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Demand assessment for on-farm natural resource management technologies in semi-arid areas of Tanzania: A case of Hombolo and Ilula villages.

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DEMAND ASSESSMENT FOR ON-FARM NATURAL RESOURCE MANAGEMENT TECHNOLOGIES IN SEMI-ARID AREAS OF TANZANIA: A CASE OF HOMBOLO AND ILULA VILLAGES

1. Introduction

The basic assumption behind this study was that, despite considerable investment in agricultural development programmes in semi-arid areas of Tanzania, the overall agricultural output is low and the natural resource base is depleting at an alarming rate. There are several factors contributing to this situation. One of them is the apparent low level of uptake by farmers of research-derived technologies for on-farm conservation of natural resources. This study set out to address this issue and assess the likely level of demand for future research outputs of this kind.

Using a case study approach some important production systems of semi-arid areas of Tanzania are identified. With the help of participatory farm management tools both livelihood and production constraints are analysed. Demands for future technological innovation are identified from the empirical data.

1.1 Background

Tanzania has a land area of 886,000 km^2 with complex climate, soils and topography. The semi-arid zones occupy about one third (295,000km^2) of the total land area and extend NE / SW across the central part of Tanzania (Hatibu *et al.,* 1995). About 80% of Tanzania receives less that 1000mm of seasonal and unreliable rainfall which is inadequate for food security and self sufficiency (FAO, 1991; SWMRG, 1994).

The semi-arid areas of central Tanzania, Dodoma in particular, receive less than 500mm rainfall per year. Droughts are a common feature in the villages such as Hombolo, resulting in frequent famine as much of the rain is lost through runoff (McFarland *et al.,* 1991; SWMRG, 1994).

Most of the soils in semi-arid areas are poor, degraded and have low nutrient reserves contributing to general soil infertility. For instance, most of the soils in Hombolo are characterised by low nutrient status, particularly with regard to phosphorus and exchangeable base content. Organic matter levels in the soil are low and soils are susceptible to erosion. Only dark, sticky cracking clays and friable and calcareous clays are found in poorly drained parts (lowland plains), which, to only a very limited extent, have satisfactory amounts of exchangeable bases (Christianson, 1980).

The situation in Hombolo is not much different from that of Ilula village in Iringa region. Ilula village is mainly covered by sandy loam soils and small patches of clay-loam and loamy sand (HIMA, 1992). The area is seriously affected by soil erosion caused by land terrain, overgrazing, rainstorms and poor farming practices. Thus, the village has remarkable fertility decline problems resulting in low crop yields.

Crops grown in semi-arid areas of Hombolo and Ilula experience water and nutrient stresses combined with the inappropriate use of inputs such as improved seed, and poor tillage and soil fertility improvement practices (Hatibu *et al.,* 1995; Mwaseba *et* *al.,* 1996*;* Senkondo *et al.,* 1998). These in turn lead to low food crop production and hence poor food security. Various on-farm natural resource management technologies have been introduced in Hombolo and Ilula in order to improve conservation of soil water, nutrients and plant genetic resources.

1.1.1 Soil nutrient management

There is a wide range of nutrient management measures that can both maintain soil fertility and sustain productivity. These are increasingly being known as integrated plant nutrient systems (FAO, 1991). They focus on improving the efficiency of inorganic fertilisers, introducing new crops into rotations that fix nitrogen or utilising organic sources of nutrients.

When crops are harvested, nutrients are invariably removed. It is virtually impossible, therefore, to maintain or increase crop production without continuous addition of nutrients. For more than two decades, the use of inorganic fertiliser has dominated agriculture production systems of many developed countries (Ofori, 1993). However, the use of inorganic fertilisers in developing countries has been drastically declining, from already relatively low levels. This has been caused by many factors, among them the energy crisis which has affected most of the developing countries (Hauck, 1982). Farmers have low financial ability to purchase inorganic fertilisers that in most cases are very expensive for small scale farmers to afford (Pretty, 1995).

In Tanzania, the decline in the use of inorganic fertilisers has been accelerated by the removal of fertiliser subsidies. Farmers are supposed to pay for all agricultural inputs including fertilisers. This has contributed a lot to low crop production in many parts of the semi-arid areas of Tanzania. Farmers who can neither afford nor rely on a regular supply of inorganic fertilisers must find another type of fertiliser, the organic, such as farmyard manure and compost. To the resource poor farmers these types of fertilisers are not only cheaper but also more efficient than inorganic compounds in terms of soil nutrients recycling, soil improvement and soil water retention (Pretty, 1995).

Tanzania is endowed with a large number of livestock such as cattle, goats, sheep, pigs, donkeys and poultry. Efficient use of manure from these animals could substantially alleviate the problem of declining soil fertility. According to Kyomo and Chagula (1983) the total animal manure output in Tanzania in the early 1980s was about 11 million tons per year which could supply total nitrogen of about 77,000 tons. Although this represents less than a kilogram per cultivated hectare, it is currently an underused resource. Very little animal manure is being used for crop production in most parts of Tanzania. For instance according to Kimbi *et al.* (1992), only 1% of farmers in semi-arid areas of Dodoma apply animal manure on land, indicating serious under-utilisation of this resource.

Gabriel (1998) reveals that one of the major reasons for under-utilisation of animal manure for crop production is lack of technical know-how by most of the farmers. This is also to a large extent due to lack of scientific basis for advising farmers on aspects such as application rates, storage techniques and appropriate manure application methods. Other factors are long distance from the manure source to the fields and poor transport facilities.

In Ilula very few farmers apply farmyard manure on their fields. This is because of limited amounts of livestock in the area compared to Hombolo. The few with livestock find it difficult to collect, transport and handle the manure (HIMA, 1992).

1.1.2 Soil water management

Soil is the most basic of all resources and essential for crop production. It is more important to the achievement of sustainable agriculture because it contains the nutrients and stores the water essential for plant growth. The manner in which the soil is managed has a tremendous impact on its productivity and sustainability (Scholes *et al.,* 1994). Increasingly, in Tanzania the most limiting factor for subsistence farming is soil quality, which calls for the need of soil conservation measures for the purpose of improving key soil characteristics, including nutrients, water and structure.

Soil conservation activities in semi-arid areas of Tanzania started under the colonial administration in the 1930s. During the 1940s and 1950s soil conservation involved measures such as reduction of stock numbers, ridge cultivation, use of contours, rotational grazing and gully control and the relocation of settlements. Village forestry was attempted on a small scale to create firewood reserves for the local people as well as controlling soil erosion (Mbegu and Mlenge, 1983). Soil conservation during this period was associated with colonial force, where some of the works were assigned to people as punishment for disobedience to local rules and tax evasion. It was thus considered as an interference with local traditions (Christianson *et al.,* 1993). In another account it is documented that because of their discriminative nature and application, these measures proved to be unpopular among the indigenous people (Kauzeni *et al.,* 1987). This was one among several reasons why conservation work was abandoned after independence (Christianson *et al.,* 1993).

The situation has changed dramatically, following strong government commitment towards soil conservation. In 1973, the government started a state-run soil conservation project in Dodoma region, popularly known as HADO (see Mbegu, 1988; Kikula and Mung'ong'o, 1992; Christainson *et al.,* 1993). Since then, the government has emphasised the use of various soil and water management practices to improve agricultural productivity, among them the use of proper agronomic practices such as proper tillage systems.

Lack of knowledge and the type of crops grown contributed to the failure to adopt soil water management programmes (Hatibu *et al.,* 1995; Hatibu *et al.,* 2000). Indeed land tenure arrangements also have some influence on adoption of soil water practices. Farmers who rent land regard insecure tenure as a constraint in the adoption of soil and water practices. Farm size and number of plots owned also influence the adoption of soil and water management practices. The majority of farmers in semi-arid areas like Hombolo own smaller farm sizes contributing to their non-use of soil and water management practices in any of their plots (Hatibu *et al*., (2000).

Availability of off-farm income is an indicator of access to financial capital and has a positive influence on investment in soil water practices. Financial capital is important to pay for additional labour when investing in soil water management, and in some cases to pay for cement for water diversion structures.

Ilula village lacks a proper land use or area plan. This imposes difficulties in implementing soil and water management activities due to the fact that the area is planned and partly surveyed following urban planning standards that may not be in favour of agricultural activities and other rural oriented activities. However, soil and water management measures are undertaken to take care of the low soil fertility of the village. These include *fanya juu*[1], tree planting, grass lines, and ridging across slopes. The most common cropping patterns being used for soil water and nutrient conservation are inter-cropping, crop rotations, and fallow rotations (HIMA, 1992).

1.1.3 Tillage

Deep tillage is normally used to break hard surface layers and mix them with soils of different textures. This method involves sub-soiling and chiselling. These methods are situation specific and generally have limited application in improving soil water conditions with natural rainfall in semi-arid areas (Pependick and Campbell, 1988). However, the merit of deep and moderately deep tillage may be that it enables plants to root deeper and access water reserves rather than any effect on infiltration rates.

No-till is a concept of farming designed to minimise tillage operations and thereby reduce energy requirements. This system involves complete elimination of mechanical seedbed preparation and reliance on herbicide and cover crops to kill or suppress weed growth (Kayombo and Lal, 1993). The applicability of no-tillage methods in the semi-arid areas such as Hombolo is limited by low quantity of crop residue and mulch attributed to poor vegetation cover and the large number of cattle grazed extensively directly in the field, rendering soils bare for most of the year. The majority of the farmers in Hombolo then do not till the land (no primary tillage): instead the previous crop residues and weeds are cleared and burnt in preparation for the next planting. This predominant practice in Hombolo is locally called *Kuberega*.

Occasionally soil moisture conservation tillage, particularly the ridging system, is practised in Hombolo, but only for some few crops such as cassava and sweet potatoes. The ridging system is not practised for crops such as sorghum and pearl millet (Swai, 1999).

Ellis-Jones *et al.* (1999) observed that household resource and cropping systems determine the adoption or non-adoption of a type of tillage system. They categorised farmers in a semi-arid area of Zimbabwe into three groups. Category 1 comprises farmers who are well endowed with resources and have large arable areas, experience no draught animal power (DAP) limitation, have a full range of implements, including a plough and ox-cultivator and regularly sell agricultural produce. Category 2 farmers have adequate land, own livestock but often have inadequate DAP, own only a plough

[1] *Fanya juu* - these are raised terraces designed to slowdown/stop run off of rainwater

and make irregular sales of agricultural produce supplemented by outside sources of income. Category 3 farmers, who were the majority in the communities included in their study, have smaller less developed arable areas, no DAP, use hand hoes and are dependent on subsistence production in good seasons supplemented by donations from drought relief and recovery programmes. Off-farm income is limited.

Farmers in category 1 and 2 are in a position to till their farms and can sometimes hire labour from outside in case of a shortage of family labour. Farmers in category 3 always provide labour for others, compounding their own labour shortage problems, which leads to extremely low crop production in their farms.

1.1.4 Plant genetic resource diversity

The most effective method for maintaining or enhancing diversity of plant genetic resources is to manage the genetic resources in a manner that will enable them to regenerate naturally. In developing countries, it is increasingly recognised that the future of agricultural progress will depend on the intensification of production which can be achieved through genetic resources diversification through the introduction of improved and/or new seed varieties (Cromwell, 1990). However, farmers have had limited access to these improved seeds which is contributing to the low yields of poor quality crops often found on small scale farms in semi-arid areas (ICRISAT, 1995; Mtenga, 1999).

Farmers in most cases prefer to adopt crop varieties which are suitable for their environment and produce higher yields. For instance in 1998/99, Sokoine University of Agriculture (SUA) introduced a new bean variety *ROJO* in Dodoma, which was the most preferred due to its drought resistance and higher yields. For the same reasons about 74% of the farmers adopted *Kilima* and *Staha* maize varieties in Kongwa, Dodoma (Machumu, 1995). Apart from the characteristics of the varieties themselves, the rate at which farmers adopt improved varieties is also determined by their farm income and their access to other resources such as land, livestock and off- farm income earning opportunities.

Machumu (1995) indicates that the extent of adoption of technologies introduced to farmers depends on factors such as age, education, farm size owned, credit facilities, drought and diseases tolerance of varieties, labour requirements, taste, market and appropriateness to traditional farming practices. This confirms Rogers' (1983) assertion that technologies that are easily observable, adaptable and compatible to farmers' traditional practices are readily adopted. According to Mtenga (1999) the adoption of new varieties depends on their marketability, colour, size of grain and taste. Farmers would like to adopt new varieties that are marketable and are tasty. For instance, SUA beans varieties introduced in *Msolwa* and *Kisanga* initially faced a market problem which delayed their adoption by the majority of farmers. However, a contributory factor was that the varieties were new to the area and farmers were not aware on where to sell them. Later, after trying the varieties, farmers are now becoming interested to plant them.

2. Objective

Discussion from Section 1.1 indicated that there has been low uptake of on-farm technological innovations in soil and water management (SWM), soil nutrient management (SNM), and plant genetic resources (PGR) in semi-arid areas (SAA) of Tanzania. This study set out to identify the reasons for low uptake and assess the demand for future technological requirements. To achieve this main objective this study had the following specific objectives:

(i) To identify the main production systems of the study villages
(ii) To identify important technologies that have been promoted in the areas
(iii) To analyse production constraints of different households
(iv) To describe and characterise adopters and non-adopters
(v) To identify social factors that influence communication network for adoption
(vi) To identify livelihood factors important to adoption and low uptake
(vii) To analyse farm input/output and their implications for adoption and adaptation.

3. Research methodology

This study used several qualitative methods to achieve its objectives. Later, quantitative methods were used to estimate the distribution of various parameters identified from the qualitative findings which are associated with adoption and non-adoption of the technologies.

3.1 Identification of the study areas

The initial stage of the methodological process required identification of the specific technologies in SWM, SNM and PGR which meet the following criteria:

(a) The technology is being practised in villages located in SSA.
(b) There is evidence that the technology is derived from research findings or has evolved from farmers' experimentation or innovations.
(c) There is demonstrated potential for widespread uptake among both resource access (RA) and resource restricted (RR) households.
(d) There has been no similar study conducted on the technology in the same village.

In order to ascertain these criteria, discussions were held with various key informants (KIs). They included members of the Soil and Water Management Research Group (SWMRG) at SUA and the Danish-funded HIMA project in Iringa, which is involved in on-farm natural resource conservation measures in the Southern Highlands of Tanzania. As a result of these discussions and mindful of the resources allocated for the study, it was decided to conduct the study in Hombolo and in Ilula villages in Dodoma and Iringa regions, respectively. Arrangements were made to visit the study villages where discussions were held with KIs from Hombolo agriculture research station which deals with sorghum and millet research, village extension staff, village leaders and prominent farmers. In Ilula, the discussions involved HIMA staff at Ilula sub-station as well as village leaders and various farmers.

As a result of the discussion and consultation described above, the following focus areas of the study were selected.

(a) In Hombolo, seed genetic resource diversification of sorghum and millet, and soil water management through improved tillage.

(b) In Ilula, seed genetic resource diversification of maize, and soil nutrient management through farmyard manure (FYM) application.

3.2 Qualitative data collection

A decision was made to use qualitative methods in collecting information, since such methods permit in-depth and detailed study of the selected area of enquiry without being constrained by predetermined hypotheses. The methods allow direct quotation of the opinions and perceptions of the farmers, which ensure rigour and evidence to support the findings. Later these findings can be used to draw out some assumptions about the technologies under study.

3.2.1 Sampling procedure

Hombolo village was stratified according to sub-village administrative boundaries. Five sub-villages were randomly selected out of seven and the results extrapolated to represent the whole village population. Administratively, three villages of Sokoni, Mwaya and Itunda form Ilula. Five sub-villages were randomly selected out of twenty and the results were extrapolated to represent the whole of Ilula.

3.2.2. Mode of discussion

During focus group and key informants' discussions, conditions were informal and enabled participants to discuss issues and express themselves freely. There was no disruption when farmers expressed a practice that contradicts technological recommended packages. Terminology or statements that would undermine farmers' practices were avoided and replaced by other synonyms. For instance, 'new techniques' for 'appropriate techniques', 'new variety' for 'improved variety', 'traditional seed' for 'poor seed'. These conditions were achieved by making discussion environments as typically local as possible. The use of conventional research materials such as papers, boards, and pen was discouraged. Discussions were held outdoors under the trees around the villages. Results were recorded on the ground using sticks, and later transferred onto paper. Natural and informal materials around the homestead were used to symbolise the distinction between different ideas and items of research.

3.2.3 Key informants' (KIs) discussions

With the aid of extension staff, twenty farmers in each village were selected as KIs. For each of the two technologies in each village there were at least five adopters. The rest were non-adopters or adapters of any of the technologies. Efforts were made to achieve a gender balance, with at least 30% male and 30% female KIs.

During the KIs' discussions the main issues explored were:

- On-farm natural resource management technologies and their source or origins
- Type of technologies introduced into the traditional production systems
- Social issues important for communication pathways and adoption

- Farmers' perception of the technologies and the implications they have on their livelihoods.

3.2.4 Focus group discussions (FGDs) with farmers

Five focus groups each of twenty farmers were formed in each village. The same criteria used to formulate KIs groups were used for FGDs and the same farmers later participated in the scored causal diagramming and the participatory budgeting.

A wide range of information highlighted during KIs' discussions were further investigated during FGDs. These included:

- Gender differences in relation to on-farm activities
- Similarities and differences between adopters and non-adopters
- Livelihood constraints to adoption
- Characteristics of adopters and adapters.

3.2.5 Semi-structured interviews (SSIs)

Semi-structured interviews were conducted to supplement some qualitative information collected from FGDs. The information included during SSIs was:

- Categories of resource access and resource restricted households
- Size of households and division of farm labour
- Farm size, number of plots, locations and type of soils
- General ownership status of farm plots
- The effect of off-farm activities on livelihoods
- Adoption of various technological innovations.

3.2.6 Participatory Farm Management (PFM)

Two main PFM tools were used in the study. In essence these tools use farmers' analysis to explore decision-making processes in the management of their production enterprises.

3.2.6.1 Scored Causal Diagramming (SCD)

The main feature of the SCD (Galpin *et al*., 2000) is that it takes the analysis of farm problems and constraints beyond the rank ordering generated by other participatory rural appraisal (PRA) methods. In scored causal diagramming the relative importance of the causes of a problem, as perceived by those participating in the analysis, can be identified alongside the interrelationships between causes and effects at different levels. In the field, the scored causal diagram can be generated by the following procedures:

- ♦ Identification of the topic related to the farm enterprise. For instance, maize production or soil nutrient management
- ♦ Identification of the main objectives for engaging in the enterprise
- ♦ Identification of the problems of the enterprise based on its objectives
- ♦ Diagrammatic representation of problems and their causes, in the form of a problem tree, using symbols
- ♦ Scoring of the causes at each level in relation to the relative contribution of each to the problem(s) to which it relates.

The 'root' causes of the main problem would be those on the edge of the diagram. The assumption is that these root causes need to be addressed in order to tackle the main problem. As well as providing an analysis of production system constraints, SCDs in this study also contributed to the investigation of factors affecting adoption and non-adoption, and the effect of various technologies on overall farm production and livelihood strategies

Causal diagrams were constructed with groups of farmers comprised of about 25% adopters of new seed varieties, 25% adopters of FYM and/or tillage and 50% non-adopters of either technology. Since each village had five sub-villages the resulting causal diagrams had some similarities and differences. They were consolidated to form one causal diagram for each village.

3.2.6.2 Participatory Budgets

The starting point for participatory budgets (Galpin *et al.*, 2000 is the time line associated with the production enterprise that is the focus of analysis. The process of constructing the PB involves the quantification of inputs and outputs during the production period and their representation against the time line. As in SCDs the inputs and outputs are represented using materials common to participants. The materials are arranged on grid lines drawn on the ground to represent months, weeks or days of the season within which the particular production enterprise can be accomplished. A distinction between PBs and similar PRA techniques is their use to address "what if" questions to look at options and the integration of various technological innovations within the enterprise.

In most parts of semi-arid areas of Tanzania, including Hombolo and Ilula, the main production enterprises are based on maize, millet and sorghum production. It is for this reason that villagers chose these enterprises to ascertain and compare the economic effects of various technologies on production inputs and output in the form of material, money, time and labour.

3.3 Sample survey

While the qualitative methods were expected to generate enough information to identify the factors associated with demand for natural resource management technologies, a sample survey was used in order to verify the distribution of these factors among the farming population. The base for this distribution was the number of the household heads within the study villages. For the survey, a random sample of households was drawn from the five selected sub-villages at each study location.

4. Results and discussion

In this section analysis of data and information from the group discussions, PFM exercises and critical observations made during the field visits are presented. Where appropriate, qualitative data/information are supported with the data from the sample survey. Data were analysed with the aid of Excel and SPSS-PC software.

A short description of the extension systems operating in the areas is presented. Detailed descriptions of farmers who participated as informants in KI and focus group discussions are presented. These are built from the results of social grouping in the study villages. Both livelihood and production constraints associated with uptake of technological innovations are synthesised and future technological requirements are highlighted as they evolved from the findings.

4.1 Promotion of on-farm resource management technologies

In both Hombolo and Ilula there are government funded extension systems of different magnitudes. In Hombolo, the efforts of the two female extension staff are occasionally supplemented with the activities of the Hombolo research station. In some instances, research activities initiated by scientists from SUA operate in the area. In Ilula, the extension system is of a greater scale and supported with subject matter specialists of various disciplines under the DANIDA[2] funded HIMA project.

The effect and evaluation of these extension systems toward the adoption of various technologies is beyond the scope of this study. However, an understanding of the social and communication issues related to adoption of the technologies is apparent, since research and extension programmes may use these social groups for technological innovation and promotion in the future.

4.2 Social grouping and communication pathways

The organisational set-up of both villages includes village extension officers. The organisation of the extension systems acknowledges the functional set-up of the villages, although communications between extension staff and individuals in the community are informal and based on spontaneous social grouping (Fig. 4.1).

4.2.1 Spontaneous grouping

During the discussion with KIs, observations were made to determine patterns of spontaneous grouping among the participants. The results helped to determine the qualitative factors that influence social inter-relationships and communication pathways.

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[2] Danish International Development Agency

Farmers and extension staff were asked to identify the similarities and differences among the groups and discuss the reasons for such formations. Arising from KIs' discussions, results show that villagers group themselves primarily on the basis of gender, i.e., men and women (Figure 4.1). While women tend to stick together, age is an important factor for further division of men. Old men who are perceived to embrace traditions would stick together, while old men who are perceived to be 'progressive' would form alliances with young men. It is in these social groups where the contact is strong and effective communication takes place. The groups display levels in command of respect and the pattern by which information passes among individuals and among different pertinent factions.

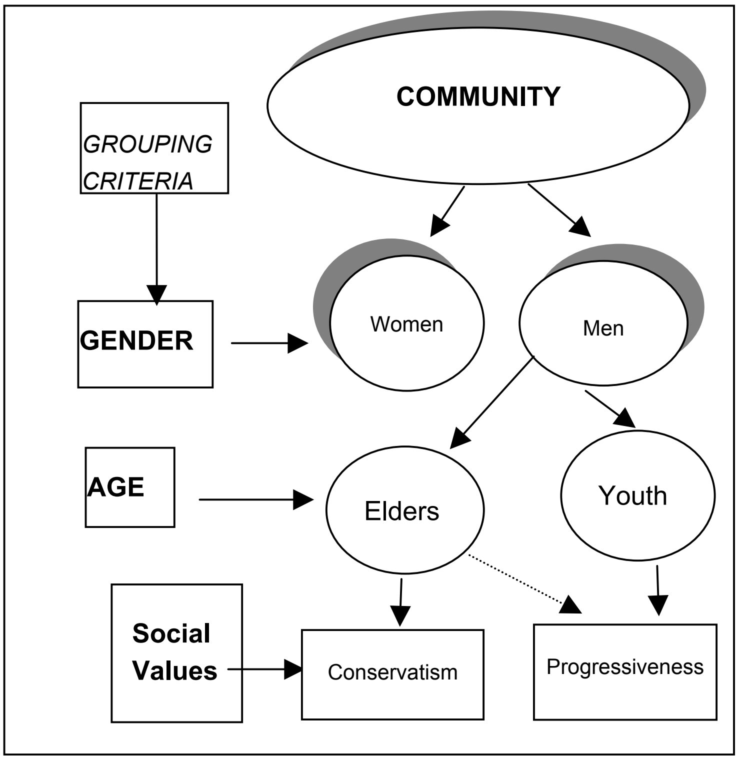

Figure 4.1 Spontaneous grouping

4.2.2 Deliberate social grouping

Although there are strong ties between group members presented in Section 4.2.1 there are as well exceptions which emerged when villagers were asked to group themselves deliberately. Similarities and differences, between and amongst the groups were apparent (Slide 1).

Slide 1 Deliberate grouping

As emerged in spontaneous grouping, in deliberate grouping rich men tend to cluster together as well as the women. However, where a woman is perceived to be better off compared to the other women, she will join the ranks of the rich men. It has been observed in this study that such shifting does not happen abruptly, but through a slow calculated move in which a rich women acknowledges the importance of women's solidarity but then disassociates to join the group of rich men. This phenomenon provides an important communication pathway within a society. It indicates that richer women may be important links and communication pathways between several groups within the study villages. Further analysis of the deliberate grouping revealed a complex pattern of similarity and differences between and among the groups (GR1 - GR6) as presented in Figure 4.2.

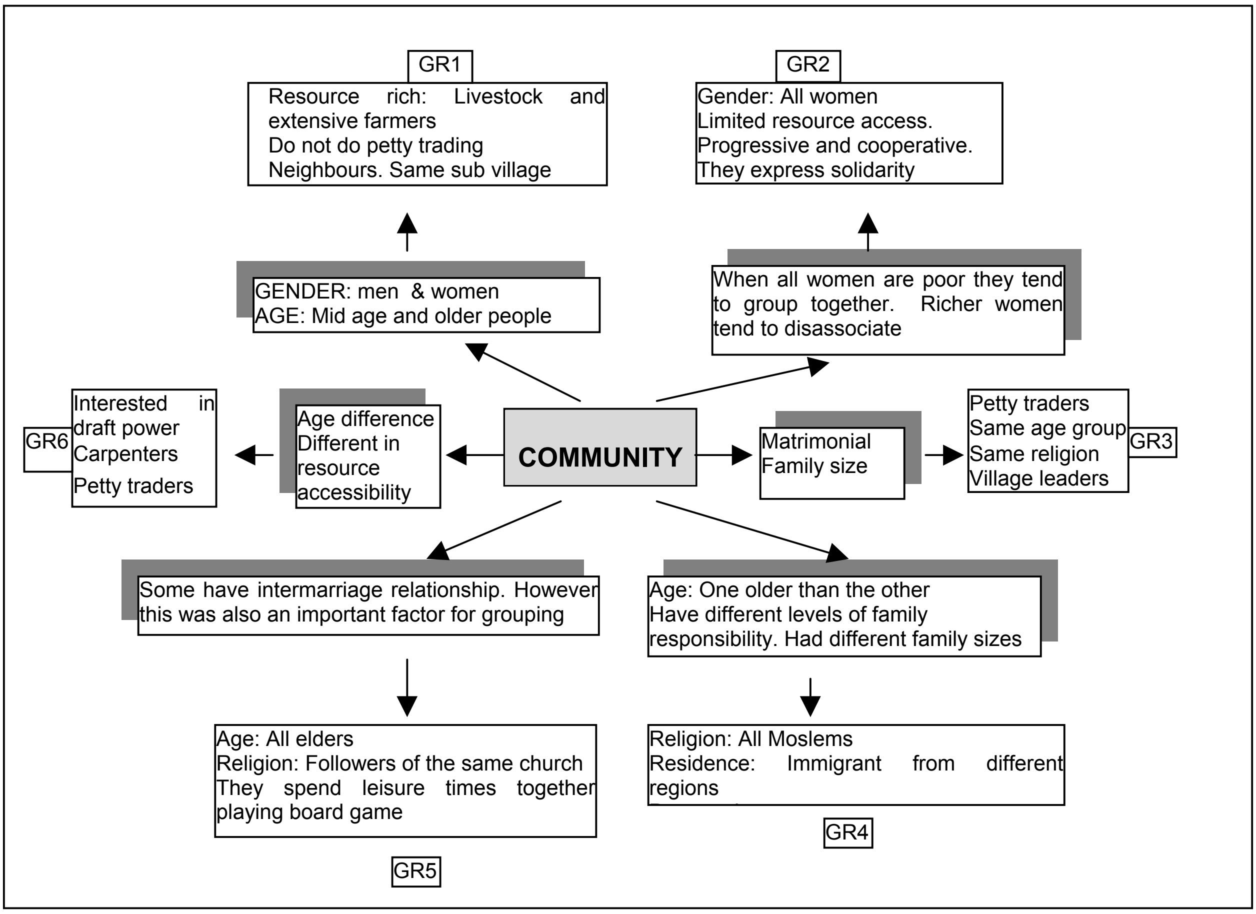

Figure 4.2 Deliberate grouping: differences in shadowed boxes & similarities in sharp boxes

GR1 shows that, regardless of gender and age differences, resource position is very important in social division. GR2 shows that women who are resource poor tend to be together in order to maintain their solidarity. GR3 shows that opinion leaders tend to get together regardless of their household size/type. GR4 is composed of immigrants who clustered together regardless of their age differences while GR5 comprises members who socialise together. It is interesting to note that there are not many differences within group five: it is a stable group of elders who have an advantage of intermarriage between them. GR6 comprises craftsmen: differences in their ages and resource positions do not appear to prevent them associating with each other.

This study uses the results from the grouping pattern as an entry point in describing the informants who participated in the qualitative study and the sample households for the quantitative survey. These divisions have an important contribution in understanding communication pathways and adoption and non-adoption of the technologies under study.

4.3 Description of the informants

This section presents the description of the informants who were involved in focus group discussions. The informants are being described using the record from the SSIs to which the respondents were randomly assigned from the participants in farmers' focus groups (Table 4.1).

Table 4.1 Description of the informants

		VILLAGE					
		Hombolo		Ilula		Total sample	
		Fr	%	Fr	%	Fr	%
Gender	Female	18	33	10	18	28	32
	Male	36	69	26	72	62	68
Total		54	100	36	100	90	100
Age of House hold head	18 to 26yrs	8	15	3	8	11	12
	26 to 39yrs	19	35	18	50	37	41
	>40yrs	27	50	15	42	42	47
Total		54	100	36	100	90	100
Resource position	Rich	19	35	29	80	48	53
	Poor	35	65	7	20	42	47
Total		54	100	36	100	90	100
Origin household head	Local	31	57	28	83	59	66
	Immigrant	23	43	6	17	29	33
Total		54		36		90	100

The description of the informants is closely related to the spontaneous grouping. Of the total informants 68% are male and 32% female. Although the proportion of women among informants is low compared to men, women's opinions expressed during FGDs were important in designing SSIs.

Age has been used to describe the informants primarily because of the role it plays in men's grouping, while resource position has been included because of the role it has in women's grouping. These descriptions complement each other, and therefore are used to give a dimension of social grouping of the informants. Among the informants 12% are young, 41% middle aged and 47% are older than 40 years; while 53% of the informants are resource rich and 47% are resource poor.

4.4 Description of the survey sample households

As in the description of the informants for qualitative study, gender is also used to describe the households selected for the sample survey. Of a total 257 respondent heads of households, 32% are female and 68% male (Table 4.2).

Often, education of the household head, labour availability, and resource position of the household have been associated with the adoption of on-farm technologies (section 1 above). The majority of the respondents in all the villages have primary education. Of the total sample heads of households, 65% have achieved this level of education. About 6% have education above the primary level. The percentage of those who did not go to school is relatively low (29%).

Across all villages the majority of households (56%) have less than three adult members as full time household labour. These adults are involved in a wide range of off-farm activities to improve the household income. In some instance the household head may have more than one such activity but the most important of all across all household heads is trading (57%). This involves selling of consumables and local brew.

Table4.2 Description of the sample households

Category		Villages					
		Hombolo		Ilula		Total sample	
		Fr	%	Fr	%	Fr	%
Gender	Female	34	29	48	35	82	32
	Male	85	71	90	65	175	68
Education	No formal education	50	42.0	24	17	74	28.8
	Primary education	65	54.6	10 2	74	167	65.0
	Secondary education	3	2.5	12	9	15	5.8
	Post secondary	1	.8	-	-	1	.4
Full-time labour	<3 people	62	52.1	81	59	143	55.6
	3 to 5 people	45	37.8	42	30	87	33.9
	>5 people	12	10.1	15	11	27	10.5
Off-farm activities	Trading	33	37.5	73	73.7	106	56.7
	Fishing	16	18.2	-	-	16	8.6
	Livestock	7	8.0	2	2.0	9	4.8
	Handcraft	1	1.1	-	-	1	.5
	Employee	5	5.7	4	4.0	9	4.8
	Fundi	7	8.0	15	15.2	22	11.8
	Other	19	21.6	5	5.1	24	12.8

4.5 Livelihood strategies

Off-farm activities and farming systems are equally important to the livelihood strategies in the study villages. Using data and information from qualitative and quantitative study, this section examines the off-farm activities and farming systems and the implications they have in the adoption and non-adoption of the technologies.

4.5.1 Off-farm activities

Both in Hombolo and in Ilula there are off-farm activities of various kinds. Many of these are interrelated/interconnected with household farming systems. They have been separated in this analysis in order to give a dimension of their importance within households.

4.5.1.1. Fishing

There is no fishing in Ilula, while in Hombolo the construction of the Hombolo dam has enabled 18% of the sampled household heads to engage in fishing. Although fishing is not specifically tied up with any particular farming system it provides an important source of protein for Hombolo residents and areas beyond. To some young and middle-aged people, it is the most important off-farm activity compared to other types of trade.

4.5.1.2 Employment and wage earning

In rural areas of Tanzania people with regular employment, especially civil servants, are well recognised. It appears the number of people with regular employment in Hombolo is higher compared to that of Ilula. This is perhaps due to the presence of a larger number of established institutions in Hombolo. Of all the people in the sample households from Hombolo about 6% are regular employees and 4% in Ilula. However qualitative information indicates that civil servants in Ilula are better off compared to Hombolo since many of them cultivate tomatoes throughout the year as a cash crop.

4.5.1.3 Trading

Trading opportunities in Hombolo are restricted by the fact that the village is far away from the main highway and Dodoma municipality. There are a few shops around but these are limited to items for household consumption. Nevertheless, it appears many people are involved in trading since 38% of the sample households reported being engaged in some sort of trading which contributes largely to the household income beside agriculture.

The relative position of Ilula is an advantage to the village trade. This is compounded with the tomato production in the area. It is important to note that most of the farmers do not engage in tomato production beyond the farm gate because of the risk involved in tomato marketing. As a result, traders from Dar es Salaam, Tanga and other areas come to buy tomatoes at the farm gate. Due to inward immigration of people, Ilula village has expanded rapidly and all kinds of trade can be found.

Both in Ilula and Hombolo, trading of local brew is widespread, and is apparently doing harm to many households. There are reports of food misuse (e.g. scarce grain being diverted from household consumption to raise cash for purchasing alcohol) and families languishing in poverty because of alcohol related problems.

4.5.1.4 Food storage

Food storage plays an important part in household livelihood strategy. According to the sample survey, in Hombolo most of the households (74%) store their shelled produce in *Vilindo*[3] which are kept in the house. In Ilula there are two main types of storage practice:

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[3] *Vilindo* are big baskets made from woven sticks. They are plastered with cow dung and kept in the house.

(a) Maize ears are stored traditionally in a *Vihenge*[4]: these are kept outside the house but raised above the ground. In recent years, there have been several versions of *Vihenge* aiming to improve security against vermin, such as rats.

(b) Shelled maize treated with agro-chemicals against grain-borer is put into bags and stored inside the house. This practice is referred to as improved storage. There are conflicting views in relation to type of storage facilities and the role they play in protection against grain borer and food misuse within households. In any case, about 62% of the sample households in Ilula store their cereals in traditional structures while 36% use improved storage methods.

> 'Look, I cannot store these maize in bags, they have already been attacked by grain borers because they don't have enough husk cover. ...You may note that, the husk coverage on maize cobs is very important feature in distinguishing new maize variety and the traditional variety. Traditional maize are well covered while new varieties are not. ... Sometimes I applied Celecron, DAP, Anvily or Acetric top dressing when packing maize cobs in my *Kihenge*…. If the drugs are safer on tomatoes are they not much more safe on maize ears. I could not apply recommended insecticides because those are only effective on shelled maize.... I do not prefer shelling maize to discourage misuse of food... It is cumbersome to handle maize in bags.... This method is effective in storing traditional maize variety any way as you can see'

A farmer showing evidence of his previous season maize stock in his *Kihenge*

Informants indicated that those who prefer improved storage generally don't have large volumes of maize and prefer new maize seed varieties. They claim that storing the crop in this form limits access to thieves. They can also count the bags of maize and plan their usage. Most of the people who plant traditional seed varieties would store their maize ears in *Vihenge* in large quantities. However, everyone, irrespective of the kind of storage, claims that their food stock is not severely attacked compared to those using different type of storage facilities. It appears that there is some truth in these claims, since those who use *Vihenge* would store maize ears from traditional varieties which are relatively resistant to grain borer compared to new seed varieties which are treated with chemicals against grain borer.

4.5.1.5 Land ownership

In Hombolo, the majority (71%) of the sample households cultivate around their own homesteads. Immigrants would temporarily live and cultivate on borrowed land but once established and approved by the Village Council they will have the right to buy land or be allocated land with undisputed user-right.

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[4] *Vihenge* are bigger stick-weave baskets. Traditionally they are not plastered and are kept outside the house.

In Ilula there are two forms of land ownership. Some households would farm on their own land and some on rented land. It is not clear what is the nature of households which normally farm on rented land and those which farm their own land. Nevertheless, it has been found from the focus group discussion that most of the households that farm on rented land would not use farmyard manure on such land but may use inorganic fertiliser. This is due to the fact that once farmyard manure is used in the farm the nutrient status of the farm increases and the owner would no longer continue to rent it out. Data from the sample survey shows that 58% of the respondents apply fertiliser. Of these, about 60% apply organic fertiliser and 38% inorganic fertiliser in their own plots while in rented plots 18% of the respondents use organic fertiliser and about 82% apply inorganic fertiliser. In recent years, landowners have put some restriction on the use of inorganic fertiliser when they rent out their land since they believe that once land is treated with inorganic fertiliser it loses its natural production capabilities.

A detailed analysis of land tenure and user rights was beyond the scope of this study but it was necessary to understand the perceptions of the farmers on soil fertility management, the ecological values attached to it and the way it is incorporated into the livelihood strategies. It emerged from the qualitative information that farmers from both villages have the following beliefs towards soil fertility management and crop production:

i. Intensification of farming system, especially the use of inorganic fertiliser, destroys the soil micro-organisms and subsequently destroys the natural regeneration of soil fertility.

ii. Crop production from a piece of land which had previously received applications of inorganic fertiliser is far lower compared to production from a piece of land with no history of fertiliser regimes and which has depended on natural nutrient regeneration.

iii. Although inorganic fertiliser can increase crop production, especially maize, organic fertiliser, such as crop residues, compost and farmyard manure are superior in soil improvement.

These beliefs suggest that farmers in the study area appreciate the use of organic fertilisers as the most sustainable way of increasing the on-farm natural resource base.

4.5.1.6 Livestock keeping

This study acknowledges that grazing and livestock keeping is part and parcel of many households' crop production/farming strategies. However, in many instances farmers gave special consideration to livestock and some households have large herds of cattle. Keeping livestock is common in both study areas: as in many other communities in Tanzania it is considered to be a sign of wealth. A household with a herd of cattle has a readily available choice to use farmyard manure or train a pair of bulls for ploughing. This kind of advantage also extends to households entrusted to take care of another household's herd on special arrangements. In such a situation an entrusted household would have access to the benefit of the herd, such as farmyard manure, milk and new-born calves. Within the sample households only 23% of the respondents keep cattle, goat or sheep. Of these 60% keep less than six cows and 42% less than six goats/sheep, while 7% keep more than 20 cows and 20 goats/sheep.

4.5.2 Production systems

The mainstay for the majority of the households in the study area is farming. However, production systems are different. While in Hombolo millet and sorghum is the most important production system in Ilula maize production is predominant. The time elapse between first rains, tillage (land preparation) and planting is very important to all production systems of both Hombolo and Ilula.

Dry planting is quite common in Hombolo and the majority of households would employ *Kuberega*[5] technique in land preparation – minimum or no tillage followed by dry planting. Of the entire household sample from Hombolo about 22% do not till their plots. The main reason given by the some of these respondents (30%) is that the soil is relatively light and about 42% blame high level of investments on labour and hard cash. However, the majority (57%) acknowledge that tillage in general improves the structure and water retention capabilities of the soil. In Ilula the majority of the sample households (74%) till all their farms using tractors or ox-plough and sow during the onset of rains, which coincides with the primary tillage.

(a) Hombolo

In Hombolo, the study recorded several important production systems as discussed below:

(i) *Millet and sorghum production*

Almost every household in the area cultivates sorghum and millet. Farmers regard this system as traditional as they do not remember when it was introduced. They also consider millet and sorghum to be the most reliable crops in the prevailing climate and soil conditions. The risk of failure of millet and sorghum is low compared to other cereals. However, farmers have realised that production of these crops is below their expectations.

(ii) *Maize production*

This is the second most important production system in the area. Maize is not a traditional crop in Hombolo but was introduced by immigrants in 1970. The ill-designed Hombolo dam irrigation scheme was supposed to increase the production of maize but it has failed to realise its objectives. Discussions with KIs revealed that there has been some effort to revive the situation by establishing farmer-managed irrigation schemes but these efforts are hampered by poor rainfall. Consequently, the salinity level in the dam has increased and the water is no longer suitable for irrigation.

In recent years the maize crop has performed poorly. The general consensus from the qualitative discussion is that preference for maize meal against millet/sorghum and increasing growing of maize crop has subsequently increased food insecurity among

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[5] *Kuberega* – This is a traditional land preparation technique in Hombolo. Using machete and hand hoe, a farmer would remove crop residues and other vegetation with minimum disturbing of the topsoil.

resource poor households. In 1998 the maize crop was affected by *El Nino* but since then the rains have not been good enough for maize crop. However, under normal conditions farmers have realised that the net return to maize investment is higher compared to that of millet and sorghum production. This is due to low labour input per acre compared to that required for millet or sorghum, and the high price of maize compared to sorghum or millet.

(iii) Simsim and groundnuts

Groundnut is a traditional monocrop grown in light soils as a cash crop. Farmers have indicated that primary tillage is important in growing the crop. Thus, large-scale production is restricted to households with large plots around their homestead where the soil is light and can be tilled to allow dry planting of groundnut.

Simsim is the second cash crop grown in the area. Immigrant farmers introduced it in the beginning of the 1990s. In recent years, production of simsim has gained momentum. The fact that it can be grown as an inter-crop in similar conditions to those of millet or sorghum has encouraged many households to grow simsim, though on a smaller scale compared to other crops.

(b) Ilula

The most important production systems in Ilula are maize and tomatoes. Almost every household grows maize as well as tomato, which has made many households self-sufficient in maize and made the Ilula area one of the main producers of tomatoes in Tanzania.

(i) *Tomato production*

Tomato production has two seasons, which makes the crop available throughout the year. The first season starts in October and ends in June. This is rainfed upland production. The second starts in July and ends in October, and involves production in valley bottoms to utilise residual moisture. Tomato production is an intensive enterprise that requires a large amount of labour and material inputs. The net profit for an acre is very high but the price is influenced greatly by market forces. Due to higher level of investment required in a single acre, large-scale production is confined to the resource rich and the resource access households. This leads the resource poor and the resource restricted households to perceive that they do not have a reliable cash crop yet. Like many other vegetables, tomatoes are prone to pest and diseases and do not keep long in the field once matured. For these reasons farmers have indicated that the use of chemicals in tomato production is inevitable. Many farmers have not acquired knowledge and necessary skills of using these chemicals. As a result there is serious abuse of agro-chemicals in tomato production. It is striking to note that abuse of agro-chemicals goes beyond tomato production. People would administer agro-chemical specially designed for tomatoes in maize storage. There are reports of farmers using DDT in maize storage.

(ii) Maize production

In Ilula there is only one production season of maize in a year, which starts in October and ends in June or July. Maize is a major food crop in the area. However, some households produce maize commercially and poor households would produce maize for subsistence. Discussions with KIs show that maize was introduced before 1947 and subsequently reduced the importance of sorghum and millet in the area. To date sorghum and millet are seldom grown in the area.

4.6 Causal diagramming

Five causal diagrams (CDs) were developed from each study village. About twenty farmers participated in constructing each one, identifying and analysing the links between various problems associated with household food production/security. The results produced some similarities as well as differences which were consolidated with the help of the research team. In some instances, it was difficult to reach consensus but views from every CD were incorporated resulting in two consolidated causal diagrams, one from each village. Farmers from both villages have indicated that 'food insecurity' is the main reason for engaging in agriculture. The chains of constraints that contribute to food insecurity in each village are presented in the causal diagrams on the following pages (Figures 4.3 and 4.4). The consolidated CDs were then scored by groups of informants (section 4.6.2 below).

Table 4.3 Levels of production constraints

Primary constraints	Intermediate constraints	Root causes
Poor crop production	Poor crop husbandry	Small size plots/too many plots
Food for cash	Drought	Labouring out
Food misuse	Small size plots	Low family labour
Store pests	Traditional seeds	*Kuberega*
Reliance on maize	Poor soils, slopes, no fertiliser applied	Lack of livestock
No reliable cash crop	Incomplete technologies	Erosion, poor, hard soils
	Lack of implements & no tillage	Cheap seeds
		Price & availability of inputs
		Distance to farm
		Crop diseases
		Theft
		Bird/vermin

Data from the CDs show that food insecurity is the result of three levels of constraints as presented in Table 4.3. The primary constraints are directly responsible for food insecurity within households, while intermediate constraints are at various levels between the primary constraints and the root causes for food insecurity.

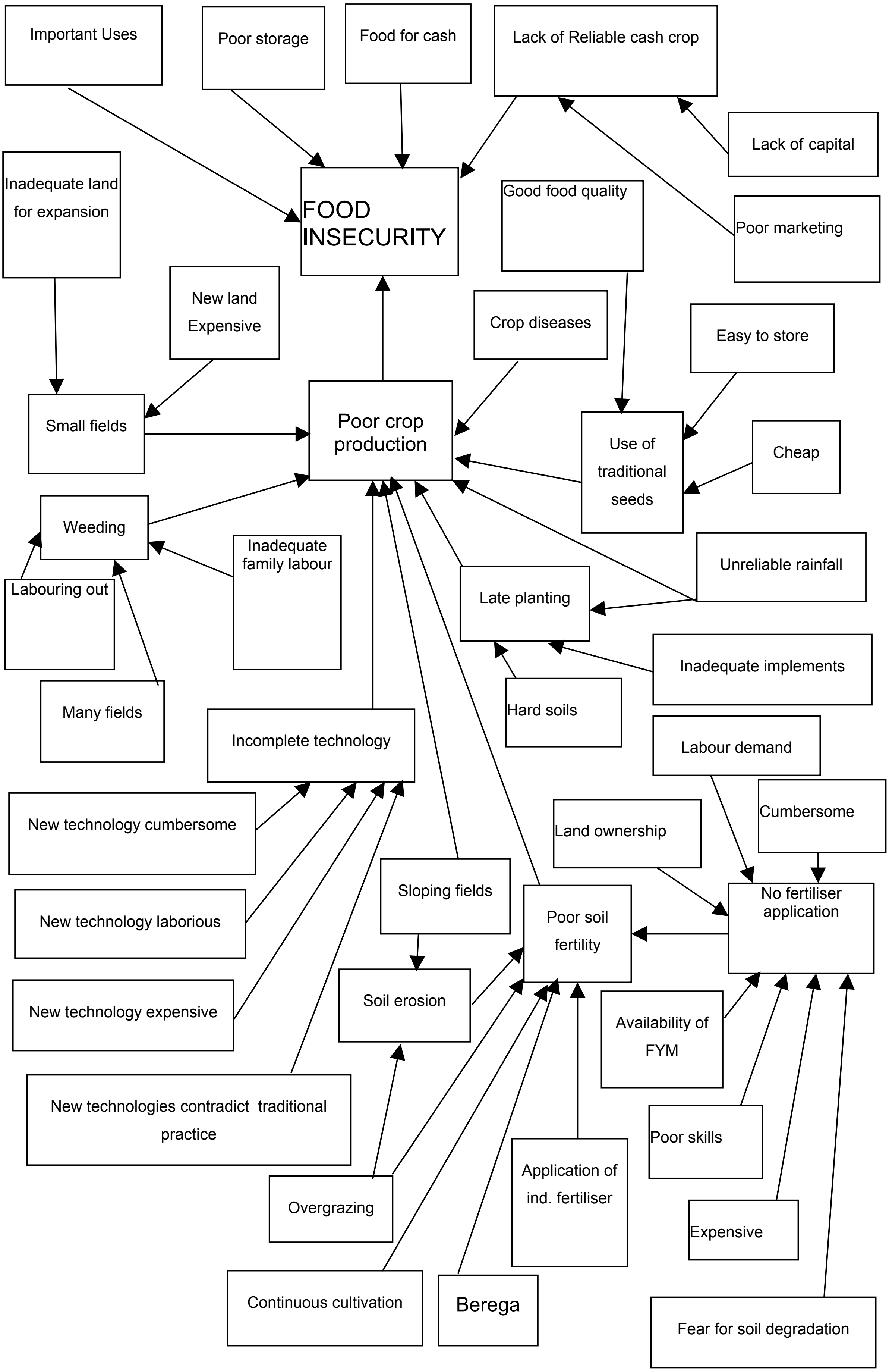

Figure 4.3 Causal Diagram for Ilula

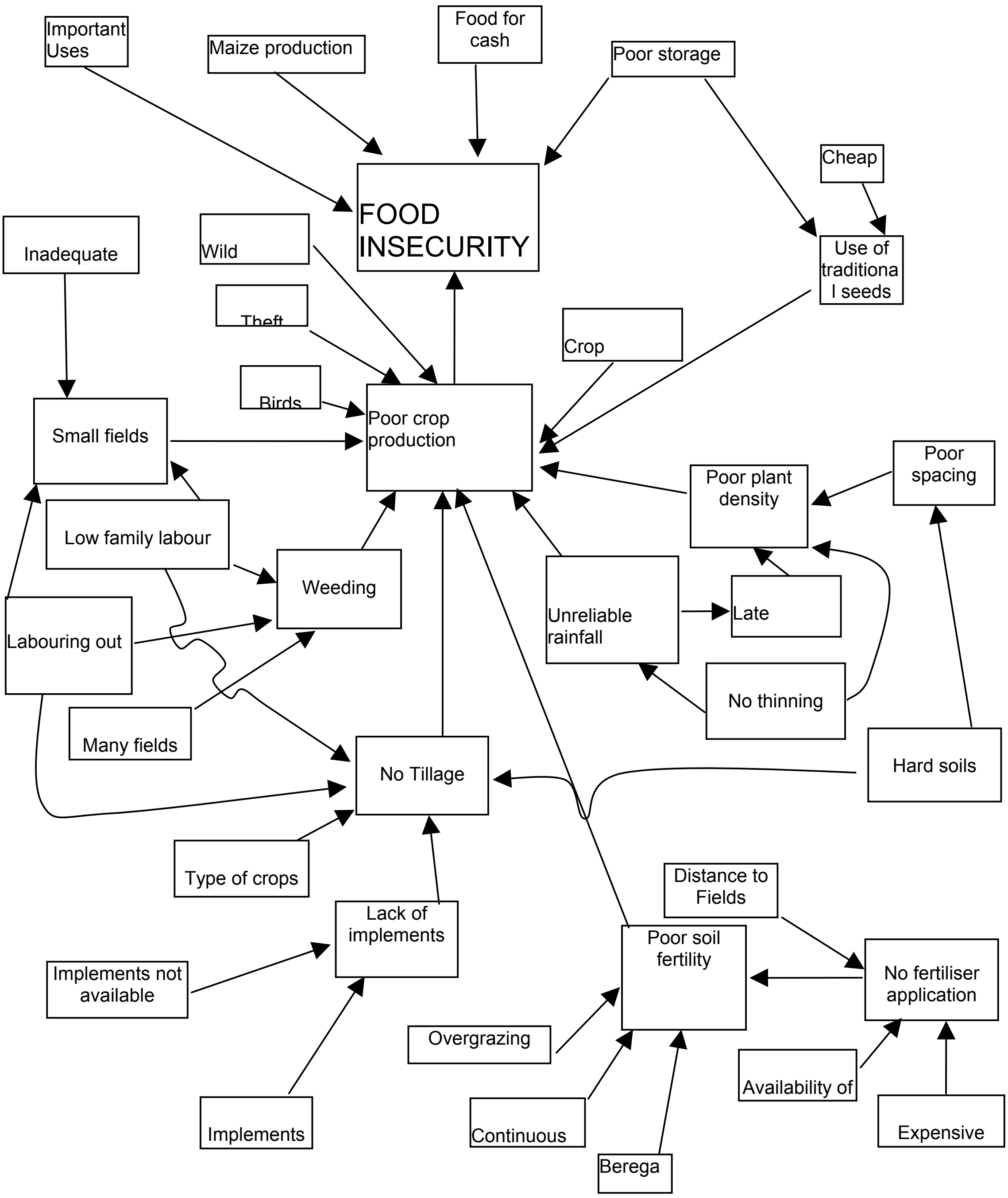

Figure 4.4: Causal Diagram for Hombolo

4.6.1 Primary constraints

There are six main constraints contributing directly to food insecurity. Some are common in both villages and some are restricted to one village.

(i) ***Poor crop production***

This constraint is common in both villages. Crop production has been reported and observed to be far less than expected for many seasons.

(ii) ***Food for cash***

In many instances households would sell its food stock for cash in order to meet the household's cash needs such as school fees, clothing and medical treatments.

(iii) ***Food misuse***

It was reported that some household members would sell or exchange part of their food for trivial or unnecessary ventures such as alcohol, visiting distant relatives/friends, or treating themselves with luxuries.

(iv) ***Grain borers and vermin***

There are reports of grain borers in almost all storage facilities, in both traditional and improved structures. Observations made during the field study revealed that farmers in Ilula particularly prefer to store maize ears unshelled. This is against the official recommendations for improved seed varieties. Combinations of reasons were mentioned which explain why farmers store maize ears unshelled. Some farmers believe that traditional seed varieties are not very susceptible to grain borer compared to new seed varieties. Livelihood conditions restrict the storage of unshelled maize ears in houses: they are stored outside and where thieves are not interested in unshelled maize ears.

(v) ***Reliance on maize production***

Maize is not a traditional crop in Hombolo. The tendency to expand maize production at the expense of sorghum or millet has been felt in all households. In recent years maize has performed poorly bringing serious food shortage in many households.

(vi) ***Lack of reliable cash crop***

Income from tomatoes has improved the livelihoods of many households in Ilula. However, there is a great difference in the conditions of the resource rich and the resource poor, since the latter group cannot invest much on the crop which is prone to diseases and sensitive to market forces.

4.6.2 Scoring causal diagrams

A total of 38 people, some as individuals and others in groups, participated in scoring the consolidated CDs, eighteen from Hombolo and twenty from Ilula. Two of the groups were of women, with three in each, one from Hombolo and one from Ilula. Among the scorers twelve were adopters of the new seed varieties, seven of tillage and seven of FYM. There were also non-adopters, twenty two of new seed varieties, eleven of tillage and ten of FYM.

4.6.3 Ranking production constraints

The recommended procedure for prioritising production constraints is to identify the constraints on the periphery of the SCDs. The highest scored constraints are the most important in descending order. While this procedure is feasible with a small number of simple SCDs, it has two serious practical problems when the SCDs are many, complex and big in size:

(a) The constraints near the main problem are likely to have the highest scores especially when some of them are not central to the line of research and need no further investigation but are equally important in household food production or food security.

(b) Constraints are treated as if they have a linear relationship, those which are far away from the main problem tend to have the minimum scores, especially when there are many causes attributed to it. Those which are close to the main problem with few causes tend to have the highest scores.

One possible solution towards these problems is to increase the number of score units (pebbles/stones) but the analytical problem will remain the same. This study therefore, adapted the interface between the qualitative and quantitative data analysis and interpretation in order to address the analytical problem since the overall interest of the SCDs is not the highest number of the scores within the population but the most frequent constraint and its contribution towards the main problem across the population. This is analogous to assessing a class performance from several examination papers. The overall best student in a class is not necessarily the best in any of the papers but one who does consistently well in all papers.

4.6.4 Analysis of the SCDs

Using scores from the CDs, a rank order for each constraint is identified and compared to the frequency across all respondents as presented in the procedure in Table 4.4.

Table 4.4 Procedure for analysing SCDs

Step	Source data	Process			Outcome	Results
		Format	Entries	Functions		
1	Field SCDs	Spreadsheet. Cases in rows, constraints in columns.	Scores	Scoring in respect relative importance of each constraint.	Ascending order of constraints causing the same problem.	Cause priorities of problems in each case
2	Outcome from step 1	Spreadsheet. Cases in rows, order of constraints in columns.	Order of scores from step 1	Rank level count for each constraint	Rank level frequency for each constraint.	Rank level frequency for each constraint
3	Outcome from step 2	Spreadsheet. Rank levels in rows against constraints in columns.	Rank level frequencies	Ranking all constraints in respect to rank levels	Rank order (ascending) of all constraints within the same rank level obtained from step 1	Overall constraint priorities for each rank level

Step	Source data	Process			Outcome	Results
		Format	Entries	Functions		
4	Outcome from step 3	Spreadsheet. Rank level (first highest three levels) in step 1	Rank levels from step 3	Rank all constraints in respect to the sum of rank level numbers in step 3	Ultimate rank order of all constraints	Overall constraint priorities
5	Outcome from step 4	Spreadsheet.	Rank levels	Descriptive analysis	Cross tabulation and frequency tables	Relationship between top ten high priority constraints and adoption status of new seeds, FYM and Tillage

Table 4.5 presents the ten most frequently mentioned constraints identified from the SCDs. For presentation purposes some of the constraints have been combined in order to verify some issues common in all SCDs. Findings from SCDs reveal that 'poor crop production' is the most frequent and highly scored constraint in all SCDs. The second is 'food for cash', which is not directly related to production constraints but has a direct impact on food insecurity. The third in the list is unreliable rainfall.

Table4.5 Ranks of the constraints

Rank	Hombolo	Ilula	Both Hombolo and Ilula
1	Poor crop production	Unreliable rainfall	Poor crop production
2	Food for cash	Poor crop production	Food for cash
3	Maize production	Poor soil fertility	Unreliable rainfall
4	Unreliable rainfall	Incomplete technology	Poor soil fertility
5	Low family labour	Store pest variety	Traditional seed variety
6	Cheap seed	Cheap seed	Cheap seed
7	Use of poor seed quality	Use of traditional seeds	Continuous cultivation
8	Use of traditional seeds	Food for cash*	No fertiliser application
9	Inadequate implements	No fallow	Maize production
10	No fallow	No fertiliser application	Incomplete technology

4.6.5 Production constraints

(i) *Unreliable rainfall*

Of all the production constraints contributing directly towards poor crop yields, unreliable rainfall or drought is the most frequently mentioned. This is not surprising for a semi-arid area. However, the likelihood of increasing the amount of rainwater does not exist. In this context farmers have indicated that the presently available technological innovations are inadequate for on-farm rainwater collection that is necessary for improving crop production.

(ii) *Poor soil fertility - Continuous cultivation- No fertiliser application*

Farmers have indicated that poor soil fertility and all other constraints of such nature are the second most frequent set of constraints towards poor crop production. Discussion arising within the groups showed that around homesteads of Hombolo the soil is light and exhausted from continuous cultivation with no fertiliser application. On the farms which are far distant from homesteads, the use of FYM is confined to the few resource access individuals and those with large herds of livestock. In Ilula the use of organic fertiliser is limited too. Large areas have been under maize production for a long time and the natural soil has not been improved resulting in poor soils. Discussion with informants revealed that improvement of soil fertility depends on the ownership of the land: an individual renting in the land is unlikely to take any action to improve the soil nutrient status beyond one farming season (cf. section 4.5.1.5 above).

(iii) ***Traditional seed and cheap seeds***

'Traditional seeds' and 'cheap seeds' are among the most frequently mentioned constraints contributing towards poor crop yields. On one hand, farmers have recognised that some of their traditional seeds are causing poor crop yields. On the other hand, they are bound to buy cheap seed since the most productive seeds are very expensive.

(iv) ***Incomplete technology***

Over a wide range of climatic conditions technological innovations respond differently and farmers have acknowledged these variations. A 'scientific' technology may be appropriate in addressing a problem but may not be adaptable or may contradict traditions that are themselves scientifically sound. Farmers have talked of incomplete technology in respect of composting, storage, and the changing in properties of new seed varieties.

4.6.6 Economics of the farm enterprise

Results from participatory budgets (PBs) show that land preparation, type of planting materials and crop husbandry practices are important factors in the economics of the farm enterprise. This section presents the implications of farmers' decisions towards the management of these economic factors. Two scenarios are considered:

(a) When a farmer discounts technologies related to tillage, improved seed varieties and farm yard manure, and

(b) When a farmer incorporates technologies related to tillage, improved seed varieties and farmyard manure into his or her production system.

Using PB techniques each of the seasonal farm activities is identified in relation to the time, material input and labour requirements for an acre of the crop. Quantities do not refer to any specific farm but are collectively agreed as being representative for the village. PBs for four cases are presented in Tables 4.5 to 4.8

Table 4.5 Participatory budget for one acre of maize without the technologies - Hombolo

		AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	
Activities and inputs	***Land Clearing***: Removing vegetation & crop residues and burning.	*Implements*: *Jembe & machete* 27000/=. @3 yr.	*Labour* 4m/day ♀												
	Planting: Dry sowing. Men dig holes women place and cover seeds			*Own seeds. Labour* 2 m/days. @ ♂ & ♀											
	Cultivation: After onset of rains & crops emergence. Weeding & tillage together. Due to drought tillage is seldom achieved. Farmers have therefore, developed a tendency of not tilling.					*Labour* 6m/days @ ♂ & ♀									
	Weeding: Referred as 2nd weeding. If there is adequate soil moisture singling out and gap filling is done. Due to long dry spells experienced during the growing periods singling out and gap filling is always not achieved adequately.							*Labour* 2m/days @ ♂ & ♀							
	Harvesting: Involves removing of ears and pealing of coats. It is common for men to prepare shelves for keeping the harvested ears before harvesting starts.											*Labour* @ 6♂days 4♀days *Transport* 5000/=			
	Threshing: It involves beating and packing. Family labour is usually adequate.													*Labour* @ 2♀days 2 ♀ days *Empty bags* @ 400/=	
	Total labour in m/days		4	4		12		4				10		4	38
	Total cash in TShs.	900/=										5000		1600/=	7500/=
Outputs from one acre	Pre-harvesting meal in April and July														1bags
	Main harvest in bags														5 bags

Table 4.6 Participatory budget for one acre of maize without the technologies - Ilula

		AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	
Activities and inputs	***Land Clearing***: Removing vegetation & crop residues and burning.	*Implements*: *Jembe* & machete cost 27000/=. For 3 yr.	*Labour* 4m/day ♀												
	Ploughing: Fields are tilled during the onset of rains. Sowing behind an ox-plough in order capture soil moisture. Men operate oxen or supervise ploughing & women drop seeds behind the plough.			*Own seeds*. *Labour* 2 m/days. @ ♂ & ♀. Plough hire 6000/=											
	1st ***Weeding***: Singling out and gap filling is also done.					*Labour* 6m/days . @♂ & ♀.									
	2nd ***Weeding***:							*Labour* 2m/days . @♂ & ♀.	*Labour* 30m/day @♂ & ♀						
	Harvesting: It involves removing of ears and pealing of coats. It is common to for men to prepare shelves for keeping the harvested ears before harvesting starts.											*Labour* 9♂days 4♀days			
	Threshing: It involves beating and packing. Family labour is usually adequate.													Lab*our* 9♀days 14 ♀	
	Total labour		4	4		12		4	30	30		13		23	97
	Total cash	900/=													900/=
Outputs from one acre	Pre-harvesting meals between April and July														1bags
	Main harvest in bags														4 bags

Table 4.7 Participatory budget for one acre of millet/sorghum without the technologies - Hombolo

		AUG	SEPT	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	
Activities and inputs	***Land Clearing***: Removing vegetation & crop residues and burning.	Implements**:** *Jembe* & machete cost 27000/=. For 3 yr.	Labour 4m/da y ♀												
	*Planting***:** Dry sowing. Men dig holes women place and cover seeds			Own seeds.& Labour 2 m/days. @ ♂ & ♀											
	*Cultivation***:** After onset of rains & crops emergence. Weeding & tillage together. Due to drought tillage is seldom achieved. Farmers have therefore, developed a tendency of not tilling.					*Labour* 6 m/days @ ♂ & ♀									
	Weeding: Referred as 2nd weeding. If there is adequate soil moisture singling out and gap filling is done. Due to long dry spells experienced during the growing periods singling out and gap filling is always not achieved adequately.							Labour 2mdays @♂ & ♀							
	*Bird scaring***: T**he most critical operation of all. It is handled by adults Birds are active in the morning and afternoon but there are bird storming during afternoons as well. The most notorious species are the *Quarrea quarrea*. The operation takes two months daily, from milking stage to grain hardening.								Labour 30m/day @ ♂ & ♀						
	Harvesting: It involves cutting of heads and carrying home. It is common to for men to prepare shelves for keeping the harvested heads before harvesting starts.											Labour 9♂days 4♀days			
	*Threshing***:** It involves preparation of beating sticks and ground, beating up heads, winnowing and packing. Labour exchange is normally practised. Local brew is prepared as an incentive.													Labour 9♀days 14 ♀	
	Total labour in m/days		4	4		12		4	30	30		13		23	120
	Total cash in TShs	900/=													900/=
Outputs from one acre	Pre-harvesting meal in April and July														1bags

	Main harvest														4 bags

Table 4.8 Participatory budget for one acre of maize of new seed variety treated with FYM - Ilula

		OCT	NOV	DEC	JAN	FEB	MAY	APR	MAY	JUN	
Activities and inputs	*Land Clearing*: Removing vegetation and past season crop residues and burning.	*Tools* - 1500/=	*Labour* 4m/day ♀								
	Spreading FYM		*FYM* 10000/= *Labour* 2 m/days. @♂ & ♀.								
	Ploughing: Fields are tilled during the onset of rains. It is a normal practice to sow behind an ox-plough in order capture soil moisture effectively. Men operate oxen or supervise ploughing women drop seeds behind the plough.			*Seeds*. 10000/= *Labour* 2 m/days @ ♂ & ♀. *Plough* 6000/=							
	1st , *2nd* and 3rd *Weeding*: Singling out and gap filling is also done.				*Labour* 6m/days @ ♂ & ♀.	*Labour* 6m/days @ ♂ & ♀.	*Labour* 6m/days @ ♂ & ♀.				
	Harvesting: It involves preparation of *Kihenge*, cutting maize ears, transporting and arranging the crop in it.								*Labour Kihenge* 6♂days Cutting maize ears 6m/days @ ♂ & ♀.	*Labour* Carrying harvest home 4m/days @ ♂ & ♀.	
	Total labour		4	4		12		4	30	30	
	Total cash	900/=									
Outputs from one acre	Pre-harvesting meal in April and July										2 bags
	Main harvest										10 bags

4.6.6.1 Inputs and outputs

Implements for land clearing are the only substantial input that needs hard cash to produce a crop, where a household is not an adopter of the new seed varieties and does not intend to invest in fertiliser application. However, when a household is an adopter of tillage, tractor or draught power will be required and a substantial amount of hard cash will be needed. In some instances, adopters of farmyard manure would have to invest a substantial amount of hard cash for buying and/or transportation of the farmyard manure.

A comparative analysis between resource inputs and outputs shows that in all cases, i.e. where a technology has been adopted as well as where no specific technology has been adopted, the overall output is fairly low. For instance, an acre of sorghum, millet or maize would produce about five to six bags. An acre of maize that has been treated with farmyard manure would produce about eleven bags. This is far less than the expected output described by recommended packages (20-25 bags), suggesting that technology recommendations are often based on unrealistic expectations of the yields that farmers might expect to achieve.

The majority (63%) of the households in Hombolo have farm sizes between one and three acres. With a minimum production output it is inevitable that most of the households in Hombolo experience severe food shortage compared to Ilula where the majority (41%) of the households cultivate between four and six acres. Furthermore, almost all households in Ilula engage in mixed cropping of maize, beans, peas and vegetables for food, and tomatoes for selling.

4.6.6.2 Non-tangible benefits

Although PBs show that households experience a net negative return from an acre of crop production, no farmer claimed to be in debt. Certainly, there is much more in the farm economics besides the monetary value of the physical resources, input and outputs. However, it is unclear why farmers would continue to farm with the kind of deficits they experience. Perhaps the following points can be used to explain the phenomenon:

- There are a lot of non-tangible benefits generated from farm enterprises.
- The fact that at the end of a season a household will have its own food stocks brings harmony to that household.
- The harmony a household obtains from these benefits is much more important to a household than the monetary value assigned to them in the PB.
- Green mealies and inter-cropped legumes are realised two months before the main harvest, thus pre-harvest famine is averted. Within the household, labour is not valued in monetary terms.
- The value of one bag of food sold in the market is far less compared to the value of the same bag used for household consumption.

4.6.6.3 Farming seasons

Across all villages the farming season is distinctive. In Hombolo it begins in August and ends between June and July the following year. The busiest time is during the millet/sorghum grain filling period when bird scaring is necessary, while the least busy time is in January and after the harvest in June-July where the traditional ceremonies prevail. In Ilula, the farming season is all year round. During and after the harvest of maize some farmers would be engaged in valley bottom cultivation of tomatoes.

4.6.6.4 Gender issues

Participation in FGDs was in the proportions 1:3 women to men. There were instances when strong arguments arose between men and women over a specific issue. Consensus was reached based on the strength of the arguments regardless of who brought the arguments forward. In many cases, women's arguments were prevailing, and it was therefore decided that there was no need to form separate FGDs especially for women. The results show that farm labour is relatively gender balanced. Farmers have indicated that 'farm activities' are carried out together between men and women. In addition, women are custodians of the food stock and responsible for household chores.

In both study villages it emerged that decision making about farm issues is vested in the head of the household. However, in many instances a couple would discuss the issues before final decisions are made. In case a man is married to more than one woman, there is a tendency for women to be more independent and make the final decision on those farms directly under their control (Box 4.1). In 'single parent' households the older members of that household influence farm decisions.

> 'Are you asking me about my livestock and fields or that of my husband?..... I do not have livestock but my husband has some....I have some access to the livestock. I have my fields with my children and I do some petty business. I have full powers on my properties. .... My husband's properties are not mine. We share with others.'

Box 4.1 Views of a woman married to a polygamist husband

4.6.6.5 On-farm division of labour

When a couple opens a new farmland from a forested area, the man would fell big trees and the woman would help in splitting fuel wood. However, land preparation in Ilula and Hombolo is not of this kind. Instead land preparation is of the previously cultivated land, where there are no big trees to fell. In this situation, land clearing is primarily a women's job though occasionally men would help. Planting, cultivation and weeding are equally shared between men and women.

Bird scaring accounts for about 50% of all labour input for sorghum and millet production. This is the most important farming activity and all adult members of the household would be on full alert. Labour input for harvesting and threshing differs in magnitude between men and women. While men's labour input tends to be higher in harvesting, women's labour is lower, although women's labour is generally higher during threshing.

4.7 [6]Description of adopters and non adopters

[6] Adopter - any household/head of household knowledgeable of a technology, and using it at the time of the data collection; Non-adopter - any household/head of household knowledgeable of a technology but has not taken it up, or used it for some time and then

Table 4.9 presents the description of adopters and non-adopters who participated in semi-structured interviews. The data show that 'resource position' and 'household size' are the strongest factors distinguishing adopters and non-adopters of technologies.

Table 4.9 Percentage of adopters and non-adopters in relation to household description

Adoption status	Size of the household								Resource position					
	1 to 2 people		3 to 4 people		>4 people		Total		Rich		Poor		Total	
	Fr	%	Fr	%	FR	%	FR	%	Fr	%	Fr	%	FR	%
Adopter	1	50	5	36	48	65	54	60	34	71	20	48	54	60
Non-adopter	1	50	9	64	26	35	36	40	14	29	22	52	36	40
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

In the case of household size there is no score difference between adopters and non-adopters of a very small household, i.e., 1 to 2 people. The difference is strong, however, between small households, i.e. 3 to 4 people (64% non-adopters) and larger ones i.e., more than four people (65% adopters). The same pattern can be observed on 'resource position'. The majority of the rich households (71%) are adopters and the majority of the poor households are non-adopters (52%).

While the descriptive differences brought by resource position and household size are strong in adoption and non-adoption, other household descriptions are also important though with less influence on adoption and non-adoption (Table 4.10).

None of these descriptions have the same pattern as that of resource position or household size. In the case of education level, the majority of those who attain primary education (58%) and the majority of those who made secondary education (100%) are adopters. There was no evidence to suggest that age is a strong factor describing adoption and non-adoption either, since the majority of interviewees in all age-ranges are adopters. The same applies to gender: the majority of both women (68%) and of men (56%) are adopters.

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dropped it later. There are households which do not fall into either of the above groups. They are not included in the qualitative data presented. These include those who are not knowledgeable of the technology, and those who are knowledgeable and have taken up the technology with some adaptive measures.

4.8 Inconsistency in describing adopters

It was mentioned in Section 3 that adoption of a technology has a direct relationship with some livelihood parameters. For instance, when a technology requires a substantial amount of resource input it would be expected that a resource rich household would be an adopter of the technology. In case of a technology which requires more labour input it would be expected that smaller households would be non-adopters.

Findings from this study show that there are inconsistencies in this pattern. While the 'resource position' has a tendency to comply with such an assumption (Table 4.11), there are other household descriptors which strongly refute such presupposition. For instance, the scores from household size indicated that the majority (88%) of adopters, and majority (72%) of non-adopters both have a large family size (>4 people). In contrast, small proportions of both adopters (2%) and non-adopters (3%) have small households.

These inconsistencies are the result of the qualitative descriptions between adopters and non-adopters. These descriptions overlap between themselves, and consequently raise some doubts about using conventional socio-economic household descriptions, such as 'resource rich' and 'household size' in differentiating adopters and non-adopters.

Table 4.10 Household descriptive variables in relation to adoption

Descriptive variable	Group variable		A	NA	Total
AGE	18 to 26ys	Fr	6	5	11
		%	55	45	100
	26 to 39yrs	Fr	23	14	37
		%	62	38	100
	>40yrs	Fr	25	17	42
		%	60	40	100
	Total	Fr	54	36	90
		%	60	40	100
GENDER	Female	Fr	19	9	28
		%	68	32	100
	Male	Fr	35	27	62
		%	56	44	100
	Total	Fr	54	36	90
		%	60	40	100
EDUCATION	No formal	Fr	13	8	21
		%	62	38	100
	Primary	Fr	38	28	66
		%	58	42	100
	Secondary	Fr	3		3
		%	100	0	100
	Total	Fr	54	36	90
		%	60	40	100
ORIGIN	Local	Fr	38	21	59
		%	64	36	100
	Immigrant	Fr	16	13	29
		%	55	45	100
	Total	Fr	54	34	88
		%	61	39	100

Table 4.11 Resource position and household size in relation to adoption

		Categories			
		Adopter		Non-adopter	
		Fr	%	Fr	%
Resource	Rich	34	52	14	29
position	Poor	20	48	22	71
Total		54	100	36	100
Hh size	1 to 2 people	1	2	1	3
	3 to 4 people	5	10	9	25
	>4 people	48	88	26	72
Total		54	100	36	100

It is the position of this study that the differences between adopters and non-adopters are more apparent in a broader set of 'characteristics' of the household rather than their socio-economic 'description'. For instance, a household which is resource rich, may be 'resource restricted' in its ability or desire to use its resources for agricultural purposes and therefore express negative behaviours towards a technology. Poor households, on the other hand, can be 'resource access' (for example through arrangements with other households, or access to common property resources) and consequently express positive behaviours towards the technology. The characteristics referred to in this context are a wider set of social-psychological parameters, such as perceptions, beliefs, behavioural intentions and the practical application of the intentions towards the technologies. Also, an individual or household may be an adopter of one technology but may be a non-adopter of another technology depending on technological differences, season, and the prevailing context for each technology. It is more instructive, therefore, to look at the characteristics of adopters in relation to separate technologies.

4.9 Characteristics of the adopters

Diagrammatic presentations of technological adaptation revealed that the characteristics of adopters and of adapters are similar. Although it is conceptually possible to distinguish between adopters and adapters, their characteristics or rather their behavioural expression are almost the same. A household which is an adapter of a technology would display the same characteristics as an adopter. However, their behavioural expression may be distinguished when an adapter uses the technology in a different form or abandons it after using it for some time. The differences between adopters and non-adopters, on the other hand, are apparent based on their characteristics since non-adopters will express negative behaviour towards the technology. Some of these characteristics might be expressed in the form of beliefs that are very difficult to observe although they would be reflected in their behaviour as presented in the following sub-sections.

4.9.1 Characteristics of adopters of new varieties

An adoption model for new seed variety is represented in Figure 4.3. The purpose of growing a crop (maize, sorghum and millet), perception of the rainfall pattern, taste preference and storage facilities are important factors for adoption or non-adoption of the new seed variety.

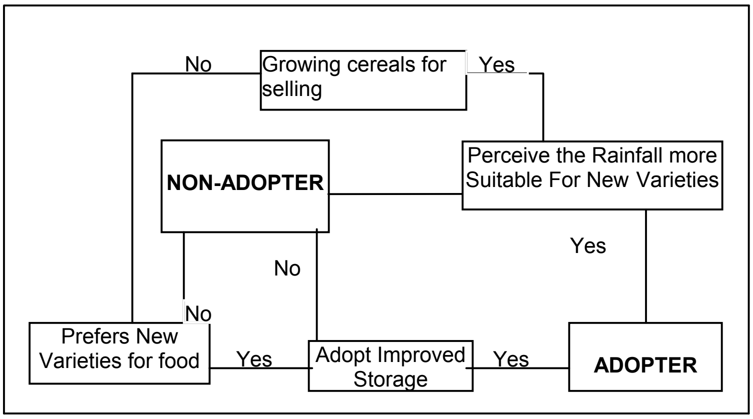


***Figure 4.3**: Adoption model for new seed variety*

(a) Where a household is growing a crop for selling and perceives the rainfall to be adequate enough for the new seed variety, such household is likely to be an adopter of the new seed variety. A household which is not growing the crop for selling (grows for home consumption) but prefers food from the new seed variety and has adopted improved storage facilities is a potential adopter of the new seed variety.

(b) A household which is growing cereals for selling but perceives the rainfall not to be suitable for the new seed variety is invariably a non-adopter, as is a household which is growing cereals for home consumption but does not prefer to eat new varieties.

(c) An exception exists when a household is growing cereals for home consumption, prefers to eat new varieties but has not adopted improve storage facilities: such a household is likely to be a non-adopter of the new seed varieties.

4.9.2 Characteristics of adopters of tillage

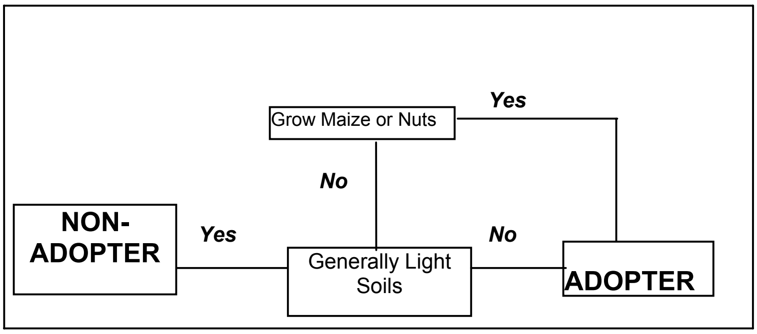


Figure 4.4: *Adoption Model for Tillage*

Type of crops and soil properties determine the adoption and non-adoption of tillage. Farmers who are growing maize and/or nuts are adopters of tillage, as well as those who are growing sorghum/millet in sandy loam soils (Figure 4.4). In Hombolo, many households realise the important of tillage when growing maize/nuts since these crops are generally grown in heavy soils. When a household is growing these crops on light soil, it is likely to be a non-adopter of tillage. However, there is a tendency of growing sorghum and millet around homesteads where the soil is light. When a household is growing sorghum and millet on heavy soil it is likely to be an adopter of tillage.

Results from focus group discussion reveals that there is strong relationship between the amount/distribution of rainfall, soil types and adoption of tillage as reflected in the low uptake and farmers' subsquent rejection of the on-farm research and promotion of tie ridging. Farmers have described three conditions in relation to non-adoption of tie ridging:

i. *With adequate rainfall*

a. There is no difference in soil moisture retention between tie-ridged and flat cultivation areas; and therefore no differences in crop production.

b. Plants on tied-ridges are not firmly held, easily fall down and get damaged resulting in low production.

ii. *With inadequate rainfall*

a. There is no difference in run-off of rainwater between tied-ridged areas and flat cultivation areas.

b. Plants on tied-ridges do not benefit from the moisture captured below the ridges, resulting in relatively low crop production in tied-ridged areas compared to traditional flat cultivation.

iii. *Intermediate rainfall*

a. There is relatively higher rainwater retention in tied-ridged areas and therefore high moisture retention followed by high crop production.

b. This is a specific range of rainfall distribution/pattern which seldom exists in semi-arid areas and has never been observed in Hombolo or Ilula.

4.9.3 Characteristics of adopters of farm yard manure

As illustrated in Figure 4.5, adopters of farmyard manure would have their own land, keep livestock, and either farm around their homestead or have no labour constraint. Farmers who don't have livestock but who perceive that grazing on their fields does not destroy soil are likely to be adopters since they would allow cattle to feed on the crop residues for them to get manure.

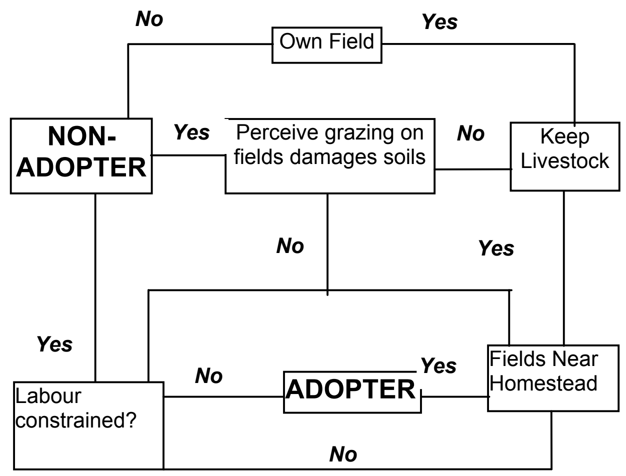


Figure 4.5: Adoption model for farmyard manure

5. Quantitative findings

This section presents the narrative analysis of quantitative data from the sample survey. The descriptive analysis was carried out using SPSS computer program. The results are presented following the pattern of adoption/non-adoption found from qualitative data and the models presented in section 4.9. The household descriptions and characteristics are treated separately. Household descriptions are based on standard socio-economic variables, including size of household, household head's gender, household head's education, and household resource position. Characteristics of the household include perceptions and the practices displayed in the course of executing livelihood strategies. Data were collected through a structured questionnaire administered to 138 respondents from Ilula and 119 from Hombolo (Appendix 1).

5.1 Diversification of plant genetic resources

The technology studied in Hombolo was the adoption of new varieties of sorghum and millet, and in Ilula the adoption of new varieties of maize. In Hombolo the study focused on adoption of two new varieties of sorghum known as *Pato* and *Tegemeo* in contrast to a traditional variety known as *Lugugu*; and the new variety of millet known as *Okoa* in contrast to the traditional variety known as *Mtama wa kigogo*. In Ilula the study focused on adoption of two new varieties of maize, Cargil 4142 and 4141, against a traditional variety of maize commonly known as *Bwana romba*. These new varieties (technologies) are promoted with the following recommendations:

i. Planting of approved seeds every season
ii. Proper plant spacing as specified
iii. Preparation of good seed bed
iv. Timely planting
v. Use of fertilisers or manure at recommended rates
vi. Proper weeding
vii. Improved grain storage facilities and techniques.

Generally the data show that adoption rate of new varieties was low in Ilula where 67% of all respondents were non-adopters, compared to 27% of all respondents in Hombolo who were non-adopters. However, 50% of respondents in Hombolo were adapters.

5.1.1 Household description in relation to adoption/non-adoption of new varieties

5.1.1.1 Age

Age distribution of household heads in the sample households in Ilula was 12% young (18 to 25 years), 43% middle aged (26 to 39 years) and 46% elder (40 years and over). Age distribution in Hombolo was 12%, 36% and 52% for young, middle and elder, respectively. In Ilula the data show that the rate of adopting new seed is higher for households with young and middle age household heads (25% adopters) compared to households with older age (11%). However, middle age and elder households tend to be more or less equally adaptive, 17% and 16%, respectively. In Hombolo the majority of each age group were fairly equally adaptive, 43%, 46% and 55% of young, middle age and elders, respectively. Adoption rate was 28.5%, 28% and 17.5% of young, middle age and elders, respectively.

There is indication from the data that age of the household head may influence adoption of new seed varieties. Young and middle aged household heads show a higher tendency to adopt than old household heads.

5.1.1.2 Gender

Women headed households (WHH) were 35% of the sample households in Ilula. However, it was found that their rate of adoption was slightly higher (21%) compared to men headed households (MHH - 18%). There was a slight reversal for adaptation rates, which were 10% and 16% adapters for WHH and MHH respectively.

In Hombolo WHH were about 29% of the sample households. Similarly, adoption rate for new seed varieties was slightly higher (26%) for WHH than that of MHH (21% . However, MHH tended to be more adaptive (58%) than WHH (32%).

This indicates some gender influence on adoption of new seed varieties. Women headed households are more likely to adopt new seed varieties than men headed households.

5.1.1.3 Education

The majority (74%) of all respondents in Ilula have attained primary education. About 17% attained no formal education and 9% attained secondary education. The adoption rate was 13%, 20% and 25% for no formal, primary education and secondary education, respectively. Very few (3%) household heads had attained education level higher than primary in the sample household in Hombolo. The majority (55%) attained primary school education followed by those with no formal education (42%). The rate of adoption was higher (32%) for primary school compared to those with no formal education (10%). However, the tendency to adapt was slightly higher (51%) for those with no formal education than those with primary school (45%). As in many studies it has emerged that education has some influence on the rate of adoption of the new seed varieties. Adoption rate tends to be higher with higher levels of formal education.

5.1.1.4 Household size

The majority (58%) of sample household heads in Ilula have larger household size with more than 4 members, 33% have medium size with 3 to 4 members and 9% have small size with 1 or 2 members. Adoption rate was found to be higher (26%) for medium households followed by large households (18%) while no one from the small households had adopted. However, small households were more adaptive (30%) than both larger (14%) and medium (11%) size households.

Large households were also the majority (56%) among the sample households in Hombolo. Medium size households were 30% and small households were 14%. Similarly medium size households showed a higher tendency (25%) for adoption followed closely by larger households (24%). Small households showed the lowest tendency (13%) to adopt. However, all household sizes showed little difference in adaptive tendency. The data show that adaptation rate was 50%, 47% and 52% for small, medium and larger size households, respectively. These results show that there is not enough evidence that family size influences adoption of the new seed varieties.

5.1.1.5 Resource position

Off-farm income activities, including livestock (cattle) keeping, were considered important criteria for wealth categorisation. A household having any off-farm activity was considered to be in the "resource access" category and one with no off-farm activity was considered "resource restricted". In Ilula the majority (72%) of all respondents had one or more off-farm income activities. Distribution of households in relation to off-farm activities were 53% trading, 11% artisans, 4% others, 3% employee and 2% livestock keeping. It is important to note that the number of households perceiving livestock keeping as an income generating activity is lower than the actual number of livestock keepers (17%) in the sample. This is perhaps due to the fact that most farmers keep livestock as safety banks in case of hunger, dowry payments and other emergencies. For those kinds of households, livestock is not readily available or at best marginally available for the improvement of household well-being.

In Ilula the data show that the tendency to adopt is relatively higher (20%) for households with no off-farm income generating activities, compared to 18% of those with off-farm income generating activities. Also, the tendency for non-adoption of new seed varieties was higher (70%) in households with off-farm income generating activities compared to 61% of those with no off-farm income generating activities.

In Hombolo the pattern was slightly different. About 24% of the sample households with off-farm income generating activities were adopters while 19% of all households with no off-farm income generating activities were adopters. Non-adopters were 25% of household heads with off-farm income generating activities and 33% of sample household heads with no off-farm income generating activities. These results suggest that the direction in which resource position influences adoption of the new seed varieties is location specific. In Hombolo resource access tended to favour adoption but in Ilula this was not the case.

5.1.2 Household characteristics in relation to the adoption/non-adoption of new varieties

Qualitative results showed some household characteristics are important in adoption/non-adoption of new seed varieties. These included the purpose of crop production (home consumption or market driven), perception of climate suitability, food taste preference and storage practices. An adoption model for new seed varieties was derived from these characteristics (Figure 4.3). Analysis of the quantitative data tests the viability of the model over a cross section of the population in the study areas. Each characteristic is discussed in turn.

5.1.2.1 Purpose of production

In Hombolo, millet and sorghum production is mainly for home consumption regardless of the variety grown: about 88% of the sample households have confirmed this fact. About 28% and 6% of the sample households grow new varieties of millet and sorghum, respectively. About 20% of those growing new millet varieties and 14% of those growing new sorghum varieties grow primarily for selling. Similarly, the majority of the sample households in Ilula grow maize mainly for home consumption. About 81% grow traditional maize varieties only 1% of which grow them for selling.

About 32% of the sample households grow new maize varieties, only 20% of which are market motivated. These results show that market motivates adoption of new seed varieties compared to the traditional seeds varieties of maize, but that market motivation alone does not explain the decision to adopt since the majority of those adopting are not growing primarily for sale.

5.1.2.2. Food preference

The majority of respondents in Hombolo do not distinguish food taste between varieties. Only 34% of the sample household could distinguish food taste between new and traditional varieties of millet and sorghum of whom 64% were adapters, 18% adopters and 18% non-adopters. But all non-adopters, 42% adopters and 67% adapters among those who could distinguish food taste preferred traditional varieties for food. The pattern on food taste found in Ilula was different from that found in Hombolo. Majority (63%) of respondents in Ilula could distinguish the taste of food between new and traditional maize varieties. However, the pattern in food preference was fairly similar to that found in Hombolo. The results show that 92% of non-adopters, 63% of adopters and 78% of adapters among those who could distinguish food taste preferred traditional maize varieties to new varieties. These data show that the chances of non-adoption are higher for those households which prefer food from traditional varieties.

5.1.2.3 Perceived suitability of crop variety to prevailing climate

Farmers' perceptions of the suitability of crop varieties to the prevailing climate was apparent among farmers growing new seed varieties in both villages. Short maturity was the reason given most frequently for growing new seed varieties (67%, from 76 responses in Hombolo and 64% of 47 responses in Ilula). The second most important reason for growing new seed varieties was productivity, which was mentioned in 32% and 14% of responses in Ilula and Hombolo, respectively.

The perception of suitability of varieties to the prevailing climate was not important for farmers growing traditional varieties in both villages. Suitability of traditional varieties for prevailing climate was mentioned by 6% of 108 responses in Ilula and ranked fifth. In Hombolo the same reason was reported by 12% of 73 responses, and again, it was ranked fifth. These results indicate that the tendency to adopt gets stronger as the household becomes concerned about the implications of the prevailing climate for crop production.

5.1.2.3 Storage practices

A consistent pattern in storage practices for crop varieties was found in both Ilula and Hombolo. The majority of adopters tend to adopt modern storage practices and the majority of both non-adopters and adapters tend to stick to traditional storage practices.

In Ilula 58% of adopters of new maize varieties in the sample households stored their produce in modern technically recommended ways, mainly in bags and with storage pesticides. In contrast 71% of non-adopters of new maize seed varieties stored their produce in traditional structures known as *vihenge*. About 52% of adapters of new maize seed varieties also stored their produce in traditional structures. The most important reason given by adopters in Ilula for applying modern techniques in storing maize was convenience in food accounting and safety against theft (69% of 48 responses). This was followed by effectiveness against rats and grain borers (25%). On the other hand, the most important reasons given by non-adopters for sticking to traditional storage practices were the ability to control food misuse (26% of 87 responses), expenses involved in modern storage practices (25%) and the lack of knowledge on improved traditional structures (24%). About 18% of non-adopters still maintained that traditional practices are most effective in the control of rats and grain borers.

The same trend was found in Hombolo. About 56% of adopters of new varieties of sorghum and millet adopted modern storage practices, while 90% of non-adopters and 73% of adapters still used traditional storage practices. The most important reason given by adopters is effectiveness against grain borers (95% of 19 responses). Non-adopters had three main reasons: effectiveness against grain borers (28% of 71 responses), avoiding expenses involved in modern practices (27%) and too small food stocks to bother about storage (24%). The results present an indication that there is a positive relationship between the tendency to adopt new seed varieties and the tendency to adopt new storage techniques.

5.2 Soil nutrient management

Soil nutrient management was studied in Ilula. The initial idea was to study composting. Later, it was found that composting technology was still at the early stages of promotion and there might not be enough adopters to include in the study. The soil nutrient management technique which was found more relevant for the study in the area was the application of farmyard manure (FYM). Recommendation package of the technology included the following:

i. FYM to be applied when it is matured enough (about one or two years old)

ii. Broadcast application every after three seasons at the following rates depending on the type:
   - Cattle manure 5 tonne/ha
   - Goat/sheep manure 10 tonne/ha
   - Poultry manure 0.15 tonne/ha.

iii. Deep tillage to incorporate broadcast manure.

Results from the qualitative phase of the study in Ilula could be extrapolated to Hombolo. For this purpose the sample survey also covered adoption of FYM in Hombolo. Sample survey results show that the rate of adoption was higher in Hombolo (40%) than that in Ilula (25%). While there were no adapters in Hombolo, in Ilula 6% were adapters.

5.2.1 Household description in relation to application of FYM

5.2.1.1 Age

Households headed by elders in Hombolo were equally distributed between adopters and non-adopters of FYM. Young and middle aged household heads were mostly non-adopters, 64% and 72%, respectively, compared to adopters 36% and 28%, respectively. There was no adapter of FYM in the sample households of Hombolo. In all age groups, in Ilula there were more non-adopters than adopters. Non-adopters were 67%, 73% and 63% of elder, middle age and young household of the sample, respectively. Adopters were 30%, 22% and 19% of elders, middle age and young household heads respectively. There is an indication that age of household head to some extent influenced the tendency to adopt FYM in Ilula.

5.2.1.2 Gender

Men headed households are more likely to be adopters of FYM than women headed households in both study areas. In Hombolo 35% of all women headed households in the sample were adopters compared to 42% of men headed households. In Ilula about 13% of women headed households were adopters compared to 32% of men headed households.

5.2.1.3 Education

The data suggest that education has no influence on adoption of FYM in Hombolo. More than half (54%) of household heads who had no formal education were adopters, and only 28% of those who had attained primary school were adopters. However, two out of three household heads in the sample who attained secondary school were adopters and the only one household head who attained more than secondary school was an adopter. In Ilula the number of adopters was less than that of non-adopters for all education levels of respondents. Adoption rate of FYM was 38%, 21%, and 33% of no formal education, primary education and secondary education, respectively.

Both in Ilula and in Hombolo, therefore, the trend of adoption rates did not follow the trend in education levels.

5.2.1.4 Household size

Adoption of FYM was low for all divisions of household size. However, small and large households had higher rates of adoption than medium size households in both villages. Adoption rate in Hombolo was 44%, 25% and 48% for small, medium and large size households, respectively. In Ilula the adoption rate was 22%, 13% and 33 for small, medium and larger size households, respectively.

The data show consistency in adoption trend between Ilula and Hombolo. However, there is no clear indication of the influence of family size on adoption of FYM.

5.2.1.5 Resource position

Again, the involvement in off-farm activities was used as the main criterion of wealth in determining the influence of wealth on adoption of FYM. Adoption trend found in Hombolo is slightly different to that in Ilula. In Hombolo the rate of adoption was higher for resource access (42%) compared to resource restricted (35%) households. In Ilula, adoption rate for resource access was 21% and that for resource restricted was 36%. This is perhaps due to intensive use of industrial fertilisers which is more common in Ilula compared Hombolo. Or, perhaps resource access households tend to depend more on industrial fertilisers than resource restricted households.

5.2.2 Household characteristics in relation to adoption/non-adoption of FYM

Household characteristics found to be important in influencing adoption of FYM during the qualitative study were land ownership, livestock keeping, distance from homestead to fields as well as the availability of family labour. These were used to develop an adoption model for FYM (Figure 4.5). The relationship of these characteristics with adoption of FYM is discussed in turn from the quantitative results.

5.2.2.1 Land Ownership

Land ownership was found to be important in adoption of FYM. In Ilula, 29% of all respondents applied FYM. About 83% of all respondents who applied FYM did so in their own fields and the rest applied in rented fields. About 33% of all respondents applied industrial fertilisers. Of these, 59% applied them on rented plots, the rest on their own plots. In Hombolo no respondent applied industrial fertiliser. However, 32% of all respondents applied FYM. The majority (87%) applied in their own plot and the rest applied on rented plots. A fairly strong relationship between FYM adoption and land ownership was found in both Ilula and Hombolo. Households tend to apply FYM in their own plots compared to rented plots. The tendency to apply industrial fertilisers is greater on rented fields than on own plots.

5.2.2.2 Livestock keeping

In Ilula 17% of all respondents keep livestock (cattle), the majority (63%) of whom apply FYM. Only 20% of those who do not keep livestock apply FYM. Those who keep goat or sheep are distributed equally between adoption and non-adoption. Seventeen percent of all respondents keep goats and/or sheep of whom 43% were adopters and 43% were non-adopters of FYM.

In Hombolo 15% of all respondents keep livestock (cattle), 83% of whom apply FYM, while only 33% of those who do not keep livestock in Hombolo apply FYM. Respondents who keep goat or sheep in Hombolo were 17% of the sample households of whom 80% apply FYM. The relationship between FYM application and livestock keeping was indicated to be strong in both Hombolo and Ilula.

5.2.2.3 Labour constraints

The size of the family labour force is not always in proportion to family size. In Hombolo about 10%, 30% and 60% of the sample households were small, medium and large, respectively. In Ilula about 10%, 33% and 57% of the sample households were small, medium and large, respectively. In case of family labour 59%, 30% and 11% of all the sample households in Ilula had low (<3 people), medium (3 to 5 people) and high (>5 people) availability of household labour, respectively. In Hombolo 52%, 38% and 10% of all respondent households had low, medium and high availability of household labour, respectively.

The results indicated that household labour has an influence on adoption of FYM in both villages. Data show that in Ilula, 17%, 33% and 47% of low, medium and high labour households, respectively, were adopters of FYM. About the same trend was found in Hombolo where 36%, 47% and 42% of low, medium and high labour households, respectively, were adopters. This indicates that the larger the amount of family labour in a household the higher the tendency to adopt FYM.

5.2.2.4 Location of fields from homesteads

Distance between homestead and field was not very important in adoption of FYM application on households' own plots in Ilula. Adoption rate was fairly equal for all own plot distance categories. About 32%, 33% and 27% of respondents with own plots located at distances of <3km, 3 to 5km and >5km, respectively, were adopters. Distance between homestead and the rented plots was, however, important to adoption of FYM. About 22%, 14% and 13% of respondents with rented plots located at distances of <3km, 3 to 5km and > 5km, respectively, were adopters. This shows that the closer the rented plot is to the homestead the higher the tendency to adopt FYM. However, this does not seem to apply for plots owned by the household.

5.3 Soil water management (SWM)

Deep tillage, as a technology, was pursued in Hombolo. The initial idea was to study tied ridges but the idea was dropped because the technology was found to be still in a development phase. It was at the stage of participatory research: the technology was incomplete and very few farmers had so far adopted (see section 4.9.3 above). As a result, tillage on flat cultivation was investigated. This is the promoted technology in the area for the purpose of SWM. The recommended and promoted practice is to loosen the top soil at least 20cm deep during primary tillage or immediately after crop emergence. This necessarily requires the use of powered (including DAP) implements during primary tillage or hand hoe when the soil is moist enough. The latter is the only possibility after crop emergence.

Some ambiguity over the definition of tillage arose during the qualitative enquiry. The first weeding operation, which is normally done immediately after crop emergence, was referred to as tillage (*kulima* in Swahili), even if no soil loosening is achieved. To avoid that ambiguity, it was agreed that the Swahili word *kuparura* be used for first weeding when no soil loosening is achieved, and the word *kulima* be used when soil loosening is achieved during the first weeding. The definitions were confirmed during the sample survey. Results on SWM for Hombolo could not be extrapolated to Ilula because of the differences in tillage practices between the villages. In Ilula primary tillage using ox-plough has become a traditional practice while in Hombolo there is hardly a household which uses ox-plough for primary tillage. Hand hoe, which is so prohibitive on tillage, was found to be a traditional practice for primary land preparation in Hombolo. The results, therefore, present findings from Hombolo, where the majority (51%) were adopters of tillage, 22% non-adopters and 27% adapters.

5.3.1 Household description in relation to tillage

5.3.1.1 Age

Young household heads showed the lowest (7%) level of adoption. Levels of adoption for other groups were almost equal. While adoption rate for middle age household heads was 28% that of the elder category was 31%. This indicates a progressive tendency for tillage adoption as the age of household head increases.

5.3.1.2 Gender

The rate of adoption was slightly higher for men headed households (28%) compared to women headed households (24%).

5.3.1.3 Education

The rate of adoption was the same (26%) for household heads with no formal education and those who had attained primary school. One out of three household heads who had attained secondary school in the sample households was an adopter and the only one household head who had attained higher than secondary education was also an adopter. This indicates that there was no strong influence of education on adoption of tillage.

5.3.1.4 Household size

Adoption rate of medium size households was lower (14%) compared to other household sizes. The rate of adoption for small and large sample households was almost the same. The adoption rate for small households was 25% and that of larger households was 26%. The non-linear pattern of the results suggests there is no influence of family size on adoption of tillage.

5.3.1.5 Family labour

It emerged that the effect of family labour availability is uneven in relation to adoption of tillage. Households with small amounts of family labour showed the lowest rate (19%) of adoption, while 37% and 25% of those of medium and large size were adopters, respectively.

5.3.1.6 Resource position

Respondents with off-farm activities and those who do not have off-farm activities were almost equally likely to report adaptation of tillage (51%). However, the rate of adoption for those with off-farm activities was higher (30%) compared to those with no off-farm activities (20%). Resource position therefore, shows some positive relation to adoption of tillage.

5.3.2 Household characteristics in relation to tillage

The adoption model for tillage was developed in consideration of the two relevant household characteristics which were observed during qualitative study. These were the tendency for the household to grow maize or nuts and perceptions of soil texture.

5.3.2.1 Tendency to grow maize or nuts

The majority (58%) of respondents who grow nuts are adapters of tillage. Only 14% of those who grow nuts are non-adopters and 28% are adopters. The relationship between the tendency to grow maize and adoption is even stronger with those sample households growing new maize seed varieties. The majority (83%) of those growing new maize varieties were adapters and 17% were adopters of tillage. The majority (63%) of those who grow traditional varieties were adapters, 16% adopters and 21% non-adopters of tillage.

5.3.2.2 Perception of soil texture

About 26% of those perceiving their soils to be light were adopters, 25% were non-adopters and 49% adapters. Of those referring to their soils as of medium texture 26% were adopters, 17% non-adopters and 57% adapters. Of those cultivating on heavy soils, 29% were adopters, 7% non-adopters and 64% adapters. There was no respondent out of 4 cultivating on rented plots who adopted tillage on light soils. The majority (50%) of respondents cultivating on rented plots with medium soils were adapters, 41% were adopters and only 9% were non-adopters.

These results show that there might be some other factors which override the perception towards the light soils, since the proportions of adoption and non-adoption in light soils are equal on own plots. This fact could not appear in rented plots perhaps due the low number of respondents in that category. However, the rate of adoption for tillage increases as households perceive the soils to be heavier in both rented and own plots.

Findings from this section (section 5) confirm the conclusions presented in Sections 4.7 – 4.9. The factors affecting adoption and non-adoption of technology are specific to the type of technology and the prevailing conditions. An adopter of one technology may not necessarily be an adopter of any other technology. Furthermore, the socio-economic description of the household may give some indication of the likelihood that it will be an adopter or non-adopter of the technology but the most accurate factors associated with the prediction of adoption and non-adoption are the characteristics of the household.

6. Demand for future research

Using the case study approach, this research has used the experience from Hombolo and Ilula in Tanzania to identify production constraints across a wide range of farmers. These include resource poor/resource rich, resource restricted/resource access, non-adopters/adopters of NRM technologies, those who farm on rented/own land, those who farm for home consumption/for selling. The rationale behind their adoption or non-adoption of NRM technologies and the ways they are incorporated into the farming enterprises of all these groups of farmers were investigated. In this section, the findings are used to assess the potential demand for future on-farm technological innovations in soil water management, soil nutrient management and plant genetic resources.

It has emerged from this study that subsistence agriculture seems to be the most prominent and sustainable form of agriculture in semi-arid areas of Tanzania, and all efforts to improve the level of agricultural output must address production constraints at the household level.

The study acknowledges all previous recommendations related to on-farm natural resources management and improvement of crop production, which are geared to sustain household food security. However, the findings reported in sections 4.6 and 5 indicate that 'poor crop production' has remained the most frequently reported constraint to attaining food security for the majority of the households, whether they are adopters or non-adopters of any of the technologies considered in the study (Figure 6.1).

6.1 On farm natural resource management

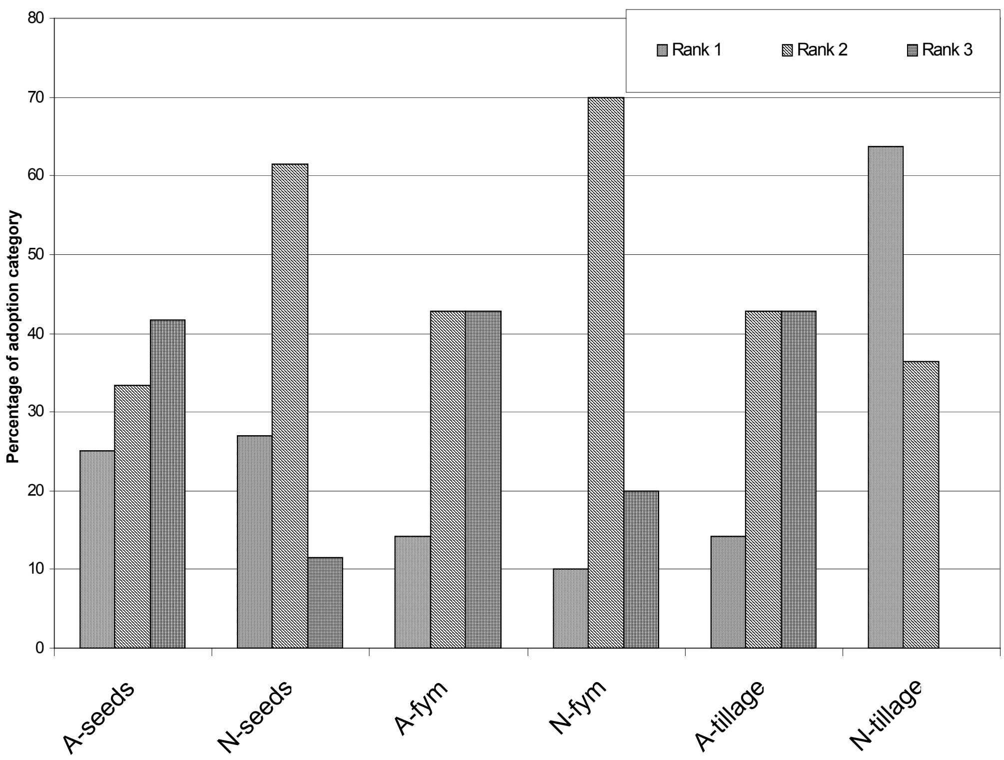
During data collection, farmers showed little interest in on-farm natural resource base conservation and enhancement *per se*, but were more concerned about increasing crop production and reducing storage loss – two key elements in household food security in subsistence-orientated agriculture. The implication is that, unless crop production is increased, resource poor farmers are not interested in long-term sustainability of the resource base which requires considerable investment of time, hard labour and cash. Natural resources are managed with a view to ensuring short term production.

On the other hand, it has also emerged that farmers who practice intensive farming do not necessarily take conscious action to conserve the natural resource base. This is true of those who engage in tomato production in Ilula. Equally, farmers who practice intensive maize production do not take into consideration the conservation and regeneration of natural soil nutrients. The prospect of increasing crop production is therefore a necessary, but not a sufficient, condition for adoption of NRM technologies. Based on these findings, new research and technological innovations should be focused, location specific and contextual.

6.2 Identification of research demands

This section uses the findings from the scored causal diagrams as a tool for identification of future research demands. The assumption is that, when the adopters of a technology highly rank 'poor crop production' as a constraint towards food insecurity, compared to the non-adopters, it indicates that the technology which has been adopted has not been effective in increasing crop production. The demand for further research increases when non-adopters of the same technology also highly relate poor crop production with food insecurity.

Figure 6.1 Frequency with which "poor crop production" is ranked as a constraint to household food security, by adoption and non-adoption of NRM technologies



A = adopter of the technology
N = non-adopter of the technology

Figure 6.1 presents data on the ranks given to "poor crop production" as a constraint on food security, as determined by analysis of the scoring of causes in Scored Causal Diagrams, for farmers who have, and have not, adopted each of the three types of NRM technology. They indicate differences between adopter categories for each technology type, as well as between technologies.

6.2.1 Demand for diversification of plant genetic resources.

Adopters of plant genetic resources are just as likely to rank poor crop production as the most serious constraint as non-adopters. The proportion giving it the highest rank is almost the same for the two categories (25% and 27% for adopters and non-adopters, respectively). The modal rank, however, is 2 for non-adopters and 3 for adopters, indicating that overall poor crop production is a more serious constraint for those who have not adopted new seed varieties.

This suggests that the new plant genetic resources have not improved crop production to a satisfactory extent. We can deduce that farmers will respond positively to future new varieties which offer higher yields, provided these are compatible with their existing production and livelihood systems. It will be important, however, to identify the reasons why some farmers have not adopted the new varieties already available, so that these reasons can be specifically addressed in future variety selection or development programmes, or in the ways in which they are introduced and promoted.

While some farmers have adopted new seed varieties of cereals, especially maize, millet and sorghum, and technological innovations in improved storage facilities, technologies in these two areas have not come up to farmers' expectations. According to farmers, non-adoption of the new seed varieties is the result and manifestation of two main factors:

i. new seed varieties change their properties when the harvests of the same seeds are grown over several seasons
ii. new seed varieties are 'light' – in other words, they are very susceptible to pest and disease infestations.

'New seeds have been promoted but they keep on changing year after another. …We are required to buy seed every season at a high price if we are to maintain the production level….What is wrong with our traditional seeds? They have all qualities I need. I am afraid I cannot afford to buy new seed variety any more! We would not like to face the same problem we have faced in tick-borne diseases of our cattle. There were birds around who did biological control of the ticks. When new technology was introduced it poisoned the birds as well as ticks. …Now the birds are extinct, grants for dipping have been withdrawn and tick-borne diseases are widespread'

A farmer in Hombolo contributing in a Key Informants' discussion

Farmers have recognised the potential for the new crop varieties in the diversification of plant genetic resources and increasing crop production. Yet there is large number of farmers who do not plant new varieties, which suggests that crop production from new varieties is not the only factor which influences their uptake. There are social, biological and ecological factors which new research and technological innovation need to address as well.

Farmers are strongly concerned with the sustainability of the new seed varieties, in terms of maintaining varietal characteristics. Since almost all cereals are cross or self-pollinated, after a few years of crop production, about 30% of the new crop will have mixed lines of various qualities.

If farmers' production capabilities are to increase they will have to produce their own seeds under stringent conditions or buy seed from commercial companies. About 76% of non-adopters and 27% of adopters of the new seed varieties have protested against high prices of the seed from commercial companies and are unlikely to buy them in the future.

Throughout the study, farmers have maintained that the level of pests and diseases in the new crop varieties is higher compared to traditional seeds. The scientific community has recognised these views and is undoubtedly taking them into account in more recent work. The most important issue to be considered in future research programmes is the specificity with which a technology can be focused, since breeding new seed varieties for a specific range of climatic conditions which are also tolerant or resistant to pests and disease may prove to be very difficult.

Further improvement of the traditional storage facilities, *Vihenge*, has fallen short of expectations. Although this research was not designed to investigate storage issues, farmers made a direct link between crop pests and diseases, type of varieties and storage recommendations. They reckon there is a basic incompatibility between these three elements. There does not appear to be a design problem as such with the improved *Vihenge,* but rather social-psychological factors in relation to food misuse, and the technical question of how insecticide could be applied on maize ears, make it difficult for them to be used effectively. There would therefore seem to be a need for continued research into storage techniques which are compatible with prevailing food use.

6.2.2 Demand for soil nutrient management

There is not much difference between the proportions of adopters and non-adopters of FYM, (14% and 10%, respectively) who place rank poor crop production as the primary cause of food insecurity. The modal rank for adopters lies between 2 and 3; for non-adopters it is 2. This suggests that low yields are seen as a more serious problem by non-adopters, indicating that those who have adopted – or been able to adopt – improved use of FYM are more satisfied with their yields than those who have not. However, as discussed earlier, there are serious constraints to the use of FYM, particularly for households with few or declining numbers of livestock. Further research outputs in this area are only likely to be taken up by those farmers who are already using manure from their own livestock, and then only if the production gains are clearly commensurate with any increases in labour or management input. Households with no livestock only access manure through post-harvest grazing by other people's animals: it is unlikely that research will provide much improvement to the gains from this practice. Any changes in use of crop residues, for example to produce compost, would require changes in local regimes of rights regarding access by livestock to fields after harvest: research in this area would therefore be around institutions and land tenure rather than technology *per se*.

6.2.3 Demand for soil water management through (improved) tillage

The difference in proportions of adopters and non-adopters of tillage ranking low crop production the most serious cause of food insecurity is much more marked than for the other two technologies: 14% for adopters and 64% for non-adopters. The low percentage of adopters indicates that tillage has helped them to increase crop production while the high percentage of non-adopters indicates that no-tillage plays a major role in poor crop production. This implies that among non-adopters there is potential demand for research related to tillage and on-farm soil moisture management, provided that it addresses the constraints that have so far discouraged or prevented them from adopting the available technologies. At the same time, over 40% of adopters of tillage ranked low crop production their second most severe constraint, suggesting that many adopters would welcome further improvement in technologies for soil water management.

Types of crops, soil physical properties, and tillage are widely associated with the conservation and management of soil moisture. Farmers would consider the water retention capability of their soils before adopting soil water management technologies. Where the soil is light, a farmer would practice dry planting, followed by minimum tillage associated with subsequent weeding. This kind of practice is very common with adopters of tillage who are growing millet/sorghum around their homesteads in Hombolo. The soils in Ilula are relatively heavy and adopters of tillage would try to plough their land on the onset of rains.

There have been some attempts to promote tied-ridging in the heavy soils of Hombolo in order to improve soil moisture retention. The rate of uptake has been very low and the adopters of the technologies have abandoned the practice altogether. Unless research and technological innovation address some of the problems identified by the farmers there will be a continued low uptake of tied-ridging technologies in semi-arid regions of Tanzania. The main reasons associated with the non-adoption of tied-ridging are:

i. Large amount of labour required for construction and maintenance of the ridges. Farmers have realised that the amount of labour required is not cost effective considering the output from the enterprise.
ii. Tied-ridging is effective only on a specific range of rainfall distribution, which seldom, or according to some farmers, never happens (see section 4.9.3 above).

Across a wide range of farmers, especially poor and resource restricted households, early planting is difficult to achieve. Renting ox-ploughs is expensive and tractors are beyond the poor household's financial ability. In many parts of Tanzania including Hombolo, ox-ploughing has been introduced and promoted. The technical designs and the overall output of the oxen-plough are adequate enough to attract farmers with oxen to adopt the practice. Yet, the rate of adoption is relatively low and the reasons behind such low uptake are not clear.

> 'I have poor crop yields this season. I could not get ploughing implements on time and subsequently I delayed planting'

A farmer during participatory group discussion, Ilula

There are some social studies on low uptake of oxen-ploughing in some other parts of Tanzania, for example among the Masaai. To extrapolate such findings to Hombolo and Ilula may prove not useful since the traditional values are not the same as those of the Masaai.

Excessive heavy rains and long dry spells are both detrimental for agro-ecological sustainability of the semi-arid areas. In Tanzania, and indeed in Hombolo specifically, there are some ongoing efforts towards an understanding of agro-meteorological conditions, which need strong support from research. Farmers have reported changing seasonal weather patterns, especially of rains. The indigenous knowledge about the weather pattern has declined and is now confronted with uncertainties due to the changing weather system at global level. The implications of understanding agro-meteorological conditions are enormous, since timely planting is a prerequisite for successful crop production in semi-arid areas.

> '…we need new seed varieties which mature earlier to cope with erratic rainfall in our area'

An adopter of new seed varieties in Ilula

> '.... The secret behind crop success is early planting. First rains are for planting. Full stop!'

A non-adopter of the new seed varieties in Ilula

Some farmers have reported that they adopted new svarieties to catch up with a bad rainy season, because even with a delayed planting they felt they could still have better yields. Non-adopters perceived late planting to be a constraint to production, arguing that they have always been successful when planting on the onset of rains. They appreciate that a delay in planting results in serious crop failure. Some farmers have lost track of the recent patterns of the rains and the way it affects their crop practices. For instance, farmers in Ilula reckoned that the current season (1999-2000) was particularly bad, while farmers in Hombolo reckoned that the previous season was worse. It is not clear whether this reflects local variations in rainfall.

> 'I am used to planting new seed varieties This season I tried traditional seeds in some of my fields...... I am disappointed that rains went off before my crops matured. I am not going to harvest anything from those fields'. ***Another farmer asked her*** 'When did you plant, first rains?' ***She responded*** 'Not really, some times later' ***The other farmer commented*** 'I always plant traditional seeds. I am going to have normal harvest this season. I managed to plant on the onset of the first rains.'

Discussion between two farmers during FGDs in Ilula

6.3 Agro-chemicals

Farmers perceive that increasing vegetable production in Ilula, especially tomatoes, depends on the use of agro-chemicals against pests and diseases. While that might be true the sustainability of tomato production and the market for tomatoes treated with heavy doses of agro-chemicals are uncertain. The processes of natural regeneration of soil nutrients are being damaged and soil micro-organisms destroyed.

Research and technological innovations have provided Ilula farmers with a good crop variety which morphologically distinguishes itself in the market. Further research efforts are needed to reverse the situation before it is too late. Customers would recognise when they see the tomatoes and relate its production techniques with the area. For instance, Ilula tomatoes were recently rejected in Malawi because of the large amount of chemical traces in the produce.

6.4 Priorities for research demands

The findings of the study indicate that there is demand for new or modified technologies which will enable farmers to maintain or increase their production in the face of a deteriorating natural resource base and variable and changing rainfall patterns. The analysis in this section suggests that the main priority is for soil water management technologies (section 6.2.3). The majority (51%) of the farmers have indicated that the main reason for investing in tillage is because it controls weeds and promotes growth and production. About 42% indicated that it improves soil structure and water retention capabilities (section 5); however the majority of those who have adopted tillage still rank low levels of crop production as their first or second most serious constraint in achieving food security (Figure 6.1).

The second highest research priority identified by the farmers is for ways of improving the nutrient status of soils (section 6.2.2). Those farmers who do not - or are not able to - use manure on their fields are more likely to be concerned about poor yields. Their situation, however, highlights the limited scope for increasing the number of farmers in the study areas who use currently available technologies. Those who do not use them, or have tried and later rejected them, either have specific resource constraints or have cogent reasons for not using them. Outputs of future research will be in demand to the extent that they demonstrate their potential to increase crop production within the resource constraints of poor households. Action to address institutional factors which limit uptake will also be needed at a policy and operational level.

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Appendix 1: Sample survey questionnaire: Hombolo and Ilula villages, Tanzania

No….. Enumerator………………………………..Village ……………………………...

A: PARTICULARS OF THE HEAD OF HOUSEHOLD

1. Age (years):(i) 18 - 25 (ii) 26 - 39 (iii) > 39

2. Gender: (i) Female…….. (ii) Male…….

3. Education: (i) No formal education (ii) Primary…(iii) Secondary…(iv) Post secondary…

B: LIVELIHOOD ISSUES

1. Number of household members (size): (i) 1 – 2 (ii) 3 – 4 (iii) >4

2. Number of (fulltime) family labour available (size): (i)1–2 (ii) 3–4 (iii) >4

3. How far do you stay from the village main road? (i) <1Km (ii) 1-2Km (iii) >3Km

4. Ownership status; distance from homestead and farm size

	Own plots						Rented plots			
	1	2	3	4	5	6	1	2	3	4
Distance from homestead to the farm (Km)										
Size of the farm in Ha.										

5. Which off farm activity largely contributes to the household income?…………………………..

6. How many of these do you keep? (i) Cattle…(ii) Goat/sheep..(iii) Poultry.. (iv) Pigs..(v) Others (names)…

C: ADOPTION ISSUES

1. What varieties of the crop(s) do you grow and for what main purpose?

	Maize		Millet		Sorghum		Others three important crops					
	Sale	Food	Sale	Food	Sale	Food	Sale	Food	Sale	Food	Sale	Food
New varieties												
Traditional varieties												

2. If you are growing traditional varieties only, have you ever grown new varieties? (i) Yes (ii) No.

3. If yes, why did you stop (one main reason)? …………………………………

4. Why do you like to grow these types of seed variety (one main reason – where applicable)?

(a) New variety …………………………

(b) Traditional varieties (one main reason) ……………………………

5. How do you store your crop produce? …………………………………….

6. What reason made you to store your crop produce in that way (Ref. No. 5)?…………………..

7. Can you differentiate the taste between maize/sorghum/millet meal cooked from new varieties and that of traditional varieties? (i) Yes (ii) No

8. If yes (No. 7) which do you prefer mostly (i) New varieties (ii) Traditional variety

9. How many of the plots you farm that you do not till? (i) All (ii) Some (iii) None.

10. Why you don't till (give only one reason - ref. No. 9- where applicable)? ………………

11. Why you do till (give only one reason - ref. No. 9 - where applicable)? …..………………

12. When do you till ? (i) before planting … (ii) after planting ….

13. Do you apply fertiliser in the farm(s)? (i) Yes … (ii) No …

14. If yes,

(a) what type of fertiliser do you mainly use in your own plots? (i) organic.(ii)inorganic (iii) both

(b) what type of fertiliser do you mainly use in rented plots? (i) organic. (ii) inorganic iii) both (c) what is the main type of soil can be found in your own plots? (i) light (ii) medium (iii) heavy

(d) what type of soil can be found in plots that you rent in? (i) light (ii) medium (iii) heavy …

15. If no (ref. No 12) or you don't apply organic fertiliser, have you used it before? (i) Yes (ii) No

16 (a). Why you don't use organic fertiliser (one main reason) ? ……………………..

16 (b). Why do you do you use organic fertiliser (one main reason) ? ………………………..