the amount of material collected for transplanting. Most farmers (81%) provide manure to the pasture, but less manure to pasture than to fruit tree areas. Quite many (36%) also used Urea and five farmers (10%) also used DAP on the pasture areas. The applied amounts of Urea (containing about 46% N) are small, amounting to 10 kg of N per hectare, substantially less than standard rates for grassland N-fertilization.

Regarding the fodder trees, seedlings for establishment or replacement are needed. All farmers also used manure for the fodder trees, however in smaller amounts per ha than for pasture and fruit trees. No other inputs were provided to the fodder trees, this is in many ways a very simple production. No CAN was provided to fruit trees, pastures or fodder trees and only one farmer provided some pesticides or fungicides to fruit trees or pastures.

Normally, farmers buy and plant seedlings when establishing a pine or eucalyptus lot. Hence, the number of seedlings in table 11 reflects the size of the plots for pine and eucalyptus. For black wattle, farmers buy and disperse the seeds on the plot where they want to establish the lot. Black wattles are quite different from pine and eucalyptus. Black wattle is mainly used for fuel-wood and charcoal and for industrial use where the bark is extracted and processed for tanning of e.g. leather ware etc. The size of the biomass is important for the production of the tanning agent. Pine and eucalyptus on the other hand are used for timber products, timberworks and poles and need to grow straight to be suited for such products.

Table 11: Forest production and factor inputs for pine, eucalyptus and black wattle

Input	Pine	Eucalyptus	Black wattle
Plot size, ha	6.2 (N=47)	1.9 (N=18)	1.9 (N=10)
Seeds, kg	-	-	2.1 (N=10)
Seedlings	2 624 (N=47)	729 (N=18)	-
Urea, kg	2 (N=1)	-	-
DAP, kg	100 (N=1)	-	-
Pesticide, ml	500 (N=2)	-	-

In general when compared to agriculture not much input are used in forest planting. However small amounts of Urea, DAP and pesticides may be applied for the planting of pine while no farmers applied any manure, CAN or fungicide to the seedlings.

3.2. Value and prices of inputs in different crops

The variable costs for the crops production depend on the price of inputs and the amounts used on a specific crop. Table 12 depicts the costs of the individual inputs for each crop and the calculated total input costs per crop and per ha of each crop. Regarding the costs of manure most farmers were unable to come up with a cost figure as they use manure from the farming animals in their crop production activities. They may, however, purchase some manure in addition. The values are in Tanzanian shilling (TSH), 1 000 TSH roughly converts to 0.6 US dollar (USD).

Table 12: Values of factor inputs in the farm crop activities

Input	Protein crops		Vegetables	Carbohydrates	
	Beans N-fixing	Sunflower	Tomatoes	Maize	Irish potatoes
Plot size, ha	2.6 (N=6)	1.0 (N=5)	0.6 (N=1)	1.0 (N=100)	1.1 (N=39)
Seed, TSH	633 (N=6)	1 180 (N=5)	250 000 (N=1)	139 (N=100)	304 ((N=37)
Manure, TSH	-	4 000 (N=1)	-	428 (N=8)	60 (N=1)
Urea, TSH	1 300 (N=1)	-	-	1 045 (N=91)	1 050 (N=24)
DAP, TSH	1 380(N=4)	1 320 (N=2)	1 500 (N=1)	1 305 (N=37)	1 370 (N=35)
CAN, TSH	-	-	-	883 (N=6)	992 (N=10)
Pesticides, TSH	2 000 (N=3)	-	3 500 (N=1)	1 597 (N=97)	2 100 (N= 10)
Fungicides, TSH	6 000 (N=1)	-	12 000 (N=1)	21 000 (N=2)	20 483 (N=29)
*Sum, TSH**	*11 313*	*6 500*	*267 000*	*26 397*	*26 359*
Costs per ha, TSH*	**4 351**	**6 500**	**445 000**	**26 397**	**23 957**

* Calculated as if all farmers used all inputs. Considering that most farmers do not use all inputs, costs would be lower.

The price for tomato seed is extremely high which makes the factor input costs for this crop sky high when compared to the other crops[4]. Other inputs in tomatoes are small by comparison. For wheat the costs is 800 TSH for seed and 1 400 TSH for DAP, in total 2 200 TSH or 906 TSH per hectare of wheat. Thus the amount of inputs in wheat production seems small. As for the Chinese cabbage (data not shown) the total input costs was 10 000 TSH for seeds and another 4 000 TSH for the manure, in total 14 000 TSH. The variable costs per hectare of Chinese cabbage amounted to 70 000 TSH. However, only one farmer in the sample cultivated Chinese cabbage, tomatoes or wheat.

Apart from the vegetables, Irish potatoes and maize have the highest variable costs per hectare, followed by the beans and sunflowers. Costs of fungicides constitute the major costs of potatoes in particular, while pesticides and urea are important for maize production.

The calculated costs of inputs for fruit trees, pasture and fodder trees are shown in table 13. The lowest annual cost per hectare is for fodder trees, which is only 121 TSH. We have only recorded costs of seedlings for the fodder trees. For fruit trees most farmers do not add any other inputs than seedlings but a few farmers also purchase manure to the fruit trees. Also we have one observation regarding Urea, pesticide and fungicide to fruit trees.

We have calculated overall average seed costs for all farmers with pasture thus the numbers in table 13 reflect the use of transplanting by some farmers. The seeding costs of pastures are lowered substantially using vegetative propagation however, the procedure requires more work. As for other inputs for the pasture area quite a few farmers (N=19) apply Urea to pasture and another five said they added DAP.

[4] Compared to special breed seed prices are still low, such seeds are produced in Tanzania and can reach prices of as high as US $ 0.25 per seed of tomatoes. http://allafrica.com/stories/201211270165.html

Table 13: Value of factor inputs in the fruit, pasture and fodder tree activities

Input	Fruit trees	Pasture	Fodder trees
Plot size, ha	0.6 (N=28)	0.9 (N=53)	0.6 (N=11)
Seedlings, seed TSH	1 835 (0-3500) (N=28)	3 915 (N=36)	73 (N=11)
Manure, TSH	527 (N=8)	50 (N=1)	-
Urea, TSH	900 (N=1)	1 045 (N=19)	-
DAP, TSH	-	1 600 (N=5)	-
Pesticide, TSH/ml	1 500 (N=1)	1 500 (N=1)	-
Fungicide, TSH	2 500 (N=1)	-	-
*Sum, TSH**	*7 262*	*8 110*	*73*
Costs per hectare, TSH*	**12 103**	**9 012**	**121**

* See footnote for table 12.

Dividing the total costs for pasture and fodder trees in table 13 by the size of the plots we arrive at a cost of 9 012 TSH/ha for pasture. As such, one hectare of pasture is less expensive than one hectare of maize. Also, we need to keep in mind that most farmers like to see that the use of manure in their crop production activities is met by supply by the farm animals and only costs of purchased manure is provided in table 13.

Below (table 14) is an overview over factor inputs for the forestry activities. It is important to note that none of the farmers had yet finished one forest rotation for pine and eucalyptus (12 years). Regarding the black wattle, farmers planted randomly and harvested whenever they needed firewood for home consumption or for sale. Thus the rotation for wattle trees was not as strict as for pine and eucalyptus that have a higher value when reached harvesting age. Rotation time is 10 years (full grown) for black wattle.

Table 14: Values of factor inputs in forestry activities

Input	Pine	Eucalyptus	Black wattle
Plot size, ha	6.2 (N=47)	1.9 (N=18)	1.9 (N=10)
Seedlings/Seeds, TSH	58 (N=47)	57 (N=18)	1 580 (N=10)
Urea, TSH	920 (N=1)	-	-
DAP, TSH	1 400 (N=1)	-	.
Pesticide, TSH	1 600 (N=2)	-	-
*Sum, TSH**	*3 978*	*57*	*1 580*
Costs per hectare, TSH*	**642**	**30**	**832**

* See footnote for table 12.

A few farmers used Urea, DAP or pesticides for the pine. Due to more extensive use of inputs in pine production the costs of pine amounted to 642 TSH per hectare compared to only 30 TSH for Eucalyptus where no farmers used any of these inputs.

The farm level input prices (min, max) for seedlings and seeds used in the tables 10-12 are: 1 581 (50 – 3500) TSH/seedling for fruit trees (N=26), 950 (300–1500) TSH/kg for beans (N=4), 606 (150–5 000) TSH/kg seed for maize (N=60), 304 (209–400) TSH/kg seed for Irish potatoes (N=37), 1 475 (200–3 700) TSH/kg for sunflower seed (N=4), 73 (20–300) TSH/seedling for fodder trees (N=11), 58 (30–100) TSH/seedling for pine and eucalyptus (N=44) and 756 (250–1 000) TSH/kg of black wattle seeds (N=9). The reported prices varied a lot in particular for maize, sunflower and seedlings for fruit trees.

Average price per kg for manure is 806 TSH (15–4 000) (N=9), 1 046 TSH for Urea (75-1 200) (N=59), 1 357 TSH for DAP (700–2 000) (N=48), 951 TSH for CAN (700–1 500) (N=10). Average price for pesticide (min, max) is 1 667 TSH/100ml (700–3 500) (N=59) and for fungicide 19 309 TSH/kg (1 500–40 000) (N=27). The price for purchased manure (dried) is very high, probably reflecting its value compared to other fertilizers. The maximum value was 4 000 TSH and excluding this value we end up with 407 TSH per kg of manure.

3.3 Crop yields and use of crops

At the farm level also the crop yields are surely difficult to record due to inaccurate measurement and assessment as well as losses at different stages of the process. The net yield can be used either for consumption by the farming household, sold or stored for use or sale in the following year. In our data only insignificant amounts of the maize crop was stored at the farm. The other crops were either consumed by the farming household or sold (table 15). In a situation where the crops can be harvested at least two times in a year that strategy can work, however not without increased risk of a food deficit due to a crop failure from time to time.

Table 15: Sum of yield and use of the yield according to type of crop

Yields and use	Protein crops		Vegetables	Carbohydrates	
	Beans N-fixing (N=6)	Sun-flower (N=5)	Tomatoes (N=1)	Maize (N=60)	Irish potatoes (N=37)
Plot size, ha	2.6 (N=6)	1.0 (N=5)	0.6 (N=1)	1.0 (N=100)	1.1 (N=39)
Production, kg	247 (N=6)	175(N=5)	600(N=1)	1 520 (N=100)	5 002(N=39)
Home consumption, kg	100(N=6)	80(N=5)	2(N=1)	511(N=76)	603(N=34)
Amount sold, kg	147(N=3)	95(N=3)	598(N=1)	1 010(N=82)	4 400(N=37)
Amount stored, kg	0	0	0	9(N=3)	0

In general we can conclude that farmers sell the largest share of the crop production, however substantial amounts are used by the farming family for home consumption or for feeding animals. When yields are low and the area limited much of the production has to be devoted to home consumption. Moreover farmers do not store much of their crop yields. There can be several reasons for this, such as lack of adequate storage facilities. Non-existing or inadequate storing facilities for the farm products may result in substantial losses. Lack of adequate storage facilities can also have great influence on the farming family's ability to feed themselves as well as taking advantage of higher prices in periods with food or forage deficits. However, since most crops can be grown two or three times in a year the need to store some of it in periods of surplus may not be recognized.

The farmer sells 1 kg of beans for 693 TSH, 1 kg of sunflower for 1 050 TSH, 1 kg of Maize for 262 TSH and 1 kg of Irish potatoes for 222 TSH. Staple food such as Irish potatoes and maize still tend to give higher incomes when sold than sunflower and beans when measured per ha. There are, however, relative few observations for beans and sunflower compared to maize and Irish potatoes. Moreover the costs are higher for potatoes and maize.

As for the other crops the recorded yields for Chinese cabbage is 20 kg out of which 10 were consumed by the household and 10 were sold, sweet potatoes 300 kg, sold 200 kg and consumed 100 by the household. For wheat the yield was 100 kg that was all used by the household. Only one household reported cultivation of Chinese cabbage, sweet potatoes and wheat in the sample. The reported yields per ha for Chinese cabbage and wheat were very low relative to the yield potential for such crops, and likely due to some stochastic influence.

The use of the fruit tree, pasture and the fodder tree yields are displayed in table 16. Regarding the fruits most of it (87%) is sold, the rest is used by the farming family or fed to pigs. Nothing was stored. The farmer expects to be able to sell 1 kg of fruits at the average price at 659 TSH, with a minimum price at 41 TSH and maximum price at 3000 TSH.

Table 16: Production and use of fruit, pasture, and fodder trees

Yield and use	Fruit trees	Pasture	Fodder trees
Plot size, ha	0.6 (N=28)	0.9 (N=53)	0.6 (N=11)
Crop production, kg	931 (N=28)	1 280 (N=53)	706 (N=11)
Home consumption, kg	121 (N=28)	1 076 (N=53)	679 (N=11)
Amount sold, kg	810 (N=28)	204 (N=53)	27 (N=11)

Naturally, a substantial share of the pasture and fodder tree production is for home consumption by farm animals and only minor amounts are sold. The yields of the pasture and fodder trees are fed directly to the animals. On the sampled farms nothing was stored. Clearly, both pasture and fodder trees can be harvested all time of the year. However in the dry season the availability of this feed may be limited due to drought and consequently a feed deficit may arise. Definitely storing some of the pasture yields for the dry season should be considered, this will require cutting and drying of the grasses as well as adequate storing facilities, as is currently practised by some livestock keepers.

For animal feed production, the farmer can sell 1 kg of grounded leaf meal (fodder flour) at 375 TSH (250 – 500 TSH) and 1 kg of raw pasture grass is valued at 153 TSH (20 – 400 TSH).

As for the forest products, the largest share of the forest production is sold. For pine and eucalyptus, < 10 % is used for home consumption e.g. simple construction and maintenance of farm house and fences while the remaining poles are sold either at the local market or transported to nearby larger markets where they can obtain a higher price per pole or sell in batches. The study shows that 93 % of the black wattle production is sold at the market as fuel-wood or charcoal.

The average market price for charcoal is 96 TSH/kg (50 – 142 TSH). Charcoal is normally sold in bags of 100 kg, but in remote villages it is possible to purchase smaller tins of charcoal. The average price for fuel-wood is 24 TSH/kg with min and max 10 – 60 TSH/kg. A kilo of black wattle timber is sold for 212 TSH. It is not known whether this is for pure timber or after burning it to charcoal. The latter is less likely. On the other hand, raw timber from black wattle is competing with other timber species.

Table 17: Forest production and use

Yield and use	Pine, poles	Eucalyptus, poles	Black wattle, kg
Plot size, ha	6.2 (N=47)	1.9 (N=18)	1.9 (N=10)
Production	2 007 (N=47)	569 (N=18)	20 350 (N=10)
Home consumption	450 (N=3)	33 (N=1)	2 840 (N=5)
Amount sold	2 214 (N=42)	535 (N=18)	18 930 (N=10)

Traditionally, black wattle is used for charcoal and tanning agent for leather production, but the raw timber from black wattle may also have other uses such as simple construction like fences since it is cheaper than buying poles from pine and eucalyptus. It is also less likely that a farmer would harvest pine and eucalyptus trees before they are fully grown as the market price is very high for well managed poles.

At harvesting age (12 years) one pole of pine is assumed to sell for 14 343 TSH while one pole of eucalyptus is sold for 18 972 TSH. These figures are estimates and as mentioned before, no farmer had yet completed a full rotation on the trees so the prices above reflects the market price for poles and hence are expected income per pole after the first harvest.

4 Work hours and costs of hiring workers

4.1 Work with crop production

To estimate how many hours each household spent on one crop rotation, the respondents stated the number of hours per man day and number of days they spent on the different crops. These are all estimates as the farmers found it hard to give exact figures on how many man days and how many hours were spent on each activity. The labour hours in the tables below (table 18 and 19) contain the sum of hours spent by the farming family and hired labour for three work periods, (1) land preparation, planting and fertilizing, (2) work in the growing season such as weeding, monitoring, watering and spraying, and (3) harvesting, transportation and other work.

The labour requirement for maize and Irish potatoes are almost similar 317 and 311 h/ha and considerably higher than for beans and sunflowers, 87 and 59 h/ha respectively. Potatoes seem to require more work on land preparation while maize require more on weeding/pruning. This can be due to the way cultivation of potatoes is conducted, farmers often use a kind of conservation technique agriculture for potatoes placing the seed potato in the bottom of a hole that have to be dug out. This technique will be advantageous for keeping water or moisture in the soil around the seed potato, but will require much work in preparation of the planting.

Table 18: Number of hours spent on cropping activities according to crop

Work* period	Activity	Protein crops		Vegetables	Carbohydrates	
		Beans N-fixing	Sun-flower	Tomatoes	Maize	Irish potatoes
1	Land preparation	96 (N=6)	10(N=5)	60(N=1)	59(N=100)	92(N=39)
	Planting/seeding	23(N=6)	5.5(N=5)	12(N=1)	39(N=100)	39(N=39)
	Fertilizing	11(N=6)	7(N=5)	6(N=1)	31(N=100)	32(N=39)
2	Weeding/pruning	50(N=6)	15(N=5)	12(N=1)	80(N=100)	63(N=39)
	Monitoring	2(N=6)	9(N=5)	1(N=1)	5(N=100)	5(N=39)
	Watering	3(N=6)	0.2(N=5)	3(N=1)	0.4(N=100)	3(N=39)
	Spraying	10(N=6)	0.1(N=6)	4(N=1)	16(N=100)	15(N=39)
3	Harvesting	24(N=6)	11(N=5)	275(N=1)	67(N=100)	93(N=39)
	Transport	7(N=6)	1.5(N=5)	6(N=1)	20(N=100)	0.1(N=39)
Hours in total		225(N=6)	59(N=5)	379(N=1)	317(N=100)	342(N=39)
Plot size, ha		2.6(N=6)	1.0(N=5)	0.6(N=1)	1.0(N=100)	1.1(N=39)
Hours per ha		86(N=6)	59(N=5)	632(N=1)	317(N=100)	311(N=39)

**Green: low labour intensity. Yellow: Moderate need for labour. Red: High need for labour.*

Farmers were also asked to state which work period was the most labour-intensive i.e. the period when the household often had to hire labour. Period 2 (coloured red) was clearly most often indicated followed by period 1 while period 3 was considered the least labour-intense period. Comparing this result with the hours in table 18 it is hard to justify why period 2 should be considered harder than 1. In general the time spent on monitoring and watering is small for all crops and also spraying is not always conducted. But the most important tasks in this period are weeding and pruning and they can be very hard tasks, particularly if there are several other tasks in this period. Moreover in this period plant growth is monitored and farmers have to adjust yield expectations in accordance with observations and this can be very stressful.

Only one household in the sample reported cultivation of tomatoes, Chinese cabbage, wheat or sweet potatoes. Tomatoes are the most labour intensive crop. Moreover, we can also see that the harvesting period requires most of the labour for tomatoes. Regarding the Chinese cabbage the amount of work was 62.5 h in total, out of which 12 h were spent on land preparation, 2 h on seeding and planting and 6 h on fertilizing (period 1), moreover 1 h on weeding or pruning, 40 h on monitoring and 1 h on watering in (period 2) followed by 0.5 h on harvesting (period 3). The sweet potatoes required in total 51 h, 14 h on land preparation and 14 h on planting (period 1), 14 h on weeding, and 1.5 h on monitoring (period 2) and in the final season 7.5 h on harvesting. As for the wheat we recorded 10 h for land preparation and 10 h for seeding (period 1), 0.5 h for monitoring (period 2). Most of the work with wheat is harvesting which required 54 h and transport another 2 h (period 3) making a total work 76.5 h. The use of work hours per hectare was calculated to be 313 h for Chinese cabbage (0.2 ha), 64 h for the sweet potatoes (0.8 ha) and 32 h for the wheat (2.4 ha).

The overall average wage rate for hired work in the study area was 564 TSH per hour with a minimum value at 250 TSH/hours and maximum value at 1 333 TSH/hour. The three villages do not differ significantly although there is a small gap; Ibumila have a wage rate at 436

TSH/hour whilst Kichiwa and Magoda have a wage rate at 618 and 665 TSH respectively. The distance to the town of Njombe is likely to be a factor influencing the local wage rate.

The work requirement for fruit and the crops specifically for feeding the animals pasture and fodder trees are shown in table 19. The specific work periods for pastures and fodder trees are related to stages in plant development, they can be planted, harvested and used in all seasons. Work period one that consists of land preparation, planting/seeding and fertilizing is the most labour intensive period for fruits while period three, harvesting, transport and other activities, are most laborious for the pasture and fodder trees.

Table 19: Number of hours spent on fruit, pasture and fodder trees

Work period	Activity	Fruit trees	Pasture	Fodder trees
1	Land preparation	54(N=28)	46(N=53)	14(N=11)
	Planting/seeding	19(N=28)	29.5(N=53)	8.5(N=11)
	Fertilizing	57(N=28)	18.9(N=53)	5.4(N=11)
2	Weeding/pruning	12(N=28)	67(N=53)	7(N=11)
	Monitoring	4(N=28)	2.4(N=53)	2.5(N=11)
	Watering	1.5(N=28)	0.4 (N=53)	0(N=11)
	Spraying	0.3(N=28)	0.4 (N=53)	0(N=11)
3	Harvesting	17(N=28)	78(N=53)	38(N=11)
	Transporting	1(N=28)	25(N=53)	4.4(N=11)
	Other activities	-	-	48(N=11)
Total	Hours spent on the crop	166.5(N=28)	268(N=53)	128(N=11)
	Plot size, ha	0.6(N=28)	0.9(N=53)	0.6(N=11)
	Hours per hectare	277.5(N=28)	298(N=53)	213(N=11)

**Green: low labour intensity. Yellow: Moderate need for labour. Red: High need for labour.*

Pastures are quite labour intensive when measured per hectare, close to that of maize and potatoes, whereas the fodder trees are simpler requiring least work when measured per ha. Much time is spent on other activities for the fodder trees which are mainly the amount of time it takes for the branches and leaves to dry in the sun before the farmer can make the grounded leaf-flour. The farmers spend 80 hours per ha on "other activities" which involves i. a. drying of the leaves before feeding.

4.2 Forestry work

Work with forests is shown in table 20. It is evident from the table that planting of trees for timber production, including preparation of the land, can be very labour-intensive. However, since land preparation, planting, as well as harvesting and transportation take place only once during a rotation, lasting 10-12 years, annual work will be lower.

The hours given for all activities related to farm woodlots are the total for a whole rotation which is assumed to be 12 years for pine and eucalyptus. Black wattle trees are normally harvested at 10 years of age when established for industrial purposes. However, the impression from farmers in Njombe is that they harvested black wattle trees whenever they needed fuel-wood. For simplicity, we assume 12 years rotation time for the three species.

The estimates regarding time for harvesting are rather uncertain as none of the farmers had yet completed one rotation or done a full harvest at the time when this study took place, and most of them just stated a number of hours per day and man days they expected harvesting would take them, assuming they would use a chainsaw. The farmers do not spend any time on fertilizing, spraying or watering the forest plantings for any of the species.

Table 20: Number of hours spent on planting operations for different tree species

Work period	Activity	Pine	Eucalyptus	Black Wattle
1	Land preparation	125(N=47)	38(N=18)	14.5(N=10)
	Planting/seeding	120 (N=47)	40.5(N=18)	15.6(N=10)
2	Weeding/pruning	112(N=47)	23(N=18)	30.4(N=10)
	Monitoring	259(N=47)	44(N=18)	3(N=10)
3	Harvesting	528(N=47)	79(N=18)	107.7(N=10)
	Transporting	88(N=47)	41(N=18)	124.3(N=10)
	Other activities	-	-	-
Total	Hours spent on the crop	1 239(N=47)	265(N=18)	295.6(N=10)
	Plot size, ha	6.2(N=47)	1.9(N=18)	1.9
	Hours per hectare (years)	199 (12)(N=47)	139 (12)(N=18)	155.6 (12)(N=10)
	Hours per ha/year	16.5 (N=47)	11.6(N=18)	13.0 (N=10)

**Green: low labour intensity. Yellow: Moderate need for labour. Red: High need for labour.*

Measured per hectare annual work time in forestry is considerably smaller than the time spent on crops such as potatoes and maize. Measured on an annual basis, and assuming 12 years between each rotation, the actual work input for forest activities is fairly small, 16.5 h/ha for pine and 11.6 h/ha for eucalyptus. The black wattle would be in between the others at 13 h/ha.

4.3 Work with livestock and maintenance of animal sheds

The respondents were asked how many hours they spent each day on the different livestock activities such as milking, feeding/grazing, moving animals, watering and other management activities. Most respondents found it difficult to give figures on time spent on a daily basis, especially for chicken which was considered as a non-labour activity. In table 21 an overview of hours per day for each livestock type investigated is provided. The total number of hours spent on livestock per farm is highest in the Kichiwa village, averaging 11.6 and 10.8 hours. Kichiwa is also the village with the most diverse farming systems, with cattle, goat, pigs and poultry, and much time spent on local cattle and goats explains the higher numbers for the Kichiwa farmers. The respondents from Ibumila spent the shortest time, in particular fewer hours on the dairy cows. But the general picture is that the result does not differ significantly between the three villages.

Amount of hours spent on dairy cattle in Magoda is higher compared to the other two villages. One reason for this result is that farmers in Magoda village have more dairy cattle. The farmers in Magoda also spent more hours on dairy cattle in the rainy season while those in Kichiwa and Ibumila spent more in the dry season.

Table 21: Number of hours spent on livestock per day in the two seasons

		Dairy cattle	Local Cattle	Meat goats	Pig	Poultry	Total livestock
Magoda	Dry season	7.9 (N=20)	7.0 (N=1)	-	2.1 (N=6)	0.3 (N=13)	9.1 (N=20)
	Rain season	9.5 (N=20)	7.0 (N=1)	-	2.1 (N=6)	0.2 (N=13)	10.6 (N=20)
Kichiwa	Dry season	3.4 (N=20)	8.9 (N=13)	6.7 (N=5)	0.3 (N=5)	0.7 (N=18)	11.6 (N=20)
	Rain season	2.7 (N=20)	8.8 (N=13)	6.7 (N=5)	0.3 (N=5)	0.7 (N=18)	10.8 (N=20)
Ibumila	Dry season	3.3 (N=20)	7.8 (N=10)	-	1.0 (N=3)	0.3 (N=19)	7.6 (N=20)
	Rain season	2.6 (N=20)	7.9 (N=10)	-	1.0 (N=3)	0.3 (N=19)	6.9 (N=20)
All villages	Rain season	4.9 (N=60)	8.3 (N=24)	6.7 (N=5)	1.1 (N=14)	0.5 (N=50)	
	Dry season	4.9 (N=60)	8.3 (N=24)	6.7 (N=5)	1.2 (N=14)	0.5 (N=50)	

In table 22 the number of hours per day is calculated per animal in the three villages and on an average for all respondents with each animal assuming similar length of the rainy and dry seasons. Since dairy cows are kept indoors the amount of time spent on them will be limited. Much time will be spent for the milking and feeding, however this will, in general, be less than moving the animals to the grazing areas and back on a daily basis and tender them while grazing for the whole day.

Average number of h spent per dairy cow is 3.4, the highest in Magoda (4.8) and the lowest in Ibumila (2.1). The time spent for local cattle is considerably lower, 2.7 h per animal with the lowest number in Magoda and highest in Kichiwa (table 22).

Table 22: Calculation of work hours spent per animal per day – village breakdown*

Village values		Dairy cattle	Local cattle	Local EA goats	Pigs	Chicken
Magoda	Daily work, h	350	14.0	-	23.1	6.4
Kichiwa	Daily l work, h	122	230	67	3.0	25.3
Ibumila	Daily work, h	117	156	-	5.2	10.1
Sum	**Daily work, h**	**589**	**400**	**67**	**31.1**	**41.7**
Magoda	Animals	73	13	-	7	121
Kichiwa	Animals	43	61	15	25	691
Ibumila	Animals	57	71	-	9	590
Sum	**Animals**	**172**	**145**	**15**	**41**	**1 402**
Magoda	Hours/animal/day	4.8	1.1	-	3.3	0.05
Kichiwa	Hours/animal/day	2.9	3.8	4.5	0.1	0.04
Ibumila	Hours/animal/day	2.1	2.2	-	0.6	0.02
Average	**Hours/animal/day**	**3.4**	**2.7**	**4.5**	**0.8**	**0.03**

* For number of observations (N) see table 21.

The illustration (Fig. 2) shows that the most labour intense livestock is the local EA goats and dairy cattle, followed by local cattle. Local cattle (also known as dual purpose cattle) and local EA goats spend time out grazing every day. We inquired specifically about time spent for this activity and on average it takes the farmers or some other member of the farming family about 1.5 hours to walk to and return from the grazing land every day. The time for these activities is included in the numbers in tables 21 and 22.

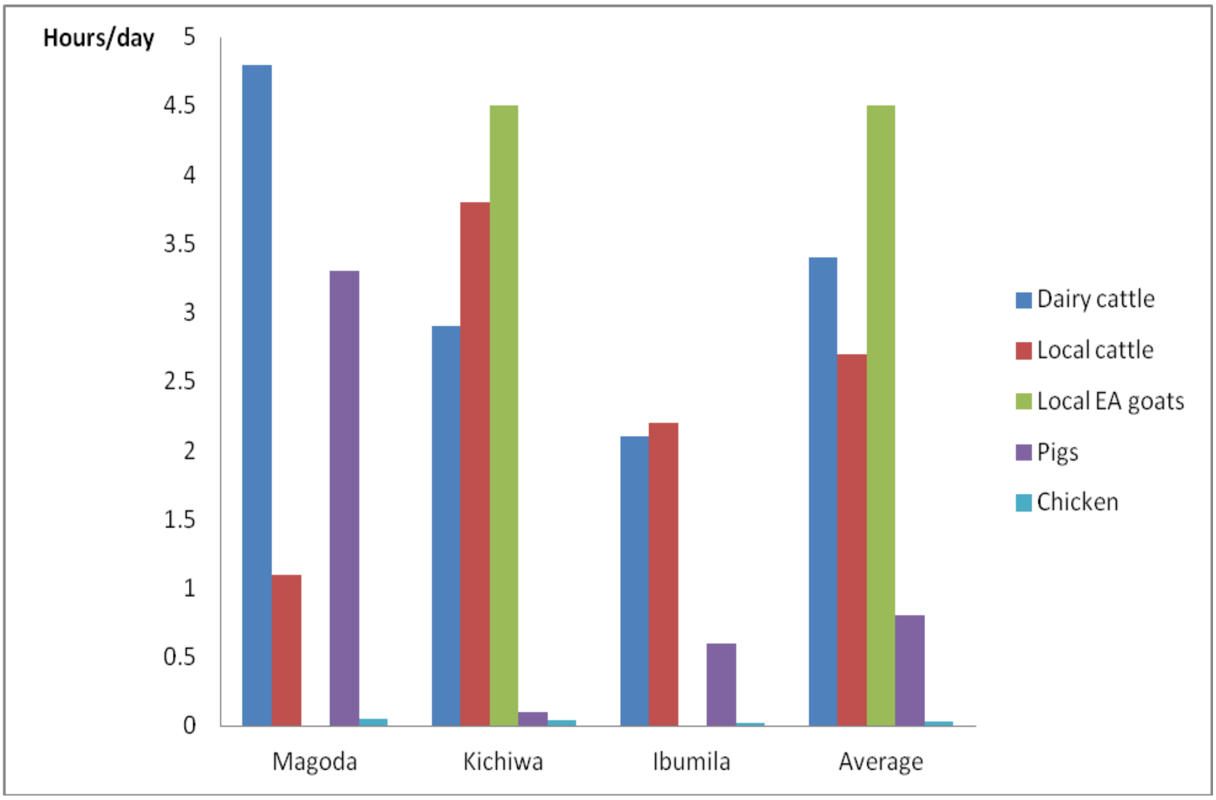

Fig. 2: Number of hours spent per animal per day in each village

The illustration above (Fig. 2) does not include the hours spent on maintenance of animal sheds, which was estimated to be 51.9 hours per year based on answers on a separate question (N=60).

5 Livestock production

Below (table 23) is an overview of livestock production in the sample, calculated as average for those who have each animal. A small number of calves were born in 2011, only 63 calves from all the dairy cows in the villages or 1.1 calves per farm. We do not know number of cows in the populations of dairy cattle or local cattle. However, it seems that a population of 3.3 dairy cattle produced 1.1 calves in 2011 while a population of 6.1 local cattle produced only 0.8 calves. Thus the number of calves per cow is likely considerably higher for the dairy cattle than for the local cattle.

Table 23: Livestock production, average numbers for the three villages

	Dairy cattle	Local cattle	Local EA goats	Pigs	Chicken
Living animals, 2012	2.9 (N=60)	6 (N=24)	3 (N=5)	2.9 (N=14)	28 (N=50)
Living animals, 2011	3.3 (N=60)	6.1 (N=24)	3.4 (N=5)	2.2 (N=14)	26.1 (N=50)
Born in 2011	1.1 (N=60)	0.8 (N=24)	2.0 (N=5)	2.4 (N=14)	26.6 (N=50)
Lost in 2011	0.2 (N=60)	0.5 (N=24)	0.8 (N=5)	0.4 (N=14)	14.8 (N=50)
Bought/received 2011	0.2 (N=60)	0.4 (N=24)	0 (N=5)	0 (N=14)	10.2 (N=50)
Slaughtered in 2011	0.02 (N=60)	0.5 (N=24)	0 (N=5)	0.4 (N=14)	5.7 (N=50)
Sold alive in 2011	0.8 (N=60)	0.5 (N=24)	0.4 (N=5)	2.4 (N=14)	8 (N=50)

The number of offspring per animal is very low compared with European figures. For dairy cattle, it was reported to be in total of 196 animals in 2011 and the total amount of offspring was 63 calves. Assuming that about half of the cattle are cows that can produce calves we would end up with 98 cows and 63 calves or 0.64 calves per dairy cow. Clearly, improving the number of offspring for the dairy cows should be given priority in order to increase milk production.

Very few dairy cattle were slaughtered in 2011, the majority was sold alive which can be for either breeding or slaughtering. The figures can be interpreted as farmers slaughter chicken and local cattle in particular for home consumption.

On average, dairy cows were reported to give birth for the first time at an age of 27 months or 2 years and 3 months. Local cattle calved the first time after 3 years (36.5 months). Meat goats were 1.5 year, and pigs approximately 9 months when giving birth the first time. Hens produce their first eggs after roughly 8 months (table 24). By way of comparison Norwegian cows typically have their first calf at an age of 24 months. And whereas dairy cows have a gestation interval of 13 months, it is 24 months for the local cattle. Meat goats and pigs are also raised quite intensively in this respect. As for hens the 4.4 months reflect the practices in the local system, as they can produce chicken any time they produce eggs.

Regarding slaughtering, dairy cows are normally not slaughtered before they are 7 years and local cows are slaughtered at 7.5 years. That gives a replacement rate of close to 0.139 for dairy cattle and 0.135 for local cattle. In addition, lost animals also have to be replaced. The replacement rates calculated have to be raised to about 0.20 for dairy cattle and 0.18 for local cattle in order to account for losses. The mortality rates seem to be high for all kinds of animals particularly meat goats and chicken. For meat goats the slaughtering age is well over 2 years (26.4 months) while it is slightly less than 2 years (23.4 months) for pigs. Chicken or hens are slaughtered after about 16 months.

Table 24: Livestock production parameters*

	Dairy cows	Local cows	Meat goats	Pigs	Poultry
Age of animal at first birth, months	27	36.5	18	9.4	8.1
Birth interval, months	13	24	8.4	5.7	(4.4)
Slaughter age, months	86.3	89	26.4	23.4	15.8
Mortality, %	6	5	27	12	46

* For number of observations (N), see table 23

As for livestock production some key parameters are found in table 25. A characteristic of the production system in the area is the rather short milking period, in particular for local cattle (5.7 months) but also for dairy cattle (8.1 months). This may be due to the climate and a natural drying up of cows in the beginning of the dry season unless measures are undertaken to prolong the milking period into the dry season. It seems that, to a certain degree, this is done for the dairy cows but not for the local cows. It is possible to extend the milking period to 10 months for dairy cows. But this will require supplementary feeding in the dry period and such feed may have to be grown in the rainy period and stored for later use.

Table 25: Livestock production – yields*

	Dairy cows	Local cows	Meat goats	Pigs	Chicken
Milking period, months	8.1	5.7	-	-	-
Milk produced per cow, l/day	9.7	2	-	-	-
Milk for home consumption, l/day	1.27	1.33	-	-	-
Milk sold, l/day	8.6	0.7	-	-	-
Manure produced, kg/year	6 646	6 454	208	405	279

* For number of observations (N), see table 23

The local cattle produce substantially less milk than the dairy cattle, affecting the amount of milk that can be sold which is 8.6 l/day for dairy cattle compared to 0.7 l for the local cattle. Also here any increase would require more feed and the feeding intensity has to be improved throughout the year. Moreover as yields are raised the feed have to be more concentrated with either good pastures or concentrates. The former can be difficult to provide in the dry season so farmers would have to rely on concentrates and fodder trees or hay. However, the local cattle do not have the same genetic potential to increase the production of milk following improvements in the feeding as dairy cattle breeds.

It was not possible to obtain figures for kg meat produced per animal so we have to rely on slaughter weights and replacement rates to calculate kg meat produced per animal. Regarding poultry 6.3 eggs were produced per day (N=44). Most of it was for home consumption which was 4.2 eggs (N=40). Sale of eggs was mainly conducted from the largest flocks, on an average 6.9 eggs (N=14) were sold per day.

Production of manure by the animals is also important in the production systems in Njombe and the manure has to be collected and distributed on crops in accordance with its importance in the household economy. Also, a few farmers in the study area have established their own small-scale biogas plant in the back yard to produce gas for cooking and lightning in the household. This study has not captured the amount of manure needed to operate the energy supply for a household, but it has a direct benefit to both household livelihood in terms of health, and from a climate change perspective in terms of reduced deforestation as long as the biogas plant is operating.

6 Forest resource use

The study considers different forest resources and non-wood forest products that are collected and consumed over a 12 month period. We have concentrated on the tree major products charcoal, fuel-wood and grass and forage for animals. Collection of other non-wood forest products indicated by the farmers includes wild fruits, medicinal plants, honey and mushrooms.

The forest resources are either for home consumption or for sale at the market (table 26). There is only one observation of selling charcoal that has been collected from a nearby forest in Magoda, the amounts were 750 kg sold every month. Only small amounts were used by the farming household. Most farmers collect fuel-wood and most of it was for the farming family's own household. However, some fuel-wood is sold at the market, more commonly in Kichiwa and Ibumila. The average market price per kg was 15 TSH for fuel-wood and 88 TSH/kg for charcoal.

The collection of grass and forages was for feeding the farm animals only; no sale of grass or forages was reported. Average amounts ranged between 500 and 800 kg per month.

Table 26: Forest resource collection and use over the last 12 months

	Fuelwood		Charcoal		Grass/forage	
Village	Own use, kg	Sold, kg	Own use, kg	Sold, kg	Own use, kg	Sold, kg
Magoda	5 928 (N=19)	0	600 (N=1)	9 000 (N=1)	8 196 (N=6)	0
Kichiwa	1 944 (N=19)	1 624 (N=19)	0	0	6 156 (N=11)	0
Ibumila	13 284 (N=15)	1 596 (N=15)	0	0	9 096 (N=11)	0
Average	6 600 (N=53)	1 612 (N=34)	600 (N=1)	9 000 (N=1)	7 752 (N=28)	0

In table 27, there is information about how much charcoal and fuel wood the households in the three villages actually consumes in the rainy and dry seasons. The numbers are aggregated from weekly numbers, assuming equal length of the rainy season and dry seasons 26 weeks each.

Table 27: Fuel-wood and charcoal consumption according to season.

	Rain season, 26 weeks		Dry season, 26 weeks	
	Fuel-wood, kg	Charcoal, kg	Fuel-wood, kg	Charcoal, kg
Magoda	2 579(N=20)	322 (N=20)	2 777(N=17)	520(N=17)
Kichiwa	1 651(N=20)	286(N=12)	1 126 (N=20)	294 (N=12)
Ibumila	2 470(N=20)	182(N=20)	1 162(N=20)	520(N=18)
Average	2 233 (N=60)	260 (N=52)	1 631 (N=57)	462 (N=47)

The numbers illustrate the households' total consumption of fuel-wood and charcoal over a 12 month period that is either collected from the private or community forests or purchased at the market.

7 Summary

This report deals with results of a survey to 60 farming households in the three villages Magoda, Kichiwa and Ibumila in the Njombe region of Tanzania, about 700 km from Dar es Salaam. The farmers were selected among those that came forward at village meetings and the survey is not representative for farming households in the region. However, it may represent farmers interested in developing their farms and looking for better ways to do farming in the area.

7.1 Agricultural production systems in the three Njombe villages

The three studied villages are located in a dairy area in the Njombe region, not far from the dairy plant in Njombe town, and all farmers in the sample had dairy cows. Some farmers have more or less only dairy cows, others have diversified into one or more other animal or crop activities. This could be either to kept some local cattle or goats that they manage in a traditional way. Some farmers also keep pigs and most farmers also have poultry. The importance of these side activities vary, a few specialize but mostly seems to be kept in order to diversify agricultural production. The degree of diversification is generally a question of what other resources the farmers have available and how such diversification will affect the risks of the farming system. Particularly the risk of a food deficit for the family can be important and decisive for farmers when choosing their system.

Regarding the crops the study shows that most farmers cultivate maize and a majority also have potatoes. Beans and sunflower are optional less than ten percent of the farmers have beans or sunflower. A few individual farmers also specialize in crops like sweet potatoes or wheat or in vegetables like Chinese cabbage or tomatoes. Since the pasture system was introduced not many years ago, a majority of the farmers have developed that whereas fodder trees are less common only about one in six of the farmers have fodder or multipurpose trees. About half of the farming households had fruit trees.

Farmers are starting to plant pine and eucalyptus for timber production in addition to the black wattle that traditionally has been used for fire-wood and charcoal in the area[5]. As far as could be observed, the tree planting mainly takes place on marginal land or steeper slopes. Farmers also collect different wild food or non-food products in the forests. However, most important is the fire-wood for the household. The Ibumila farmers have specialized more in planting of pine, eucalyptus and black wattle, compared to the other two villages.

The household analysis indicates that Magoda farmers have less farm area than those in the other two villages. They specialize in dairy cattle and have the highest number of dairy cattle per household, with few local cattle and other animals. They also have fewer crops and plant less trees for timber in comparison with the other villages. Furthermore, they have little pasture and fodder trees. In Kichiwa farmers seem to have the most diverse agricultural systems with dairy cows and local cattle, some pigs, goats and poultry. They have most land per household and plant a variety of crops and forest trees. Ibumila farmers fall in between the other two with fewer dairy cattle than those in Magoda but more local cattle, pigs and poultry. The Ibumila farming households also seem to have more land and crops than those in Magoda but less than Kichiwa. Still we think the differences in production system among the villages are not huge and we will not undertake separate analysis for the tree villages.

7. 2 Management strategies for developing the production system

There are several ways for developing the production system in the area. A task for economic analysis is to identify the most efficient one that is likely to be adopted by the farmers and driving economic growth in the area.

Starting with the crops it seems clear that yields can be increased with <u>increased use of inputs</u>, both fertilizers and lime, as well as plant protection agents, both pesticides and fungicides. Whether this intensification of crop production is profitable to the farmers is another question, the cost of the inputs has to be lower than the value of the additional production. The yields has to be used by the farming household or farming animals, sold in the local market or exported out of the region. The price will be limited by market and it can be problematic to defend use of such inputs produced in industrial countries overseas. Moreover it can be expensive to bring in the inputs from Dar es Salaam in spite of the newly developed road to the area.

Another rather clear conclusion from this study is that it should be possible to <u>intensify and expand animal production</u> in the area by improving the productivity of the animals. This part of Njombe is a dairy area and measures targeting the dairy sector should be given priority. There are several options for increasing productivity of dairy cows. The milk yield of the dairy cows in the area is low compared to that of dairy cows of the same breed elsewhere. The best option for increasing yield per animal is probably to prolong the milking period, currently about 5.7 months for local cows and 8.1 months for dairy cows. This would result in more milk in the dry season. Another option is to, lowering losses or shortening birth

[5] The Tanganyika Wattle Company (TANWAT) has also been planting the black wattle for industrial purposes since the late 40s in the Njombe-region.

intervals, assumed to be 13 months for dairy cows and 24 months for local cows. Cows could be replaced at a younger age than 7-8 years currently to increase meat production. In general these changes would require stronger feeding and perhaps also improved veterinary services. The changes would require more use of feed, in particular concentrate feed that can either be produced in the area or purchased from other areas.

There are opportunities for producing more feed concentrate as well as roughages in the area. As for concentrates, maize or perhaps soybeans production can be developed and maize can be fed fresh or made into concentrate. Also cakes of other crops, such as sunflower could be an option. Most likely the potato industry should not be developed for feeding animals however, surplus potatoes can be fed to cows. A strategy for enhancing farm yields and animal milk performance through improved feeding with concentrates will be given priority in the further studies. As for roughages, more haymaking of the grass of the pasture in particular, but also more fodder trees, should be considered. This would help to encounter the feed deficit mostly experienced in the dry season and necessary to prolong the milking period. The flocks are small and the amount of hay needed for the dairy cows during the dry season can possibly be harvested in the rainy season using simple scythe techniques for cutting the grass and the technique drying the grass on racks has been tried in the area. As these techniques are simple and not requiring much capital and costs of workers are low in the area this can be worth studying. The economics of producing hay for the dry season in particular should be examined.

One long run risk of too strongly emphasize the development of the dairy production is declining milk prices. This can be encountered by developing alternative industries such as forestry. A strategy of increasing forest plantings of pines, eucalyptus and black wattles should be compared with that of developing the dairy cow industry in the Njombe area. We think it will not be much of clash of interest among dairy and forest plantation as dairy cows are much kept and fed indoors. However there can be more so for farmers with local cattle and possibly also with grazing interest of the pastoralists. Since the number of pastoralists is small in Njombe we think these problems can be managed, however more care might have to be taken to these issues in other areas. Also wildfires are a risk with developing the forestry plantings in the area.

As for meat goats there may be an opportunity to use them more extensively for browsing shrubs and under vegetation in forest plantations in order to lowering risks of forest fire. Goats can also have several kids so a strategy of increasing the number of kids per female would allow for more animals for grazing during the rainy season, slaughtered in the end of the rainy season and fewer to be fed during the dry season. Such a strategy would be difficult to implement for cattle. However, we think in the current situation goats should not be given priority in the Njombe area.

Regarding the local cattle similar management strategies as those for goats seems difficult to develop. Cattle are grazers and not suited to browse shrubs and woody vegetation in forest plantations. Moreover a strategy to increase the number of calves per birth in order to have more animals for grazing during the rainy season would likely also fail for cattle. Since local cattle are generally free roaming a strategy involving supplementary feeding during the dry season might work but can be expensive to develop. Much of the local cattle are also owned by pastoralists that can be difficult to reach with feed in a drought situation. Improving management by e.g. regulating the number of animals fed during the dry season may be the best option in semi-arid areas, see e.g. Díaz-Solís *et al.,* 2011. As strategies regarding development of the local cattle would have to involve the pastoralists we think it needs more considerations first.

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