Why do smallholder farmers in Northern-Ghana choose to plough by hoe, with bullocks or with tractors?

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March – August 2017

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Acknowledgment

My thanks go first of all to my supervisor Mirja Michalscheck who helped me to structure my research, gave valuable feedback and guidance at different stages of the research. It was very nice to have your company and moral support in Ghana. My gratitude goes also to my second supervisor Jeroen Groot, who gave valuable feedback and guidance during the course of the thesis.
I would also like to thank my supervisor from Africa RISING, IITA, dr. ir. I. Hoeschle-Zeledon, who supported my research through administrative and logistical support.
I thank Dr. Asamoah Larbi, the scientific leader for Ghana for Africa RISING, for hosting us.
This research would not have been possible without translators; my thanks go to Baba, Mohamed, Sulimana, Mussah, Roger and Prosper.
Many thanks also to my parents who supported me strongly, morally and financially.

Summary

Ghana is an agricultural country, with 60% of the domestic product coming from agriculture. But even so mechanization in agriculture is still underdeveloped. In the North of Ghana ploughing can be done in three different levels of mechanisation; the land can be ploughed by hoe, with bullocks or with a tractor. All three techniques are used next to each other.

Farmers were interviewed in two communities in Ghana, Duko in the Northern Region and Nyangua in the Upper East Region. There is a great heterogeneity between these two communities The communities have a different social organisation and different access to main cities. Which leads to different forms of ploughing between the two communities. Within the communities there is also a big heterogeneity. To analyse the heterogeneity within communities, the HH's were divided into three groups according to their resource endowment. This research thus analysed why farmers chose to plough with which techniques and how it is different for both locations and for different resource endowments.

Ploughing with tractor required less time (2.12 SD 0.9 hours/ha) than with bullocks (16 SD 9 hours/ha), while farmers indicated that ploughing by hoe took the most time (171 SD 101 man-hours per ha). Farmers cultivated on average 5.7 (SD 4.4) ha and 2.3 (SD 2.4) ha per HH, in respectively Duko and Nyangua. Therefore it is for most farmers impossible to plough all their land by hoe, as they would not be able to plough all their land on time. In Duko they used mostly tractors for ploughing and in Nyangua mostly animal traction.

Farmers were unsatisfied about hired ploughing services as costs were high, operations were delayed and the quality was poor. This is for farmers one of the reasons to buy their own bullocks, as they would save this cost. The delayed ploughing causes lower yields; farmers estimated late ploughing losses on average at 1104 (SD 964) GH₵/ ha in Duko and at 1466 (SD 1242) GH₵/ha in Nyangua. These costs were tremendously high compared to other farming costs and it can be argued that these are the main reasons to choose for a technology. This delay existed because there were not enough tractors and bullocks. Farmers complained about the difficulty to get an operator to their field as well as at the quality of the work done by the operator.

When looking at the agro-economical performances of each technique there was no consensus among the farmers on which technique yields most. Nor is there a consensus on which technique requires a higher fertilizer application, causes a higher amount of weeds later in the season, compacts the ground more or gives better soil moisture. This is surprising but similar discordance concerning ploughing was also found in literature.

It can be concluded that farmers chose for one of the techniques based on what they think is economically best for them, this taking their financial potential and the social implications into account.

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0. ABBREVIATIONS

AT	Animal Traction
AR	Africa RISING
GH₵	Ghana cedi
HH	Household
HHH	Household head
HRE	High Resource Endowed
HW	Hoe Work
LRE	Low Resource Endowed
MOFA	Ministry of food and agriculture
MRE	Medium Resource Endowed
NR	Northern Region (region in Ghana)
TP	Tractor Ploughing
UER	Upper East Region (region in Ghana)

Definitions

Bullocks describe oxen or bulls used for ploughing.

1. INTRODUCTION

1.1. Background

Lack of labour is a major productivity constraint in African farming systems (Ashburner et al., 2002). This is mainly caused by lack of mechanisation which on his turn leads to labour intensive production, yield losses, uncultivated land and outmigration of young labour force to cities (Loos, n.d.). This migration of young men to the cities constitutes a significant loss of labour force. Also school enrolment causes a lower amount of labour.

Methods reducing labour are thus essential for developing African agriculture and food security (Ashburner et al., 2002). This is also the case for Ghana, a country in which 60% of the domestic product, 65% of employment and 50% of exports come from agriculture and where mechanization is still underdeveloped (Loos, n.d.).

Land preparation is one of the most labour intensive farm activities in Northern Ghana. It is done with by hoe work (HW), with animal traction (AT) or with a tractor ploughing (TP) (Houssou et al., 2013). As land preparation by hoe is very labour intensive and tractors are not consistently available, ploughing is often done with draft animals, mostly bullocks and sometimes donkeys (Houssou et al., 2013). It is important to know about the historical context of land preparation with hoe, animals or tractors, to understand how the actual situation came into place and understand how farmers decide which technique to use.

Historic situation

Before the colonial era, land preparation was done with HW. The British colonial government introduced AT in the 1930`s. At that time, training centres were created where farmers could learn about the technique. The use of AT increased until the independence of Ghana (1957), when the government changed strategy by importing and subsidising tractors (Dibbits and Bobobee, 1997). As the new government perceived AT as not modern enough, they stopped supporting AT, withdrawing credit opportunities to buy animals or equipment (Panin, 1989). But the tractor promotion did not work as planned: farmers faced supply problems, broken tractors, lack of knowledge, lack of finance, lack of spare parts, etc. (Dibbits and Bobobee, 1997).

The use of AT declined further until 1970, when the Ghanaian-German Agricultural Development Project wanted to promote fertiliser use but realised tillage was a bigger problem. They then encouraged AT again, as they saw tillage problems in the region and something had to be done about them. The project opened training centres and provided material for AT to the farmers. The project stopped in 1985. After that, farmers continued using AT, due to low numbers and high costs of tractors and tractor services (Dibbits and Bobobee, 1997).

Current situation

In Ghana, from 1991 to 2005 the draft animal population, mainly bullocks and donkeys, increased from 160 000 to 438 000 animals (Houssou et al., 2013). AT is only used in the three northern regions, where soils are relatively loose, dry and sandy. In the South of Ghana, the wet soil is too heavy and there are cattle diseases, making AT unviable. Traction animals are mainly used for ploughing and transport. In the Upper East region they are also used for weeding (Houssou et al., 2013). As AT equipment for ridging and weeding is not always available, weeding is still done a lot by hand (Dibbits and Bobobee, 1997).

1.2. Africa Rising

This research was done in the context of the project Africa RISING (AR, Africa Research in Sustainable Intensification for the Next Generation). This research for development project is funded by the United States Agency for International Development (USAID). As a research for development project, AR has community-based experimental stations, in intervention communities, aiming to test new technologies and demonstrate these to the local communities. The study was done in two of these communities, Duko in the Northern Region (NR) and Nyangua in the Upper East Region (UER). In these two communities AR already collected data from 38 farmers in Duko and 32 farmers in Nyangua. This data is compiled in the 'Ghana Africa RISING Baseline evaluation survey' (GARBES).

1.3. Farm typology

Previous research from AR focussed on resource endowment of farmers. The resource endowment of farmers is expressing their wealth. The building material of their roof, the amount of bicycles and motorbikes they own, the amount of land of which they dispose and the amount of animals they keep are all indicators of the resource endowment of a household (HH). We hypothesize that the ploughing technique is related to the resource endowment of the farmer. We tested this by categorizing the farmers in existing farm typologies and tested whether or not different techniques are used by farmers of different resource endowment.

1.4. Research questions

Main research question

What determines a farmer's choice for preparing the land with hoe, animal or tractor traction?

Specific research questions

1. What is the current form and prevalence of ploughing with HW, AT and TP in Duko and Nyangua?
2 From an economic perspective, what are the costs and benefits of ploughing with HW, AT and TP?
3 Which social factors do farmers perceive as important for choosing?
4 Can farmers' perceptions be confirmed their own realities?

1.5. Objectives and hypotheses

The research questions can be translated into objectives, and these objectives have matching hypotheses. In table 1 it can be seen how the research question relate to the objectives and which hypothesis match with them.

Table 1: Objectives (in bold), sub objectives and their matching hypothesis.

Research question	Objectives	Hypotheses
RQ 1	**Find out what the prevalence is of the three techniques in both communities and across the three resource endowments.**	**TP is more prevalent in Duko than in Nyangua since Duko is closer to its regional capital.** **Higher resource endowed HH's use more TP. HW is used when farmers can't afford AT or TP, which implies it to be used**

		mainly by lower resource endowed farmers.
RQ 1	Find out if farmers use different techniques or only one.	Farmers use AT or TP and not a combination of both, except if they have very heterogeneous fields.
RQ 1	Do LRE farmers have access to AT?	Low resources endowed farmers want to use bullocks, but can not afford them.
RQ 1	Why do men plough but not women?	Ploughs pulled by animals are too heavy to operate for woman and this is the reason why men are in general in charge of ploughing.
RQ 2	Find out what the main advantages and disadvantages are from the three techniques.	HW AT and TP have all various agro-economic advantages and disadvantages.
RQ 2	Which technique compacts the soil most?	Tractors compact the soil more than humans or animals. Soil compaction can lead to lower yields.
RQ 2	Is delay of ploughing a problem?	The delay in tractor arrival causes fields to not be cultivated at all, causing high yield losses.
RQ 2	Will the crop management be different when using different techniques?	With different land preparation techniques the crops will have different needs for: fertilisation, weeding, watering, etc.
RQ 3	**Find out if farmers find social factors like knowledge and prestige important for taking decisions.**	**Social factors are of great importance.**
RQ 3	Is AT considered as primitive?	AT is considered to be primitive. If farmers have sufficient resources, they prefer to pay for tractor services, even if AT would be a more economic option.
RQ 3	Are farmers willing to buy bullocks?	As owning bullocks is risky, mainly due to theft and diseases, people prefer not to take the risk of buying bullocks and hiring tractor services instead.
RQ 4	**Find out if farmers agree with each other on different factors concerning ploughing.**	**Farmers have different knowledge on the effects and trade-offs of land preparation with HW, AT or TP (ground compaction, soil moisture, yield, price awareness, maintenance, etc.). Farmers perception is not always the same as what can be found in literature.**

2. MATERIALS AND METHODS

2.1. Study area

The case study was held in two communities in Northern Ghana: Duko (NR, 54 HH's) and Nyangua (UER, approx. 150 HH) (Fig. 1). Duko is wealthier than Nyangua. Duko is also closer to its regional capital (Tamale) than Nyangua (whose regional capital is Bolgatanga) (Fig. 1). Development cooperation is active in both communities. In Duko TP is mostly used for land preparation whereas in Nyangua AT is more prevalent. Duko and Nyangua are intervention communities of the AR project, allowing to tap into a large pool of additional data and expertise.

Both communities are in the Guinea Savannah zone. In the NR the rainy season goes from May to October, the annual rainfall lies between 750 mm and 1050 mm. In the UER the rainy season goes from May/June to September/October, the annual rainfall lies between 800 mm and 1100 mm. In both regions agriculture, hunting and forestry are the main economic activities. In the NR 71.2% of the economically active population works in agriculture in the UER it is 80% (Modern Ghana). The crops grown are maize, soya bean, cowpea, groundnut, rice, millet, bambara bean, pigeon pea, yam, cassava and vegetables. The farmers keep some of the harvest for own consumption and sell the rest to the market. Farmers also have fallow land, mostly due to a lack of financial resources to pay for ploughing, to buy seeding material or fertilisers (Baba, pers. comm.).

Fig. 1: Map of Northern Ghana with the two communities.

2.2. Farm typology

To group the farmers typologies were used. Several farm typologies have already been developed for Northern Ghana (Kuivanen et al., 2016; Signorelli , 2016 and Michalscheck et al., 2017). Michalscheck et al. (2017) divided the farms in three categories according to their resource endowment: low, medium and high resource endowment (LRE, MRE and HRE). One of the aims of typologies is to allow comparability of farms across regions. In this research we used typologies to compare the different results for different farm types. In Table 2 the typology indicators can be found as used by Michalscheck et al. (2017).

Table 2: The farm typologies and the indicators that are used to determine them can be seen here, for Duko and for Nyangua (Michalscheck et al., 2017).

Farm Type	Land Size (hectares)	Animal Number and Type	Roofing Material	Means of Transport
Duko, Northern Region				
LRE	0.8-1.2	Few poultry	Thatch	Bicycle
MRE	2	No cattle	Mixed	Motorbike
HRE	4-6	Cattle, many small ruminants	Zinc	Motorbike(s)
Nyangua, Upper East Region				
LRE	0.4	Some poultry	Thatch	On Foot
MRE	0.8 – 1.2	Some poultry, small ruminants	Mixed	Maybe: bicycle
HRE	2 or more	Cattle, small ruminants, poultry	Zinc	Motorbike

2.3. Measurements

Answers of the farmers were given in acres, but are here translated to hectares (ha). Prices were always given in Ghana cedi (GH₵), as this is the price that farmers buy and sell things for. One GH₵ was equivalent to 0,25 US dollars in 2016. When ratios are indicated (e.g. 8/12), it means 8 out of 12 farmers.

Information mentioned in the text will be for both communities unless otherwise mentioned.

When percentages of farm land will be mentioned in the rest of the text it will be about percentages of the farm land excluding vegetable gardens, yam and cassava fields, as these are mostly cultivated in other seasons and are always ploughed by hoe. Yam and cassava fields are always ploughed by hoe, this because mounts need to be formed. Sometimes the fields are pre-ploughed with a TP or AT to make the formation of the mounts easier.

In Duko rice fields are sometimes ploughed with TP and AT. As the AT ploughing is done last these fields will be considered as AT fields.

2.4. Interviewing farmers

Translators were used to communicate with farmers (see Annex 1 for the names and experience of the translators). We mostly interviewed the household head (HHH) first, as it is the local cultural norm to consult them first in general HH matters (van Veluw, pers. comm. and Baba, pers. comm.). An advantage in interviewing the HHH is that he is aware of most of the farm features. For some HH's the HHH was considered as too old (by the translator) to be interviewed, the (oldest) son was then usually interviewed. When other HH members were around they helped in answering, this was helpful to check the veracity of the answers. In case of female headed HH the sons were mostly helping, as they knew more than their mother, concerning ploughing.

Information was collected in different ways: a main survey with closed questions was done, during that survey additional information and explanation was asked. At the end of the data collection period, community level interviews were performed.

2.4.1. The main survey

The main survey had as aim to get a deep understanding of the farming systems. The interviewed farmers were chosen using as a basic principle for selection an MS Excel® randomisation

complemented by additional cases to fill gaps, to achieve a minimum number of HH's per farm type as well as a minimum number of HH's using the different traction techniques. The Excel randomisation was done using the list of farmers already covered under the 'Ghana Africa RISING Baseline evaluation survey' (GARBES), in order to link this study with past and on-going activities of AR. The list of farmers was randomized using Excel. The farmers were then visited in the order of this list. The farmers were found using their GPS coordinates. To compensate for farmers from the GARBES list that were not present the day we passed, farmers that were encountered when walking in the village were interviewed. We also interviewed some extra LRE and HRE farmers, as these were less prevalent in the list. In Duko there were only four farmers owning bullocks, and we interviewed three of them while they were not all on the list. The fourth farmer owning bullocks was not surveyed as when we asked a list of all farmers owning bullocks, the AR facilitator did not mention him. In total 51 farmers (25 in Duko and 26 in Nyangua) were surveyed. One to four surveys were done in a day, depending on the translator, the analytic skills of the farmer and the complexity of the farm.

The survey consisted of 5 parts. The first part was performed to collect some general information about the HH and to classify the HH according to their resource endowments. The second part of the survey aimed at quantifying how expensive it was to own bullocks. The third part collected data on the fields of the farmers; this part was to see if farmers farm differently when they use different ways of ploughing. In the fourth part labour figures were made, to see if the different techniques required different amounts of labour across the cropping season. Finally, in the fifth part, the farmers were asked how they perceived the technologies for different factors. This was done to see how farmers think on different aspects concerning the techniques.

During this five parts farmers were asked to motivate their answers. Farmers also gave comments concerning the questions. These motivations and comments were written down. In the results information coming from there will be written down as "farmers mentioned that".

1. General information about the HH

In this part of the survey general information was asked to the farmers. We asked to farmers how many animals, bikes and motorbikes they had; this was together with a visual assessment of their house and the amount of land they had used to determine the resource endowment of the farmers. The farmers were also asked their name, and the name of the HHH, if they were answering for him/her. The farmers were also asked how many men and women lived in their HH.

2. Costs of owning bullocks

Bullock owners were asked all their costs. The costs were asked following a list of costs for owning bullocks (see annex 2) that was based on expert interviews (Baba, pers. comm.). Farmers that had no bullocks were asked to estimate the buying price of a pair of bullocks, the amount of years a pair of bullocks can be used, their selling price when old and the price of the implements. All farmers were also asked to estimate the price of a tractor.

3. Plot-level data

Farmers were asked about the locations and distance of each field (from the HH or the HH members) to the homestead. This yielded a map of all the HH fields, cultivated or fallow. As farmers often omitted to mention some fields, for every crop grown in the region the farmer was asked again to mention all their fields. For each field it was asked if they ploughed it with HW, AT or TP. Farmers were then asked how much fertilizer, herbicide and pesticide they applied per field, as well as how much they paid for the products. Farmers paid different prices for their inputs depending on which

one they used, when they bought them and if they managed to buy some that were subsidised. Farmers were also asked how much yield they had and if they were able to plough at the optimal time. Delayed ploughing leads to delayed planting and to a lower yield. This delayed ploughing is often due to unavailability of traction services. It was thus asked to the farmers how many weeks later they ploughed due to unavailability of traction services. If they ploughed later than they wanted we asked them how late and what yield would they have expected would they have ploughed on time, et ceteris paribus.

4. Labour figures

Farmers were asked how much labour was needed to crop maize, soya and cowpea. These three crops are common crops in Duko (NR) and Nyangua (UER) and play a central role in different AR trials. Farmers were asked for one of their maize, soya and cowpea fields how many men and women from inside and from outside the HH, worked for each labour task and how many days and hours per day they spent on it. As farmers do not record the hours they work, they were asked from what time to what time they performed each task and how long of a break they took. Farmers often mentioned the time with the position of the sun, which leaded to some lack of accuracy in the data. For labour from outside the HH it was asked how much and how they were paid. The questions were asked following table 3. The amount of days and the hours were multiplied and then summed for all persons to get the amount of man- hours needed for each labour task.

Table 3: table used to collect the "labour data".

(Inter) Crop								acres					
Ploughing technique					Total Labour in person days by								
Labour Tasks	Timing	HH Males			HH Females			hired Males			hired Females			Costs
		Amount of people	days	hours	Amount of people	days	hours	Amount of people	days	hours	Amount of people	days	hours	
Land Preparation														
Manure aplication														
Plowing														
Planting														
Fertiliser aplication														
Herbicide aplication														
Pesticide aplication														
Weeding														
Harvest														

5. Perceived performances

Farmers were asked how important they found certain factors for taking decisions on a Likert scale from 0 to 3: no (0), low (1), medium (2) and high (3) importance. Farmers were then asked to quantify how they perceived the performance of the different factors, on a scale from 1 to 5, for HW, own AT and TP, and rented AT and TP (see Table 4).

Table 4: table used to collect the "Perceived performances" data

	Technique	Why? **How does the technology perform** in your view in terms of ... (0 to 5) 0 = none, 1 = ver small, 2 = small, 3 = medium, 4 = much, 5 = very much											
		Cost	Labour for ploughing	Organisation / Accesibility	Risk of theft	Yield	Fertiliser	Amount of weeds	Amount of seeding material	Ground compaction	Soil moisture	Knowledge techniques	Prestige	Other :
	How important are these aspects for you in relation to decision taking --> 0 = not important 1 = low importance 2= medium importance 3 = high importance													
	HW													
Owned	AT donkey (only in UER)													
Owned	AT bullock													
Owned	TP													
Rented	AT donkey (only in UER)													
Rented	AT bullock													
Rented	TP													

2.4.2. Community level interviews

After the main survey was completed a short list of questions was asked to farmers (see Annex 3). This was done to get additional contextualising information and to check if some interesting information from the main survey was also valid for other farmers. For these questions it was aimed to interview farmers that were not interviewed yet in the main survey, but due to the difficulty to encounter sufficient farmers, some farmers from the main survey were interviewed again. During walking through the village we chose the farmers. We asked all encountered male adult farmers that agreed to be interviewed these questions. As few farmers were in the village at the moment of taking these interviews, most farmers that were around their houses on these days were interviewed (the other farmers being at the market, in town, on far away fields, sleeping or at funerals). Due to high levels of alcoholism in Nyangua it was sometimes challenging to find farmers that were in state of being interviewed. Depending on if they were alone or not, the farmers were interviewed alone or in group, this was also recorded.

In Duko two of these interviews were performed in group and eight to farmers alone. In Nyangua eight of these interviews were performed in group and eight to farmers alone.

2.4.3. Resource Endowment

In Duko all HHs that were not visited for the main survey were visited to determine their resource endowment. This was done the same way as the general information was asked in the main survey. In Nyangua this was not done as they were to many houses and HH's; the difficulty to find trustworthy farmers was also a reason for this.

2.5. Expert interviews

Farmers, Wageningen University staff, AR project staff and employees of companies providing services (for example selling inputs) to smallholder farmers were considered as experts (see annex 4). Experts were consulted before, during and after conducting the field work. The expert interviews previous to the start of the surveys aimed to get information on the current situation and to ratify the farmers' survey. The expert interviews during the survey taking had as aim to adjust the survey or the way of

taking the survey, where needed. The expert interviews at the end were done to interpret the results of the research and contextualise them (Fig. 2).

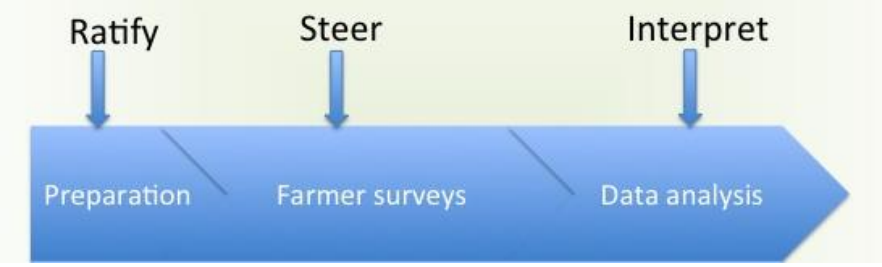

Fig. 2: Contribution of expert at different stages in the research.

Experts were also asked more general question about Northern Ghana and not just about the two villages, putting this thesis in a wider perspective .The questions can be found in Annex 5.

2.6. Statistical analysis

The data was analysed in Excel. When averages were calculated the standard deviation going with that average was also calculated.
All data for which a comparison had to be tested was tested on normality using the shapiro-wilk. The mean differences were compared using a Mann-Whitney test as the data were not normally distributed,.

3. RESULTS

3.1. Description of the case study sites

Duko and Nyangua are two communities in two different regions of Ghana, they had differences and similarities. Duko had 54 HH consisting of 343 women, 354 men, 56 cattle, 250 sheep, 311 goats, (99 bikes and 44 motorbikes) and many chickens and guinea fowls. Nyangua is a bigger community, the amount of HH was estimated at 150 HH living in 75 compounds. In Duko every HH had one compound. In Nyangua different HH lived together in one compound, this created a great social cohesion in the village, which made farmers help each other frequently and have prices for labour service which were not fixed. As the prices for labour tasks like weeding and ploughing were not fixed per area of land but agreed upon by the two parties, farmers did not know how big their land was, but gave approximations. It might also be the other way around, that farmers do not charge per area of land because they do not know it. In Duko the houses were grouped in a village in Nyangua they were scattered all over the community. In both communities the livestock was not used as a daily protein source but to eat during ceremonies or to sell on the market (Baba and Sulimana, pers. comm.). (see table 5)

The farmers in Duko cropped together 232 ha or an average of 4.3 (SD 3.4) ha per HH. The total cropped area in Nyangua could not be estimated, as it was time wise not feasible to visit 150 HH. In Duko most farmers had small fields (0.3 ha SD 0.21) in the village and a higher number of bigger fields (0.9 ha SD 0.9) further away, on average 21 (SD 16) minutes by bicycle. The average total land size per HH was 5.7 (SD 4.4) ha. As there was no centralised village in Nyangua the concept of fields close by and further away was more complex, but the average field size was 0.5 (SD 0.4) ha and the average total land size per HH was 2.3 (SD 2.4) ha. As the size of the land was big in Duko farmers needed to use TP to be able to cover all and as the walking time to the fields could be high farmers tried to lower the labour intensity by using TP and herbicide. In Nyangua the land size was smaller and farmers thus manage with AT.

Using the typology of Michalscheck et al. 2017, we counted 20 LRE HHs, 24 MRE HHs and 10 HRE HHs in Duko, while in the main survey there were 6 LRE HHs, 12 MRE HHs and 7 HRE HHs. In Nyangua we did not determine the resource endowment of the entire community, but in our main survey we chose 5 LRE HHs, 10 MRE HHs and 11 HRE HHs. In Nyangua there were many female headed HH, this was according to the village coordinator (mr. Martin, pers. comm.) partly due to men dying from alcoholism. 6 female headed HH`s were interviewed. Duko is a Muslim community, men do thus not die from alcoholism. This might be one of the reasons we only interviewed one female-headed HH in Duko, following the list of farmers to interview.

Table 5: Comparison of both communities, concerning the amount of HH, the land areas and the village organisation.

	Duko	Nyangua	Statistically significance
# of HH	54	~ 150	n.a.
land/HH	5.7 (SD 4.4) ha	2.3 (SD 2.4) ha	0.000
average field size	0.8 (SD 0.9) ha	0.5 (SD 0.4) ha	0.000
house organisation	centralised	scattered	n.a.

3.2. Current ploughing practices

3.2.1. HW, AT & TP

Fields can be ploughed by HW, AT or TP, which are three different techniques for preparing the land. TP goes deeper in the soil, and does the work faster. TP could plough one hectare in 2.12 (SD 0.9) hours, while one pair of bullocks needed 16 (SD 9) hours or 6.8 (SD 6.6) days as bullocks could only work a limited amount of hours per day. HW needed 171 (SD 101) man-hours to plough one ha. TP used discs to plough the land. AT used mouldboard ploughs in Duko and ridging ploughs in Nyangua (Fig. 3). Ploughing was mostly done to cover weeds and loosen the soil. A ridging plough makes ridges on which the plants can be seeded. Discs and mouldboard ploughs on the other hand aim at a flat field after ploughing.


a. b. c.

Fig. 3: a. a mouldboard plough, b. a ridging plough and c. a man ploughing by HW are shown.

3.2.2. Bulls or oxen

In Nyangua bulls were used for ploughing whereas they used oxen in Duko. Bulls were preferred in Nyangua as oxen would be worth less money when they would sell them. In Duko they said that oxen are calmer than bulls, thus easier to train. In the both communities there were two main cattle breeds, the Fulani and the local cattle. The Fulani cattle are stronger, but were also more expensive. Due to previous cases of theft farmers kept their valuable bullocks inside their compound: in Nyangua in a yard and in Duko in a separate (roofed) building.

3.2.3. Prevalence among farm types

Concerning differences in ploughing techniques among farm types, we observed that as bullocks were expensive only MRE and HRE farmers could afford them. In Duko 4 of the 54 HH's owned bullocks while in Nyangua 8 of the 26 surveyed HH owned bullocks. As there were so few bullocks in Duko only a fraction of the land could be ploughed with AT (32 ha). The HH owning AT in Duko ploughed own land (14 ha or 3.5 SD 1.9 ha/farmer) with them, but also other farmers land (18 ha or 4.5 SD 4.2 ha/farmer). Even though they ploughed other farmers land with their own bullocks the four farmers still rented TP for 29% to 76% of their own land. As an example one farmer in Duko even told he provided AT service to have money to pay for the tractor.

Farmers in Nyangua ploughed with own bullocks if they had some or borrowed the bullocks from other farmers.

To compare the three techniques, the surveyed farmers in Duko ploughed together 6 ha with HW, 17 ha with AT and 110 ha with TP. In Nyangua the surveyed farmers ploughed 6.4 ha by HW and 53 ha by AT. Only one of the 25 interviewed farmers in Duko and one of the 26 interviewed farmers in Nyangua ploughed all their land with HW, they were LRE HH's. In Duko the HW using farmer cropped 2.2 ha and in Nyangua 1.6 ha. In Duko all other interviewed HH's used TP. In Nyangua only one HRE farmer used a tractor for ploughing, this next to using his own bullocks. Most farmers in Nyangua did not know that somebody in their village used TP (the AR facilitator said nobody ploughed with TP the year before

and when doing the main surveys most farmers mentioned they had never seen TP, only when doing the community level interviews we found out that one farmer used TP).

3.2.4. Gender differences

Men were responsible for ploughing, as for most other labour tasks around crop cultivation. No woman, in Duko or in Nyangua, (was) reported to be actively involved in ploughing. In Duko one female headed HH was interviewed, the son answered more questions than his mother as he was more aware of what happened on their land. In Nyangua the six female HHH were also often in the presence of their sons, but could answer (more) independently. Women were unaware of any prices related to ploughing, some even started laughing when they were asked about prices of bullocks or ploughs, as if it was embarrassing or as if they were not allowed to know it. No female headed HH was found who owned bullocks. In Nyangua in female headed HH, other HH members usually did the ploughing together with some people owning bullocks. All female headed HH were LRE (1 in Duko and 3 in Nyangua) or MRE (3 in Nyangua).

3.3. Agro-economic reasons of choice

The agro-economic reasons of farmers to choose for one of the ploughing techniques were the cost of the ploughing itself, the cost of not or late ploughing and the yield. The yield was influenced by various other factors.

3.3.1. Cost of ploughing services

Prices for ploughing services were higher and were also perceived as being higher in Nyangua compared to Duko (table 6). In Duko the prices for ploughing were fixed. In Nyangua on the contrary there was a wide variation in prices for AT services and for the price of TP the experts said it was an approximation. There were various ways of paying for ploughing services like paying in kind, paying with labour or paying in money. The wide variation of ways of payment and prices was because farmers bargain about the price and way of payment. As there was a great social cohesion, the price depended on the relationship of both parties. In 40% of the fields that used rented AT, the farmer did not pay for the service.

Table 6: Prices and the perceived cost of ploughing services, for services paid in money.

Technique	AT	TP	AT	TP
	Price in GH₵/ha		Perceived cost Likert scale	
Duko	86	123,55	2.9 (SD 0.7)	4.3 (SD 0.9)
Nyangua	74-247	~ 198	4.6 (SD 0.7)	5 (SD 0)
Statistically significance	n.a.	n.a.	0.000	0.044

3.3.2. Cost of delayed ploughing

An even higher cost than the cost of the ploughing service was the costs of not being able to have the ploughing service on time. The average cost of delayed ploughing as estimated by the farmers was, similar (sig 0.299) in both communities, 1104 (SD 964) GH₵/ ha in Duko and at 1466 (SD 1242) GH₵/ha in Nyangua. This yield loss was estimated by subtracting the yield farmers would have expected if they would have ploughed on time from their actual yield. As tractors and bullocks were lacking in Northern Ghana, not every field can be ploughed on time, therefore farmers delay their

ploughing. Delay in ploughing caused delayed plant growth during the rest of the cropping season and as the seasons are short, delay in ploughing caused large yield losses.
In Duko, all six LRE farmers reported yield losses due to delayed ploughing and most MRE farmers and HRE farmers also had losses due to delayed ploughing (8/12 for MRE and 5/7 for HRE). In Nyangua, LRE, MRE and HRE farmers reported yield losses (4/5 for LRE, 8/10 for MRE and 5/11 for HRE). In both communities farmers with a pair of bullocks did not report delayed ploughing. But in Nyangua farmers with only one bullock did report delayed ploughing. This as they had to wait on the another bullock to pair with. Costs of delayed ploughing were estimated to be higher for higher resource endowed farmers (see fig. 4). For MRE and HRE farmers the yield losses were higher in Duko as farmers had more land they could thus lose more.
As this yield losses are very high it can be argued that this is the main driver for farmers to choose a ploughing technique independent of their resource endowment.

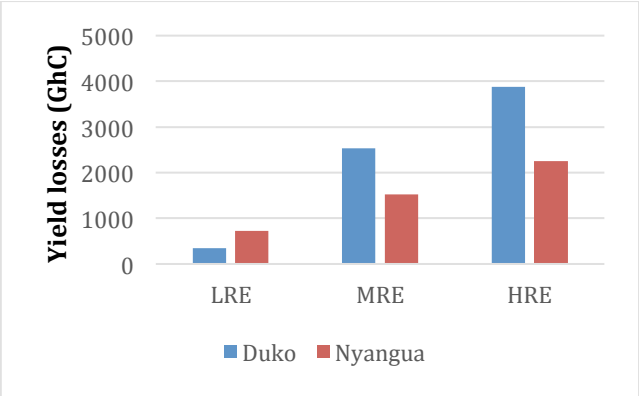

Fig. 4: Estimated average yield losses* in GH₵** per farm
* For farmers reporting yield losses
** as value of all crops

3.3.3. Ploughing conditions

As timing of the ploughing was crucial to get a high yield, 5 farmers in Duko mentioned it was the main reason to choose for a technology. Timing was not only important to be able to plant on time, but also to have good ploughing conditions. There is an optimal period for ploughing with AT, it is based on the soil moisture, there should be sufficient moisture in the soil to support the growth of the seedlings (Sulimana, pers. comm.). As AT ploughing takes time, farmers had to start ploughing before the optimal day and continue ploughing after it, which causes suboptimal ploughing conditions, leading to suboptimal planting conditions. Ploughing with a wrong humidity or on a too weedy field or wrong operating can have a negative effect on the quality of the ploughing (Sulimana, pers. comm.). For example: a HRE farmer using bullocks in Duko had to start ploughing before the optimal ploughing moment (to be able to cover more area), the soil was thus a bit too dry and when ploughing with his mouldboard plough he formed small ridges, while he wanted to plough flat, this will cause the seeds to be seeded at uneven height (the ridges were too small to be of any use in later seeding). This farmer also rented TP, because he would be unable to plough all his land by AT within the period that has good humidity for ploughing. Farmers would prefer to plough with AT or TP but did still plough some of their fields by HW as they did not want to miss the ideal time on all there fields.

3.3.4. Yield

All farmers considered yield as an important factor for choosing a technique (Fig. 5). But not all farmers agreed on which technique yields best. This was because various factors affected the yield, the main ones were the planting density, mentioned by five farmers in Duko and the quality of the

ploughing itself. But for the planting density there was again no consensus on whether it was higher for AT or TP. 9 farmers in Duko said planting density is one the main factors driving the required amount of fertiliser per ha, but there was also no consensus on which technique required more fertiliser inputs. From the field information from Duko, applied fertilisers was similar (sig 0.991) for the different techniques, as well as yield (sig 0.262).
For the amount of weeds there was again no consensus among farmers. Two farmers mentioned that deep ploughing (TP) buries weed seeds two other farmers mentioned it brings them up. What we could see from the field data is that with a higher level of mechanisation there was a higher level of herbicide use (sig 0.017). From the labour figures we saw that weeding time was similar (sig 0.891) on fields ploughed with HW, AT and TP, for maize in Duko.
For compaction and moisture there was again no agreement. Four farmers in Duko explained that with deeper ploughing the soil becomes looser thus less compacted three other farmers explained that the heavier tractors cause more compaction. Concerning the moisture two farmers in Duko explained that deep ploughing brings up gravel, one said it causes bad water retention the other said it slows infiltration thus increases water retention. Only the perceptions for Duko were noted down here as most farmers in Nyangua could not answer the questions concerning tractors, as they told they were not aware of it. No clear pattern was found between the resource endowment and perceived quality of the ploughing by AT and TP.

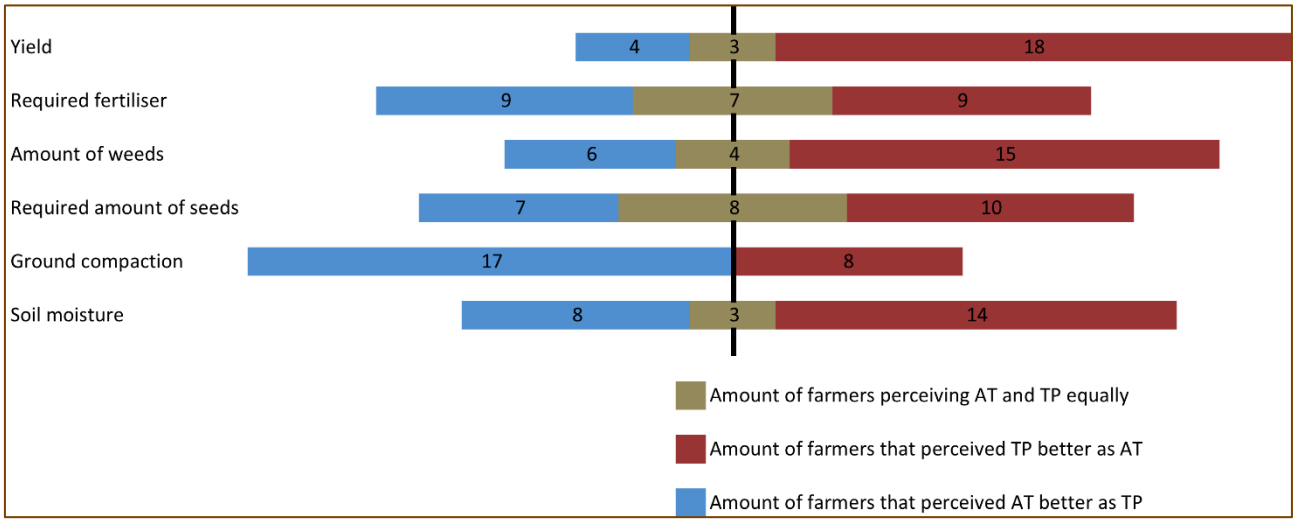

Fig. 5: Number of farmers perceiving TP or AT better for different factors in Duko, the black line shows the neutrality line.

3.4. Social reasons of choice

Farmers did not only choose how to plough based on what was cheaper and yielded more; they also took social factors into account. The difficulty to choose an operator, the bad quality of the work of the operators and the prestige of the techniques were important factors to take into account.

3.4.1. Skills to speak to operator

Another *factor of choice* encountered with renting AT or TP was the skills required to speak to the owner or operator. Farmers mentioned that it cost them a lot of time to look for the operator to plough for them. For TP service some mentioned they had to follow the tractor operator for several days to be sure he would come to their field afterwards. When we saw tractors ploughing in the fields around Duko or AT ploughing in the UER we saw farmers waiting there to get the tractor to their field afterwards. (Fig. 10).


a.

b.

Fig. 10: a. Father and son ploughing one field in Duko and b. 4 farmers ploughing one field in the UER

3.4.2. Careless operators

Famers mentioned that the AT or TP operator was not always doing the job like he should do it. They mentioned that some operators did not plough at the required depth, avoided weedy parts, cutted corners of field, etc. with the aim to be done faster. 8 farmers in Duko and 15 farmers in Nyangua mentioned the job would be done better if they would have done it themselves.

3.4.3. Prestige

Some farmers (11 in Duko and 24 in Nyangua) found prestige ('what neighbours will think of them') important for taking decisions, others (14 in Duko and 2 in Nyangua) did not find it important. Which techniques were considered as prestigious differed. For example most farmers found that HW is not prestigious as it is a sign of being poor, but 5 farmers in Nyangua found it prestigious as they considered it as a sign of strength and health.

3.5. Trends

As investments in AT were high we were wondering if farmers would really consider investing in it if they would have the possibility. Another question was why do farmers not use their AT equipment for other labour tasks when they already have bullocks.

3.5.1. High demand for owning bullocks

In Duko 5 famers who did not have bullocks said they would like to buy some, provided they had the money for it. Owning bullocks would lower their costs of delayed ploughing. In Duko, it would also spare them of the high cost of TP service.

In the small community based interviews most farmers thought that AT was decreasing (in Duko 6 interviews said it was decreasing while two said it was increasing in Nyangua 11 interviews said it was decreasing while 3 said it was increasing).

3.5.2. Multi-purpose technology

In Duko neither animals nor tractors were reported to be used for labour tasks other than transport of manure and ploughing, while they could be used for weeding. In Nyangua it was used by some farmers, said 7 community level interviews. This was in Duko, according to one farmers of older age, because younger farmers lost knowledge about how to weed with bullocks. Another reason he mentioned was that farmers in Duko did not use ridging ploughs anymore, but mouldboard ploughs. Ridging ploughs could be used for weeding, mouldboard ploughs not. In Nyangua farmers still used ridging ploughs, but AT was not widely used for weeding as one community level interview said it to be double work.

He said he would still have to finish the weeding by hoe after going through with the bullocks. In both communities farmers said during the community level interviews (1 in Duko and 2 in Nyangua) that they did not use AT for weeding because their bullocks were not trained enough, In Duko 6 of the 8 community level interviews concluded that they did not have knowledge about weeding with AT. In Nyangua one community level interview said that farmers prefer to use the scarce service rather for ploughing than for weeding, and as there was a lack of bullocks few people used them for ploughing. In villages neighbouring Nyangua we met two farmers using bullocks to weed (with the ridging plough and with a weeder), they both bought their weeders long time ago and did not know where it could be bought now.

4. Discussion

In this section the results will be discussed and compared with literature. But first the bias that might have happened will be discussed. This to bring awareness on the problem. During the entire research we tried to avoid it as much as possible, but avoiding it completely is not possible.

Bias

Bias in farmer's interviews is a main problem in research like Crawford (1997) mentioned. Crawford (1997) called "Influence of groups at interview" as a form of bias. During the main survey family of the farmer or other villagers were often around. Family members helped to give correct answers when the HHH did not know it, but they also influenced the decision especially during the questions on perceived performances. When the other persons were HH members it can be argued that this was not such a big problem, as when the farmer would chose for one of the techniques he would also listen to the other HH members. Future research could look at who takes the decisions and link that to the persons that are best present during an interview.

Farmers can also voluntarily give wrong answers like following example: One farmer was interviewed, later he was interviewed again, and we realized that the data on labour were completely wrong, we did them again with his wife and children, at the end he admitted in local language to his wife that he lied to show himself as stronger than he was. In this case the voluntarily wrongly given answer was detected, but it is not known how much of the answers were given incorrectly or imprecise, purposely or mistakenly. Another factor concerning the exactness of the data is that some farmers might have tried to omit or add information, because they thought it would increase their chances of projects giving them stuff.

As most of the farmers from the GARBES data received help from AR, and not all the other farmers, these might have created a bias in the results. The fact they received help might explain why they were less LRE farmers in the GARBES data. The length of the survey might also have caused farmers to lose their reflection capacity and answer the questions less good.

It is thus of great importance for future research to think about the effect, positive or negative, other persons might have on the answers; to make sure the farmer gives the correct answers.

Discussion of the results

The aim of this research was to understand farmers' choices concerning the ploughing of their land. Various agro-economic and social reasons were found, but we are unable to firmly say which technique is better as there was discordance among various factors. In literature we found that there were many differences and similarities with other research in Ghana and elsewhere.

In this research, we found that farmers plough on average 3.5 ha of own land and 4.5 ha of other farmers land in Duko. Houssou et al. (2013) found similar values for Northern Ghana (3.8 ha/farmer of own and 2.9 ha/farmer for other farmers land).

Women were not involved in ploughing in Ghana as in Ethiopia where it is also not culturally accepted to plough for a woman (Aune et al., 2001). Aune et al. (2001) said that this leads to more vulnerable HH's when they are headed by women. We indeed did not find any female headed HH that was HRE, but if it is because of the ploughing or other reasons, can not be concluded out of this research. This taboo for women to plough is certainly not something universal in Botswana for example a higher percentage of widowed woman (47%) provided their own ploughing compared to men (45 %) (Brown 1983). A lot of strength is required from a person to handle the plough. Probably partially for this

reason, women and children were less involved in the management of draft animals then men (Houssou et al., 2013). It is important to know who is responsible for which tasks as these are the persons that projects need to address when addressing the task.
In Ghana bulls as well as oxen are used for AT, in Ethiopia (Aune et al, 2001) they use oxen like in Duko. This is because they are easier to handle and train.

High prices for ploughing are not something that is only so in Ghana; Brown (1983) indicated that ploughing was also expensive in Botswana, the prices were even so high there that they were not always paid back with the low yields. In Duko and Nyangua only fields with nearly no yield would not be able to pay the ploughing back out of the yield. This was rare but it could be discussed that it might happen more frequently with changing climatic conditions, and dropping yields.
In Nyangua prices for ploughing were based on the relation between the two parties while in Duko there was a fix price indicated in money. In Ethiopia like in Nyangua they also rented AT service from relatives (Aune et al., 2001). In Ethiopia prices for ploughing were in percentage of the yield while in Duko they were fixed, in Nyangua they did also not depend on the yield (Aune et al., 2001). It could be discussed that if the prices would be based on the yield like in Ethiopia, operators might plough more carefully. In Ethiopia the price for ploughing was 50% of the harvest (Aune et al., 2001), which was considerably higher than in Duko or Nyangua. Farmers in Ethiopia paying with exchange labour had to work two days per day the oxen worked (Aune et al., 2001). In this research this was not looked at, but could be an interesting factor for future research, as it would lead to a better understanding of the social interactions in Nyangua.

Farmers in Duko found it difficult to get farmers to come and plough their land. This was also found by Diao et al. (2014) who also had farmers in Ghana telling them that there was a strong lack of tractor services, and that they had to approach more than one operator to get a tractor to their field. Careless operators were not only a problem in Ghana, in Ethiopia Aune et al (2001) also noticed that farmers owning bullocks ploughed their land more intensively, the quality would thus be worse for farmer not owning AT.

Various authors (Nyagumbo, 2017; Biamah et al, 1993; Wilcocks and Twomlow, 1993) also mentioned that ploughing on time is important for the yield, but they did not quantify the costs of the delayed ploughing. Brown (1983) found that in Botswana resource poor farmers got their fields ploughed late or not at all, in Duko as well as in Nyangua farmers from all resource endowment got delay in their ploughing. This might be because in Duko prices are fixed and it was not the one who offers most who got the service first. Costs due to delayed ploughing were tremendously high in Duko and Nyangua. It might be a recommendation for project wishing to help, to provide reliable ploughing services instead of providing inputs.

Most farmers in Duko and in Nyangua said that AT was decreasing this contrasting with what Houssou et al. (2013) found for the UER, where they found more farmers thinking AT was increasing and similar to what they found in the NR, where they also found more farmers thinking AT was decreasing.

There was a great discordance among farmers on which technique performs better, Pingali et al (1987) also found that farmers were not agreeing on weeding time after AT or TP. This discordance might be because there is no or only minor difference in the performance. Pingali (2007) found that there is generally no yield difference between AT and TP. Similarly Herdt (1983) and Binswanger (1974) found that the difference in yield between AT and TP were more due to different amount of

inputs than to the technologies themselves. We found that farmers were not agreeing on which techniques causes less weed problems; Pingali et al (1987) also found that farmers were not agreeing on weeding time after AT or TP. Future research might want to look experimentally at the performances of both techniques like García-Tomillo et al. (2017) did, they found that TP causes more compaction than AT. Not all farmers in Duko agreed upon this.
There was thus a vast disagreement among the farmers, the question that was not answered is, was this disagreement due to different realities or due to different ways of thinking. Further research could look at this by linking the perceptions of farmers to their agro-economical realities.

Many farmers mentioned, they would buy bullocks if they would have money to buy some. It can be discussed whether they really meant it. As farmers preferred to invest in cows, which reproduce. It can also be discussed if the farmers telling they want to buy bullocks only told this because they wanted the West to give them some, or because they were really thinking of buying bullocks.

Labour shortage was a main problem in smallholder agriculture, it was for ploughing only a problem if we relate labour to the time window in which the task should be done. We would thus suggest that future research, making labour figures, does not only look at the amount of time a task takes, but also at the time window for it. Gender should also be looked at as the available labour can be available for some labour tasks but not for others as different people have different responsibilities.

This study serves as an example for the benefits of multidisciplinary research. It shows that farmers' perceptions are not always what we would expect that they are, nor what can be found from field data or literature. Farmers act out of their perception, it is thus of uppermost importance that next to knowing if a project would work from an experimental point of view, if farmers would also perceive that the project would work. The study thus helps to spend development money or "private commercial" resources well and help research for development efforts to actually reach and benefit the farmers.

5. CONCLUSION

The aim of this research was to understand farmers' choices concerning the ploughing of their land in two communities in the North of Ghana.

Nyangua was a community with more HH's then Duko. In Nyangua the compounds were scattered around while in Duko they were centralised. Even though the compounds were scattered in Nyangua there was a bigger social cohesion. All three ploughing techniques were still present in both communities and all resource endowments, with a widespread use of TP in Duko and a widespread use of AT in Nyangua.

Ploughing was a responsibility of men in the two communities and among all resource endowment; in projects concerning ploughing the focus should therefore lay on men.

Farmers that did not own bullocks (or a tractor) rented them, this was expensive and the quality was not always optimal. On top of that, due to the lack of tractors and bullocks, the service often arrived late, leading to big yield losses.

There was no consensus on which technique was better from an agronomical point of view. Farmers contradicted each other as on which technique yields more, compacts the soil more; causes more weed problems, etc. This discordance was also found in literature. Part of the farmers also considered what other farmers would think of them in choosing a technique.

What farmers agreed upon is that ploughing late causes tremendous yield losses. This threat might be the main economic incentive to choose for a technique.

It can thus be concluded that farmers chose for one of the techniques based on what they think is economically best for them, this taking their financial potential and the social implications into account.

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ANNEX 1: TRANSLATORS

In Duko 4 different translators were used:

- Mohamed Ghana Idrissu: a retired MOFA (ministry of food and agriculture) officer, that already worked for AR in Duko
- Mohamed: a master in agriculture student
- Musah: a MOFA officer
- Suliman Al Hassan: a bachelor in agriculture student that already worked with AR in Duko

In Nyangua 2 different translator were used, the latter one was only used one day:

- Prosper: a high school graduate that already worked for AR in Nyangua
- Roger: translator that already worked for AR in Nyangua

ANNEX 2: COSTS OF OWNING BULLOCKS

	Animal	Plow	yoke	nose ring	rope
Price					
When bought?					
Remaining time					
Reaparing costs					
Salvage value					
what does it become					

	training	
Who		O=owner, H=houshold member, E=external
Price		
Time		
High skills	Y/N	

	own land	other HH	external
Acres ploughed			
Money asked			

	Feeding	Fulani
Feed in season		
Price		
Feed Off season		
Price		

	Where	costs	lifetime	Maintenance	Other use %
Animal housing					

	What	Costs	When
theft			
fatal deseases			

	How much	Which task	value
Use outside season			

ANNEX 3: COMMUNITY LEVEL INTERVIEWS

Why do you think there is no TP in Nyangua? *only for Nyangua
Mention the advantages and disadvantages of TP and AT.
What are the consequences of using the different techniques on the labour requierments during the grouwing season?
Why is mechanisation not used for other labour tasks, for example using AT for weeding?
Does delay in ploughing cause high yield losses to you?
Do you believe there is enough feed for more bullocks in Duko/Nyangua?
Are the amounts of tractors and bullocks increasing or decreasing? (lacking?)
Do you consider theft as being a problem?
Do you consider the bad quality of the service ploughing as a problem?
Would people chose different crops, if they would plough with different techniques?

ANNEX 4: EXPERTS

Next to the translators following persons were considered as experts.

- Mr. Martin the community facilitator of Nyangua.
- Sumani Assafani the community facilitator of Duko.
- Dukurugu who is working for AR.
- An employee the TIF, whose position is unknown.
- Kipu Natomah working for Mazara N`Arsiki, an organisation that is providing inputs and input credits to farmers.

ANNEX 5: EXPERT INTERVIEWS

Following questions were asked to Mr. Martin, Dukurugu, Mohamed Baba Idrissu and Kipu Natomah

Mention the advantages and disadvantages of TP and AT.
Why is AT not used for other labour tasks?
Do you agree that delay in ploughing causes high yield losses?
Is bad quality in ploughing services a problem?
Are AT and TP decreasing or increasing and why?