ADOPTION OF IMPROVED TECHNOLOGIES FOR SORGHUM AND PEARL MILLET PRODUCTION IN DODOMA REGION IN CENTRAL TANZANIA

BY

JUDICATE NAFTAL WANGAEL MWANGA

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ABSTRACT

A study on adoption of improved technologies for production of sorghum and pearl millet was conducted in Dodoma region in Tanzania. A two stage cross sectional research design was adopted for data collection. A structured questionnaire was administered to a random sample of 240 farmers. The results shows that 88% of sampled household heads were aware of improved sorghum and 48% were aware of improved pearl millets varieties. About 49%, 36%, and 4% of sampled sorghum farmers were growing Pato, Tegemeo, and Macia respectively. Only 10% of pearl millet farmers were growing Okoa. Results from logistic curve estimation showed that the annual rate of adoption for improved sorghum varieties was 0.56, 0.79 and 0.53 for Pato, Tegemeo and Macia respectively. Okoa was adopted at an annual rate of 0.46. Adopters of Pato were characterized by being younger, with lower farming experience and had more years in formal school compared to non-adopters. Adopters had more number of livestock, larger farm size and more non-livestock wealth value than non-adopters. Major factors, which were, found to limit adoption of sorghum and pearl millet innovations, were: Lack of market, lack of credit facility, low varietal turn over rate, weak seed supply system, and lack of appropriate extension messages. Other factors include age of households' head, years in formal schools, capacity to hire labour, exposure to research intervention, number of tropical livestock units (TLU), and opportunities for non farm income. Based on the empirical findings of this study it is recommended that seed development and release process should be improved. Breeding work should target the end users. Private sector and processors should be involved in research on the use the two crops in brewing, food and animal feed industries. Special program in collaboration with sorghum and millet

program in Central and Eastern zones should focus research on post harvest processing and product utilization. Market development bureau should look for external markets to encourage export of sorghum and pearl millet. Marketing promotions are required to encourage local consumption of sorghum and pearl millet products.

DEDICATION

To the Lord Jesus Christ, the same Lord yesterday, today and forever. But they that wait upon the Lord shall renew their strength (Isaiah 40:29-31). This work is dedicated to my parents, the late Mr. Naftal Wangael Kileo Mawaia, and Mrs. Elisifa Elia Kyaro Mankya, who paved the way for my academic career.

DECLARATION

I, **JUDICATE NAFTAL WANGAEL MWANGA** do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation is my own original work and has not been nor is it concurrently being submitted for a degree award in any other University.

Signature.....

Date 30/8/2002

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ABBREVIATIONS AND ACRONYMS

ARI	Agricultural Research Institute
CBOs	Community Based Organizations
CDF	Cumulative Distribution Functions
CIMMYT	International Centre for Maize and Wheat Improvement
COSTECH	Commission of Science and Technology
DAEA	Department of Agricultural Economics and Agribusiness
DANIDA	Danish Development Agency
DAT	Draft Animal Technology
DCT	Diocese of Central Tanganyika
DRD	Department of Research and Development
DRT	Department of Research and Training, MoAC
EAC	East African Community
EAFRO	East African Agricultural and Forestry Research Organization
ESRF	Economic and Social Research Foundation
FSA	Farming System Approach
FSR	Farming System Research
FYM	Farm yard manure
GDP	Gross Domestic Product
Ha	Hectare
HADO	Hifadhi Ardhi Dodoma
ICRISAT	International Crops Research Institute for the Semi-Arid Tropic
IDM	Institute of Development Management
Kg	Kilogram
Km	Kilometre
LPM	Linear Probability model
MAFS	Ministry of Agriculture and Food Security
m.a.s.l	Meters above sea level
mm	Millimetre
MoAC	Ministry of Agriculture and Co-operatives

N	Nitrogen
NARS	National Agricultural Research System.
NGOs	Non Government Organizations
NRI	National Research Institute
NSMIP	National Sorghum and Millet Improvement Programme
OFR	On Farm Research
^{o}C	Degree Celsius
PRA	Participatory Rural Appraisal
SADC	Southern African Development Community
SAPs	Structural Adjustment Programmes
SMIP	Sorghum and Millet Improvement Programme
SGR	Strategic Grain Reserve
SMINET	Sorghum and Millet Improvement Network
SNAL	Sokoine National Agricultural Library
SPSS	Statistical Package for Social Sciences
SUA	Sokoine University of Agriculture
TALIRO	Tanzania Livestock Research Organization
TANSEED	Tanzania Seed Company
TARO	Tanzania Agricultural Research Organization.
TARP	Tanzania Agricultural Research Project
TOSCA	Tanzania Official Seed Certification Agency
TORITA	Tobacco Research Institute of Tanzania
UCLAS	University College of Land Sciences
UD	University of Dar Es Salaam
URT	United Republic of Tanzania
VAEO	Village agricultural extension officer
VEO	Village Executive Officer

CHAPTER ONE

INTRODUCTION

1.1 Background

1.1.1 Agriculture in Tanzania

Agriculture continues to be the backbone of Tanzanian economy. It accounts for about half of the national income and slightly more than half of merchandise exports, and is a source of livelihood for about 80 percent of Tanzanians (World Bank, 2001). Agriculture's prominence is also due to the fact that it contributes to the non-farm sector by providing food and raw materials to agro-processing industries. Moreover, about 75 percent of the Tanzanian population resides in rural areas practicing small-scale farming. The future of small-scale farmers depends largely on availability of agricultural technologies and ability to apply improved technologies in agricultural production.

1.1.2 The National Agricultural Research System

Department of Research and Development (DRD) of the Ministry of Agriculture and Food Security (MAF) currently coordinate the National Agricultural Research System (NARS) in Tanzania. The Department of Research and Development evolved from restructuring of the Department of Research and Training (DRT) in 1999. DRT was created as one of the four departments in the former Ministry of Agriculture and Co-operative MAC in July 1989, following the dissolution of the Tanzania Agricultural

Research Organization (TARO) and Tanzania livestock Research Organization (TALIRO), responsible for crop and livestock research respectively.

Currently, DRD is under the Ministry of Agriculture and Food Security (MAFS) and is responsible for crops, special programmes, socio-economics and farming system research, following the recent changes which led to formation of two new ministries. These are Ministry of Water and Livestock Development and Ministry of Cooperative and Marketing. Under DRD there are 15 Research institutes and eight research centres organized in seven agro-ecological zones. The zones are Central, Northern, Eastern, Lake, Western, Southern and Southern Highlands with responsibility for applied and location specific adaptive research. Under each zonal research centre there are a number of substations catering for specific commodities.

In 1974, research was organized on commodity level along crop interests. Sorghum and millets research was coordinated from Ilonga Agricultural Research Institute (ARI-Ilonga) and the major co-operating Institutes were Ukiriguru, Hombolo, Research stations and the International Crop Research Institute for Semi Arid Tropics (ICRISAT). Currently agricultural research in the country is organized by programmes. The National Sorghum and Millet Improvement programme coordinates sorghum and millet research from ARI-Ilonga. Together with the DRD there are other government institutions involved with agriculture research, these include universities, public research institutes and private sector.

Public research institutions include Tropical Pesticides Research Institute (TPRI), the Tanzania Tea Research Institute (TRITI), Tobacco Research Institute of Tanzania (TORITA), University of Dar Es Salaam (UD) and Sokoine University of Agriculture

(SUA). Others are University College of Land Sciences (UCLAS) formally known as Ardhi Institute and Institute of Development Management (IDM) Mzumbe.

Recently, opportunities for private sector involvement in agricultural research have opened up. These are largely involved with export crops such as tea, coffee, Tobacco, cashew nuts and cotton. The activities of private sector are more elaborate for input supply and marketing of agricultural products. Example of such private institution includes multinational seed companies. Foreign individuals with permit from Commission of Science and Technology (COSTECH) do also conduct agricultural research in the country. Also non-governmental organizations (NGOs), for example, Economic and Social Research Foundation (ESRF) are conducting agricultural research in Tanzania. In order to address the small holders problems, Department of Research and Development has been and will continue to be a major stakeholder in generating demand driven, client oriented technological packages.

1.1.3 The Role of sorghum and pearl millet in food security

Sorghum (*Sorghum bicolor* (L) Moench) and pearl millet (*Pennisetum typhoides* (Burn) Staph *et* Hubb) are crucial crops in the world food security. Both crops are staple food for the people of the dryer areas of Asia and Africa. Due to the worsening of food production in many parts of Asia and Africa, there is increasing interest by those in government to make decisions that could improve food crop yields. This can be accomplished with high quality seeds of improved varieties and better cultivation practices.

Sorghum and millets are among the six main food crops in Tanzania. The two crops contribute about five percent of agricultural Gross Domestic Product (GDP) (Table 1.1).

Sorghum and pearl millet are important food crops and income sources for many rural households particularly those in the Semi-arid areas (Ishuza, 1994; Msambichaka and Mashindano, 1999).

Table 1.1: Contribution of agriculture to national output

Commodity	Gross Domestic Product (Million T sh. at 1992 prices)	Percentage of agricultural GDP
Maize	168,492	22.8
Paddy	59,333	8.0
Wheat	3,487	0.5
Millet/Sorghum	33,780	4.6
Cassava	33,602	4.5
Beans	38,673	5.2
Other food crops	144,212	19.5
Cash crops	67,991	9.2
Total crop Production:	549,569	74.3
Livestock	98,680	13.3
Forestry, Hunting, fishing	91,691	12.4
Overall Total:	739,940	174.3

Source: World Bank (2001)

Since they are drought resistant crops, sorghum and pearl millets play an important role in rain-fed agricultural production like that of Tanzania (Ishuza, 1994). These semi-arid areas include Dodoma, Singida, Tabora, Shinyanga, and Mwanza region. These regions together produce 50% of the country commercial sorghum output (Msambichaka and Mashindano, 1999). Production of millets is mainly concentrated

in Rukwa, Singida, Dodoma, Mwanza, and Mara. These regions produce about 96% of the total finger and pearl millet production (Msambichaka and Mashindano, 1999).

Sorghum and millet accounts for one fifth of the area planted with cereal grains and 17% of the total cereal production in Tanzania, (Banda, 1993). According to Kiriwagulu, (1998); Msambichaka and Mashindano, (1999) the yields ranged between 0.9 tonnes to 2.5 t/ha for sorghum and between 0.65 and 2 t./ha for millet in different parts of the country. Among other reasons for low production of these crops is the use of local varieties and limited use of fertilizers. Evidence from Sasakawa Global 2000 shows that by adopting improved sorghum seeds and small quantity of chemical fertilizer, small-scale farmers can produce yields greater than two tons per hectare.

Sorghum and millet are hunger relief crops some times called drought staple crops (Ishuza, 1993). They have great potential to thrive during the threatening periods of food insecurity caused by drought. They fall under first priority research commodities in the central zone, which experience frequent famines due to drought. Tanzania experienced serious droughts in 1974, 1991, 1993 and 1999 where sorghum and millet played a very important role of hunger relief.

Sorghum and pearl millet as food security crops

Food security is defined as the availability of and accessibility to adequate food at all times to all people (URT 1992). According to FAO (1983) as quoted by Maxwell and Frankenberger (1992) food security is defined as an assurance that all people at all

times have both physical and economic access to the basic food they need. This definition encompasses three specific goals: (i) ensuring adequacy of food supplies (ii) maximizing stability in supplies and (iii) securing access to the available supplies for all those who need them. The World Bank (1986) in Maxwell and Frankenberger (1992) broadly defines food security as access by all people at all times to enough food for an active healthy life. Its essential elements are the availability of food and the ability to acquire it. From the definitions above, food security stands on three major pillars namely availability, accessibility, and affordability of food by all people at all times. According to this perspective therefore food insecurity refers to the lack of access to enough food.

According to URT (1997a), Dodoma region is generally a food deficit area due to frequent droughts. During good years, e.g. in 1991/92 seasons, about 75% and 41% of national sorghum and millets respectively came from Dodoma. Although the two crops contribute very little in terms of household cash income, they form the most important food supply. In general, pearl millet is the most important staple in Dodoma rural areas followed by sorghum and maize. Other important crops during famines are maize, cassava, finger millet, cowpea and pigeon pea.

In order to distribute risk, farmers tend to plant both improved short term and local, long-term sorghum and pearl millet varieties. Fast maturing varieties are vulnerable to bird attack and thieves while long term maturing varieties are likely to suffer moisture stress. Horticultural crops are becoming important in household food requirement since they provide variety of vegetables and fruits.

Utilization of different parts of sorghum and millets

Despite the fact that sorghum and pearl millet are staple food crops in Dodoma, commercial utilization of these crops is limited to very few uses. The main uses are porridge, stiff porridge and local brew. Sorghum and pearl millet milling industry is growing very slowly because the two crops cannot compete with maize as commercial food product (Laswai *et al.* 1999; Mgonja *et al.* 1999). The major constraints in utilization of sorghum and pearl millet by small-scale farmers are centred on lack of knowledge and poor processing techniques. Commercial milling is curtailed by low consumer demand for sorghum and pearl millet meals.

Contribution of sorghum and pearl millets in households' livelihoods

Sorghum and pearl millet has significant contribution to households' livelihoods in Dodoma region (URT 1997a). Based on discussion with farmers in the study villages and (Monyo *et al.* (1998), the main uses of the two crops are food sources, income source, livestock feed, construction materials, ethno medicine and source of fuel.

Livestock feed

The vegetative part of sorghum and pearl millet is used for livestock feed. Varieties that remain green during dry season are most important for forage supply. In mixture with other grains, sorghum can be used in feed industry, despite the tannin content. In Tanzania feed industry, this potential has not been exploited, probably because maize is readily available (Monyo *et al.* 1998). Pearl millets are free from tannins and owing to their small grain size; they can be fed to chicken and other birds as whole grains. Sorghum is potential

raw material for brewing. Recently a new brand of opaque beer known as "Mwamba" was commissioned to the market. Unfortunately it is not yet popular enough to command a large market share and subsequent expand market for sorghum (Monyo *et al.* 1998).

Food and income source

The grains are used to make different products. These include local brew (Ubabu from pearl millet), stiff porridge, porridge, and bread. Kande is a recipe that is prepared in similar way as rice. Togwa (chamoto) is a sweet non-alcoholic but quite nutritive drink and it resembles power malts. Mabumunda (pop sorghum) are prepared by roasting the grains of white Langalanga variety, due to its popping characteristic. In some villages they can make pancake and (vitumbua) from pearl millet. The grains from the two crops are used for safari food popularly known by Wagogo as (chamhombogwa). The safari food is prepared by roasting, grinding, adding salt to grains and packing the product. During consumption, some water is added to make a paste like texture consumed as safari food. In Kondoa district, farmers tend to mix sorghum and maize when just about to mill. According to farmers blending of sorghum and maize improves the quality of resulting meals.

Some varieties have got sweet stalks, which are chewed as sugar cane. According to farmers Ibiwa a local sorghum landrace is one of very sweet varieties. This is popular where sugar canes are scarce. This attribute is lacking in pearl millets varieties.

The stalks and leaves are used as construction materials and also as fuel. According to farmers in the study area, juice from boiled pearl millet roots is used to initiate labor pains and enhance removal of retained placenta in cattle.

1.2 National Sorghum and Millets' Improvement Programme (NSMIP)

The importance of sorghum and millet in household's livelihoods in semiarid areas of Tanzania necessitated the initiation of research activities. Thus in 1932 sorghum and millets' improvement research programme was initiated by the colonial government at Ukiriguru Research Station and later moved to Ilonga Agricultural Research Station in 1972. After independence and formation of the East African Community (EAC), sorghum and millet research was co-ordinated by the East Africa Agricultural and Forestry Research Organization (EAAFRO) based at Serere Uganda. After the collapse of EAC in 1977, research activities on sorghum and millet were carried over by the National Sorghum and Millet Improvement Programme (NSMIP), which was formally formed in early 1980's. NSMIP is based at ARI - Ilonga in Morogoro region and Hombolo sub-station in Dodoma region. The two stations (Ilonga and Hombolo) have a mandate for research on drought tolerant crops.

The main objective of NSMIP was to promote the production of small grains by providing farmers with improved varieties with high grain yields, desirable agronomic characteristics, and resistance to major pests and diseases (Saadan and Mndolwa, 1999). In 1992/93 the NMSIP research activities were prioritised following the limited resources allocated to the programme. Technology transfer ranked very high (Saadan and Mndolwa 1999). Other activities included variety development, crop protection, seed production and distribution, to develop linkages between grain producers and industrial consumers and finally promote processing, marketing, storage and utilization.

The NSMIP conducted research in collaboration with International Crops Research Institute for Semi-Arid Tropics (ICRISAT) based in India. There is also collaboration with the Sorghum and Millet Improvement Programme (SMIP), an organ of Southern Africa Development Community (SADC) / ICRISAT based in Bulawayo, Zimbabwe. Through institutional collaboration, new genetic materials were introduced from SADC/ICRISAT. As an output from collaborative activities in sorghum and pearl millet research, several improved varieties and appropriate agronomic packages were developed and disseminated to farmers.

Under NSMIP, the main research activities involved development of improved varieties and appropriate agronomic packages. However, Tanzania just like many other developing countries is said to be characterized by very low utilization of biological, chemical, mechanical inputs, and limited use of improved varieties (Msambichaka and Mashindano, 1999; Heisey and Mwangi 1996).

According to Myaka *et al.*, (1999), NSMIP scientists based at Ilonga and Hombolo research stations have released several improved technologies. These includes three sorghum and two pearl millet commercial varieties, management practices namely tillage and land preparation, sowing methods and sowing dates, spacing and plant population, pest control, disease control and inter-cropping. Others are inorganic fertilizer, and farmyard manure application, harvesting and storage. Sorghum and pearl millet require the same management recommendations for most practices.

The programme has also been active in community based and on-farm seed production in collaboration with a bilateral seed project under Danish Development Agency (DANIDA) by providing breeder seed.

1.3 Agricultural Extension, Farmer and Nsmip Linkages

Agricultural extension has a major role to play in agricultural technology transfer. However, a key factor in the effectiveness of technology transfer and diffusion is the strength of linkage between Farmers, Research and Extension (F-R-E linkage) and other stakeholders e.g. NGOs, and private sector companies.

The development of extension service in Tanzania has a long history. Between 1960 and 1970 the government introduced different approaches for technology transfer. These include settlement scheme, farmers training centres and demonstration plots (MOAC, 1997). From 1972 there have been regular policy changes leading to repeated institutional changes with direct bearing on effectiveness of extension and agriculture (Isinika, 1995). Example in 1972 extension service was under the Prime Minister's office. Four years later, Ministry of Agriculture was split in two separate ministries. One for crops and the other for livestock, and extension service was organized under respective ministries. While in 1984 Extension service was under Ministry of Agriculture, in 1998, was shifted to the local government authority. In 2001 the responsibilities of the Ministry of Agriculture and Cooperatives were split in to three independent ministries. The Ministry of Agriculture and Food Security, Ministry of Water and Livestock development and Ministry of Cooperatives and

Marketing. All the above changes have impact on effectiveness of extension service. Together with the changes in organisational set, there has also been a change in approach. For instance in 1988 Training and visit (T&V) was introduced. This approach has been modified in early 1990s and replaced by farmers' group approach (Nombo, 1995; Swai, 1998). However these approaches have proved failure due to the following reasons: (a) Lack of Farmers - Research - Extension linkages. (b) Some of technologies developed by research centres were not demand driven so, they were rejected since they were not beneficial to farmers e.g. sorghum variety Serena. (c) Poor working facilities and means of transport and (d) lack of motivation for extension personnel (MOAC, 1997; Tibendelena 2000).

Diffusion and adoption of improved technologies will depend mostly on effectiveness of extension service in disseminating information to both farmers and researchers. Village Extension workers have been involved in NSMIP's on-farm trials and verification of various technologies. Farmers' participation in the NSMIP programme has been on-farm trials and community based seed multiplication activities. Regional Agricultural Extension Officers (REOs) and Regional Agricultural and Livestock Development Officers (RALDOs), District Agricultural Extension Officers (DEOs), District Agriculture and Livestock Development Officers (DALDOs) and representatives of farmers attended the research planning sessions at zonal centres to ensure the linkage.

During the implementation of National Agricultural, Livestock and Extension Rehabilitation Project (NALERP) supported by World Bank in 1990 to 1999, Monthly Training Sessions (MTS) and Bi-monthly Workshops (BMWs) were organized to bring together Researchers and Extension officers to get exposure to new technologies at district level. The objectives of these workshops were to identify the farmers' problems and formulate extension messages. As such they were potential mechanism for creating linkages between research and extension.

1.4 Problem Identification and Justification of the Study

1.4.1 Problem statement

Considering the importance of sorghum and millet into national economy and households' livelihoods, the Tanzanian government purposively initiated NSMIP. The role of NSMIP was to develop improved sorghum and millet varieties, technologies and recommend them to appropriate farming systems. A number of improved varieties have already been developed and released for public consumption. Examples of these are Pato and Okoa, which are sorghum and pearl millet varieties respectively. Development of improved varieties is accompanied by agronomic practices that include spacing, seed rate and weeding. By adopting improved technologies, at individual or community level, households could improve food security, end hunger, raise income, and improve household livelihood while preserving land and natural resource.

Despite the importance of these crops in the rural economy, little is known about the determinants of sorghum and pearl millet adoption. In addition little had been documented about the contribution of sorghum and pearl millet to people's livelihoods in Tanzania. There are very few empirical studies specifically focused on adoption of sorghum and millets in Tanzania. The existing literature dwells more on qualitative analysis e.g. (Minde and Mbiha, 1993). No study has attempted to quantify the rate and intensity of adoption of sorghum and pearl millet in Tanzania. Therefore there was no empirical evidence that farmers use recommended practices for sorghum and millet. If at all they were used, the extent to which farmers have adopted these recommendations was not well known, quantified and documented.

1.4.2 Justification

Before the introduction of Farming System Approach (FSA) in Tanzania in 1970, farmers' involvement in technology development and transfer was minimal. As a result feed back of farmers problems to research was weak. Apart from poor feedback, the National Agriculture Research System (NARS) has been suffering from insufficient funding (Anandajayasekeram *et al.* 1996; MoAC 1998b). Table 1.2 shows that between 1994 and 1997 the proportion of the MoAC budget, to DRT declined from 26.7% to 17.9% in 1996/1997.

Table 1.2: Ministry of Agriculture and Research budget allocations (T sh. 000,000)

Fiscal year	Total budget				
	GOT	MoAC		DRT	
	Value	Value	% GOT	Value	%MoAC
1994/95	496,695.9	15,270.8	3.3	3,979.8	26.7
1995/96	632,364.0	18,679.7	3.0	3,505.3	18.8
1996/97	758,896.8	18,054.5	2.4	3,236.0	17.9

Source: MoAC (1998b).

The external aid has continuously been slashed, and donors' interests have been re-oriented (Anandajayasekeram *et al.* 1996). In order to attract more investment in agricultural research, there is a need for researchers to produce evidence that research and technology dissemination investments have been competitive compared to other alternatives (Anandajayasekeram *et al.*, 1996). A study on adoption of improved technologies for sorghum and pearl millet is important because it will generate key indicators for measuring farm level impact. Results from this study will help the researchers to refine their technologies to suit farmers' needs. A study by Minde and Mbiha (1993) identified market to be the prime factor, but in a real sense farmers do not produce only for the market. That is why it is important to look into other socio-economic factors.

It is also interesting to find out why farmers cling to their local varieties, which are low yielding and mature late. Although farmers are rational in their decision-making, there are several socio-economic, institutional, technical and environmental factors surrounding the farmers upon which they base farming decisions. Empirical evidence show that adoption of a particular technology is influenced by a number of factors such as

the appropriateness of the technology, institutional factors, and farmer related factors, technology related and environment factors (CIMMYT, 1993). In order to improve the adoption levels, analysis of these factors need to be carried out. The results of this study will therefore facilitate in drawing the implications for stakeholders aimed at improving the two crops and ultimately farmer's welfare.

1.5 Objectives of the Study

1.5.1 General objective

The general objective of this study is to determine the extent of adoption and examine factors that influence farmers' adoption of improved technologies for production of sorghum and pearl millet.

1.5.2 Specific objectives

The specific objectives of the study are to:

(i) determine the rate of adoption of improved sorghum and pearl millet varieties,

(ii) assess the intensity of adoption of improved sorghum and pearl millet varieties,

(iii) characterize and determine the proportion of farmers adopting improved sorghum and pearl millet technologies and

(iv) identify socio-economic factors influencing the adoption of sorghum and pearl millets' technologies in central Tanzania.

1.5.3 Hypotheses of the study

(i) Adoption is independent of combined efforts from various stakeholders in technology development and dissemination.

(ii) Although improved agricultural technologies are more resource efficient in terms of land productivity than local varieties, the rational farmers will always invest more land to varieties that will maximize utility.

(iii) Adoption behaviour is directly or indirectly associated with specific socio-economic and demographic characteristics, farmers' circumstances and the prevailing micro and macroeconomic environment.

1.6 Organization of the Study

This dissertation consists of five chapters. Chapter one is an introduction giving an overview of the study and problem statement. Chapter two presents the literature review. Chapter three provides conceptual framework and the methodology employed in the study. Chapter four presents the major findings of the study. The conclusions and recommendations of the study are presented in chapter five.

CHAPTER TWO

LITERATURE REVIEW

This chapter presents the literature review on adoption of innovations. It explores the experiences largely from the past studies in Tanzania, and other parts of the world. Particular interest was paid to methodologies employed in adoption studies and factors affecting adoption of agricultural innovations.

2.1 Adoption Defined

Adoption of innovation is defined as a decision to apply innovation and continues to use it, (Van de Ban and Hawkins, 1996). Some authors tend to modify the above conventional definition to include real adopters and potential adopters (Nell *et al.* 1999). The argument is that, had there been no limitations in accessing and using the innovations, the potential adopters would become adopters. Willingness to change and desire to try new ideas are the main causes of innovative behaviour.

Adoption processes refer to series of changes that take place within an individual with regard to an innovation. These changes start from the moment the farmer first becomes aware of that innovation to the final decision to use it or not (Van de Ban and Hawkins, 1996). The adoption process, involves various stages. These are: (a) Awareness stage in which the farmer or potential innovator hears about the innovation for the first time. (b) Interest building stage in which the farmer seeks more information about the innovation. (c) Evaluation stage in which the farmer weighs the advantages and disadvantages of using the innovation. (d) Trial stage in which the

farmers test the innovation on small scale to avoid risk associated with using innovations. (e) Adoption stage in which the farmer applies the innovation on large scale in preference to the old technologies. In this study a definition by Van de Ban and Hawkins, (1996) will be adopted.

The primary question in adoption study is what constitutes adoption? What is the minimum proportion of farmer's field that should be planted with new variety for them to be called adopters? According to CIMMYT (1993) adoption can be measured by determining the rate of adoption (percentage of farmers growing improved variety). It can also be measured by looking at the intensity (percentage aggregate area under improved variety). Adoption can also be measured by percentage aggregate sorghum and millet output of improved variety.

2.2 Adoption and Diffusion of Innovation

Adoption of an innovation is distinguished from diffusion by time factor. According to CIMMYT (1993), adoption is measured at a point in time, whereas the diffusion of innovation is the spread of the innovation across the community over time.

There are several theories on adoption of innovations. These are classified as sociological and economical theories (Semgalawe, 1998). Under sociological theories there is: (a) Decision theoretical model in which adoption is regarded as learning process (Van de Ban and Hawkins, 1996). (b) The adoption curve model in which adopters are divided into five categories namely innovators, early adopters, early majority, late majority and Laggards. (c) Group dynamic model that takes into

consideration the influence of community into adoption process. According to adoption curve model, adoption behaviour differs across socio-economic groups and overtime. Because of this, some innovations have been adopted only by a small group of farmers (Feder *et al.* 1985). Cumulative proportion of adoption follows an "S"-shaped curve in most cases (Rogers 1983). This implies slow initial growth in the use of technology, followed by a more rapid increase and then slowing down as the cumulative proportions of adoption approach maximum (CIMMYT, 1993). Lionberg and Gwin (1991) asserted that the curve has three parts. In part one, majority of people want to see the innovation tried locally by someone else first. In part two majorities of society adopt the technology as a result of interpersonal communication and finally in part three the adoption rate declines. This is a period when some farmers having tried the innovation, decide to discontinue using depending on how they perceive it.

Under economic theories there are four adoption models. (1) Utility maximization model that explains households' behaviour towards decision making towards various choices confronting them (Upton, 1976). (2) The profit maximization model that states that the rational behaviour of household is profit maximization (Gravelle and Rees 1992; Upton, 1976). (3) Technological change model that is based on technical efficiency (Fagerberg, 1991). It implies that the household's willingness to change and ability to make production investment is influenced by the output and profit levels associated with technology use. (4) Risk and uncertainty model (Upton, 1976; Gravelle and Rees 1992). According to this model, household risk aversion inhibits

diffusion and adoption of innovations that could increase output and income of the household.

All the above two major approaches used in adoption studies are useful depending on the nature of study and the professionals involved. Adoption study by sociologists will tend to draw more from sociological models while economist tend to apply more of economic theories. Since farmers' decisions to adopt innovations are influenced by both sociological and economical factors, it is imperative to combine both theories.

2.3 Improved Sorghum Varieties in Tanzania

For the past one and half decades, the breeding work was geared towards development and testing of new varieties that are high yielding and well adapted to farmers' actual environment (Rohrbach 1999; Saadan *et al.* 1999). NSMIP in collaboration with SADC/ICRISAT, using germplasm from SADC / ICRISAT have so far developed three varieties. These varieties include Tegemeo, Pato and Macia. Along with the variety development NSMIP has recommended appropriate agronomic package. Three sorghum varieties namely Dobbs, Serena and Lulu were developed under EAFRO before the collapse of EAC and were widely used in Tanzania in the 1960s to 1970s.

Dobbs is a variety selected in Western Kenya during colonial era, and was recommended to be suitable along the shores of lake Victoria (Ackland, 1971). It found it's way to central Tanzania through charity aids and relief food supply during

famines. It is perhaps the oldest improved variety. It is brown seeded and matures at about 4 months.

Serena was developed in Serere research station in Uganda and it was released in 1960's by EAFRO. It is brown seeded, medium height (150 cm. high), resistant to shoot fly, and partial resistant to striga infestation. It is high yielding variety and early maturing, about three and half months (Ackland, 1971).

Lulu was released when EAFRO was in operation between 1960 and 1977. It is a high yielding variety 1.8 t/ha, early maturing, with short stems and white grains. Unfortunately it is highly susceptible to grain mould disease, resulting in poor viability and poor storability (Saadan and Mdolwa, 1999). Due to grain moulds it is not suitable for livestock feeds and human consumption.

Tegemeo was bred and released in Tanzania in 1983 and reinstated in 1999. It is a high yielding variety giving up to 3.5 t/ha, with good stability, cream coloured, large, hard grains that allow pounding. It is early maturing. It has medium stalk height and but semi-compact panicle (Mgonja *et al.* 1999).

Pato was developed by NSMIP and pre-released by Tanzania Variety Release committee in 1995 and fully released in 1997 as a medium stalk height variety with grey coloured grains. It is an early maturing, very high yielding variety. Under research management it may yield up to 6 t/ha. Under good farmers' management it

gives 4 t/ha and at ordinary farmers' management it yields 2.5 to 3.5 t/ha (Mgonja *et al.* 1999).

Macia is a variety released by NSMIP in 1999. It has so far been released in five SADC countries. It is a high yielding with yields ranging between 3.6 to 4.41 t/ha, early maturing variety (115-120 days to maturity) with short stalks and white grains. It produces white flour that is said to be preferred by consumers in the country (Saadan *et al.* 2000). It has low dehulling losses, good cooking taste, better malting or brewing quality than Tegemeo and Pato. It is non-tillering variety that remains green even after harvest an attribute that makes it suitable for animal forage.

Two sorghum varieties P 9405 and P 9406 are still at on-farm testing stage and they have found their way to farmers' hands through on-farm trials conducted by ARI - Ilonga. Both are resistant to striga, high yielding on striga infested fields and very early maturing (70 days), hence escape drought.

2.4 Improved Pearl Millet Varieties and their Characteristics

There has been very little research work on pearl millets. This is because the breeding work concentrated mainly on collection of germplasm for photo sensitive, early, medium and late maturing pearl millets. NSMIP has so far released only two improved pearl millet varieties. These are Okoa and Shibe (Saadan and Mdolwa 1999).

Okoa was developed by NSMIP and released by the Tanzania Variety Release Committee in 1994. It is a high yielding 2.0 to 2.5 t/ha, medium maturity pearl millet variety with bold, white grains. It has a long head (Saadan *et al.* 2000).

Shibe was developed by NSMIP and released also in 1994 as high yielding 1.8 to 2.0 t/ha, medium maturity pearl millet variety with small and white grains. It has a long head (Saadan and Mdolwa 1999).

Based on both on-station and on-farm research activities conducted by researchers at ARI-Ilonga, a number of agronomic technologies have been recommended. Since the two crops share most of the production conditions, recommendations apply for both. These recommendations are mainly time of sowing, plant spacing and density, weeding regimes, fertilizer application and intercropping.

Time for sowing

According to Holtland (1994) the traditional season starts from September/October with clearing of fields. After clearing the land the planting holes are made and seeds are dibbled without any prior cultivation. The advantage of this kind of dry planting is that it is very quick. In the semi-arid areas where moisture is the limiting factor, time of planting is of crucial importance in determination of yield (Myaka *et al.* 1999; Holtland 1994). Recommendation on planting time depends on agro-ecological zonation and the type of seed involved. Improved varieties are early maturing so in order to avoid bird attack and grain mould they are planted a bit late. For central agro-ecological zone, time of planting is November to December for local varieties.

Due to unreliability of rainfall in Dodoma region, the recommended date of planting for improved short term varieties is late December to mid January (Myaka *et al.* 1999).

Spacing and seed rate

The farmer's spacing is usually wider one step by one step between rows and between plants respectively. It is recommended that sowing should be done in rows. Recommended spacing is 30cm x 75 cm for single seed per hill and 60cm x 75 cm for two seeds per hill (Myaka *et al.* 1999). Under farmers practice, the plant population is very low but number of plant per hill is high and thinning is a rare practice. When planting using dibbling, seed requirement is 4-6 kg /ha. Since pearl millet has got smaller seed size, the seed rate may be lower than that for sorghum. According to Myaka *et al.* (1999) farmers have accepted the spacing of 80/75 X 30 cm partly because it allows intercropping.

Inter cropping

Intercropping is one of strategies to minimize risk resulting from drought and it also maximizes the returns from land (Holtland, 1994). It is recommended to inter-crop sorghum and pearl millet with legumes. For both sorghum and pearl millet, the most common intercropped legumes are cowpea and pigeon peas (Myaka *et al.* 1999).

Weeding regime

Weeds are major problem such that about 75% of all fields are weeded thrice (Holtland 1994; Myaka *et al.* 1999). Basing on the maximum returns to land, it is

recommended to perform weeding operation twice per season. The first should be done two weeks after planting and the second should take place 30-40 days after planting.

Fertilizer and farmyard manure recommendations

In order to exploit the potentials of improved varieties, the use of fertilizer is prerequisite. So far there is no specific recommendation for fertilizer use in central high plateau. Inorganic fertilizer 50 kg N / ha and 40 kg P_2O_5 / ha is a blanket recommendation to the area. It is recommended to apply farmyard manure (FYM) in sorghum and pearl millet production, 5 tons / ha (Myaka *et al.* 1999). For sustainability reasons it is important to re-apply FYM after every 4 years. The recommended post harvest technology includes storage of grains under-dry conditions, application of insecticide and storage of grains in sealed storage.

2.5 Seed availability at farm level and distribution in Tanzania

Efficient seed production and distribution system is an important aspect in adoption of improved varieties because farmers need a basket of seed from where to pick the varieties of their own choice. In seed production, five terms are used to categorise seed. These are breeder seed, foundation seed, registered seed, certified seed and milling seed. According to URT (1978), Breeders Grade means seed recognised by Director of Crop Development of Ministry of Agriculture. It is a seed of variety that has been produced by the plant breeder responsible for breeding and maintenance of that variety under conditions, which have ensured that the special characteristics of

the variety have been maintained. It should be able to provide the source for and recurrent increases of the pedigreed grades. In Tanzania, breeder seed for sorghum and pearl millet is usually obtained from Ilonga research station in small quantities. Foundation grade means the approved progeny of breeder seed produced by the growers authorized by the Tanzania Official Seed Certification Agency (TOSCA) for the production of this grade and which has been so managed as to maintain genetic purity and identity which provide a source for the initial and recurring increase of seeds (URT, 1978). Foundation seed is produced in relatively large quantities compared to breeder seeds. Registered grade refer to progeny of breeder or foundation seed that is so produced and handled such that the crop meets the standards prescribed as to genetic identity and purity and for which a crop registration and certification has been issued by the Chief Certification Officer (URT, 1978). This grade of seed is produced in relatively large quantities. Certified grade means the approved progeny of breeder, foundation or registered as certified seed so managed as to maintain satisfactory genetic identity and purity, the production of which is supervised and approved by TOSCA and which provides the source for the initial and recurring increase of seeds (URT, 1978). Contracted farmers or seed companies can grow certified seed. It is this type of seed that is eventually sold to farmers who in turn produce milling seed. Milling seed refers to seed that is disposable for food processors and consumers.

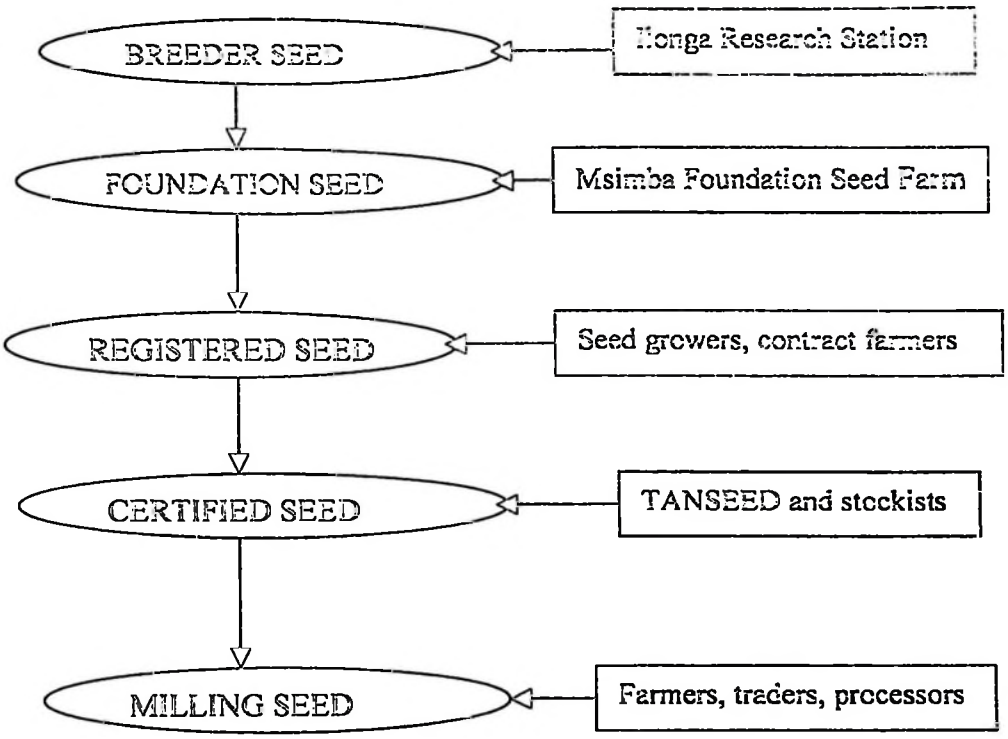

Figure 2.1: Sorghum and millet seed chart in Tanzania

Msimba Foundation seed farm is the only one out of five seed farms in Tanzania involved in production of sorghum and pearl millet foundation seeds (Figure 2.1). Before liberization of seed industry, TANSEED was the sole buyer of foundation seed from foundation seed farm.

In response to seed shortage, there has been a shift from public seed enterprises towards smallholder seed production (Mtenga, 1995; Almekinders and Louwars 1999). These initiatives include Community Based Organizations (CBOs). Results from the study by Mtenga (1999) indicated that smallholder seed production through community mobilization is potential and viable approach, but unavailability for seed market was the most limiting factor. Figure 2.2 and figure 2.3 shows the institutional seed system local seed systems respectively.

According to the agriculture and livestock policy of 1997 the performance of the seed sub sector for many years has been very poor. Availability of seeds is more than 10% less than total seed demand (URT 1997b). This is mainly due to monopoly of seed industry by the inefficient, parastatals organization Tanzania seed production company Ltd 1973 (TANSEED) and lack of proper seed control and failure to abide with seed production and distribution regulations.

Appendix 4.4 shows that TANSEED has been ordering very limited amount of foundation seed compared to amount from Msimba Seed Farm. Worse still, TANSEED purchases foundation seed for sorghum but not pearl millet. This situation amplifies shortage of seeds at farm level.

Rohrbach (1999) noted that private seed companies are not interested in sorghum and millets probably because it is not profitable. Some of non-governmental organisations such as Norwegian Peoples Aid (NPA), World Vision International and

DCT have taken initiatives to distribute seed from the community based seed production units.

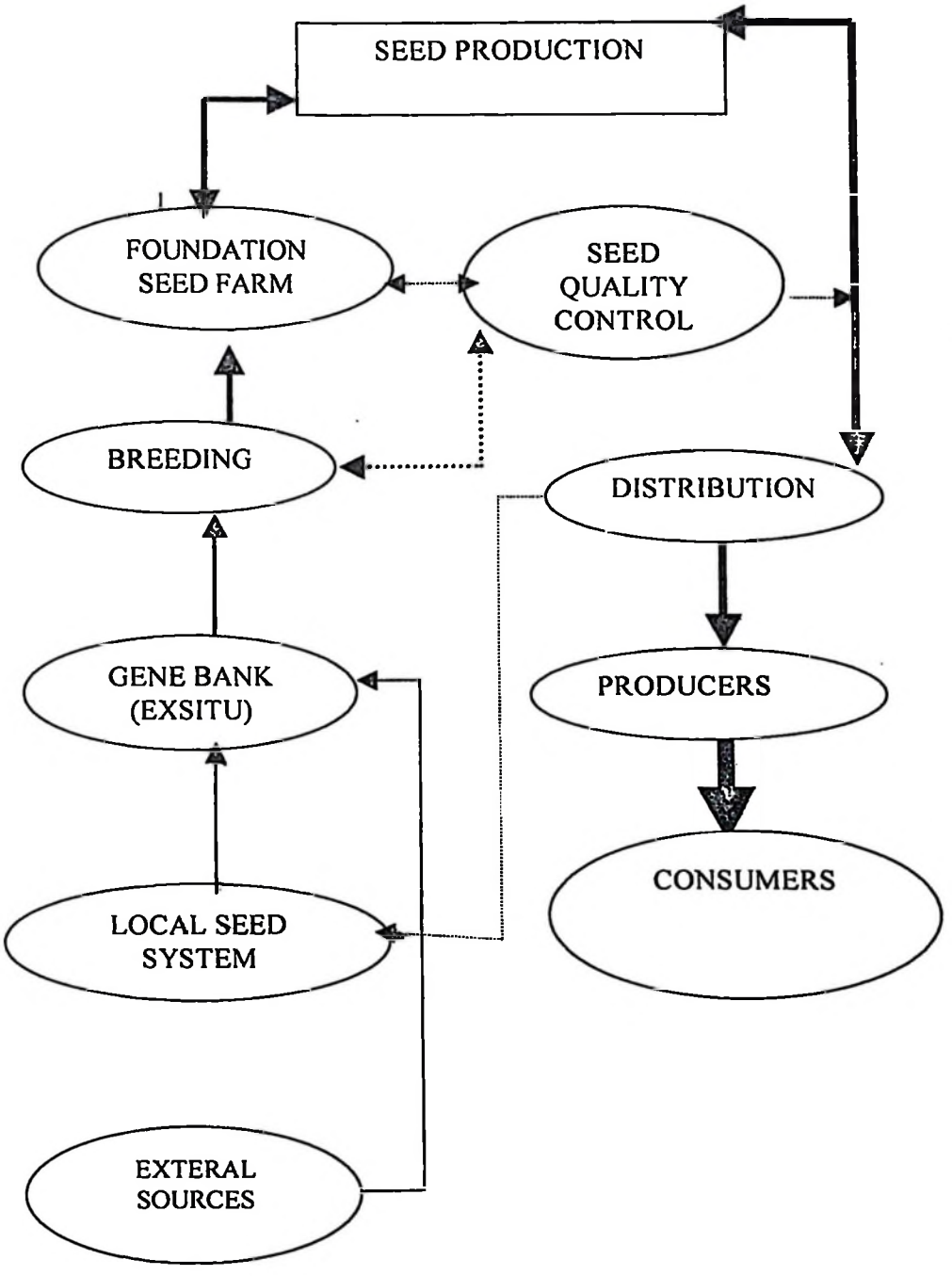

Figure 2.2: Institutional Seed System

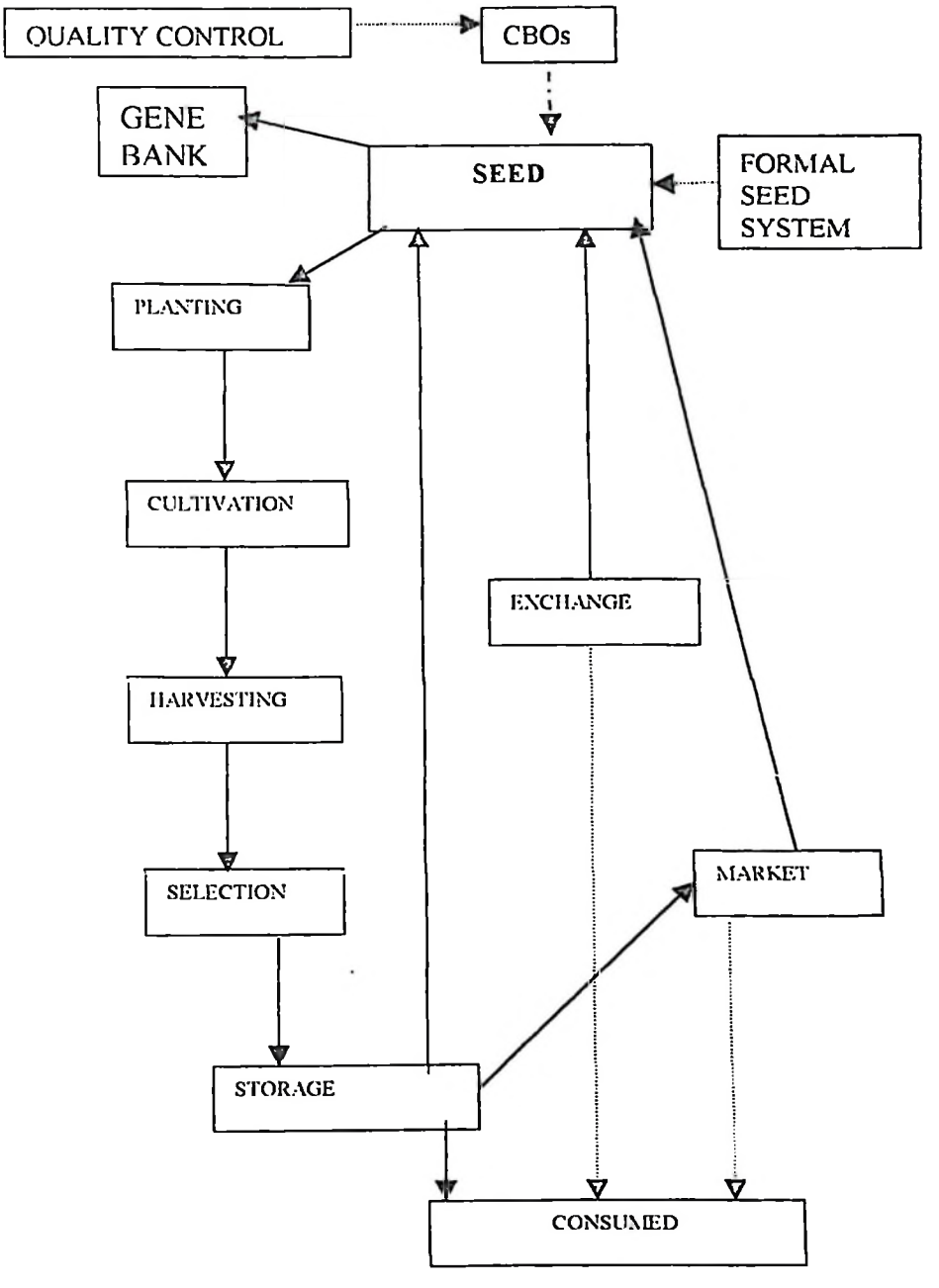

Figure 2.3: Local Seed System

As observed in table 2.1 foundation seeds have been available for three sorghum varieties and only one pearl millet variety. Before 1998, Msimba foundation seed farm produced mainly Serena and Tegemeo sorghum varieties and there was no single pearl millet variety produced. Foundation seed delivery to seed growers has been very low (appendix 4.4). For instance, data from Msimba seed farm shows that in 1998, ten tonnes of Pato had to be sold at lower price as certified seed while in 1999 twelve tonnes out of fourteen tonnes produced were not sold. The price for breeder seed was T sh.16 000 per kg, foundation seed T sh.4 000 per kg, between T sh.500 to 600 per kg, for certified seed. Milling seed at between T sh.70 to 200 per kg. Since sorghum and pearl millet fall under hunger relief crops, and it is the government that finances the research, the government supplies to foundation seed farms free of charge in order to enhance seed production, distribution and make the seed affordable to small-scale farmers. There has been a concern on the price of T sh. 4 000 per kg of foundation seed, especially when considering that the breeder seed is provided free of charge. According to management of Msimba Foundation Seed Farm, high production costs dictates the price of foundation seed. Given these high prices, there is need for foundation seed farms to work hard to reduce the overhead costs so as to set affordable price for foundation seed.

Table 2.1: Production of Foundation Seeds, by Msimba Seed Farm

Crop	Type	1998/99	1999/2000
		Amount (Tonnes)	
Sorghum			
	Pato	10	14
	Macia	-	2
	Tegemeo	-	0.8
Pearl millet			
	Okoa	-	3.5

Source: Msimba Foundation Seed farm (2000/01)

2.6 Factors Influencing Adoption of Innovations

Adoption of a particular technology is influenced by a number of factors. These factors have been classified into four broad categories namely: Demographic, Institutional, Environmental and Farmers' subjective perception of agricultural technology (Akimwuni, 1995; Anandajayasekeram *et al.*, 1996; Achour 1990; Adesina and Zinnah 1990). Examples of demographic factors are education level, gender, experience, age, religion, and marriage status. Institutional factors include extension services, input and output marketing system, credit facilities, land tenure system, information and communication infrastructure. Farmers' perception is associated with the characteristics of technology as perceived by them, e.g. palatability, cooking time, seed colour, and seed size (Bisanda and Mwangi 1996). Some technologies may have a relative advantage, for example high yielding variety. Others may be easy and compatible to the existing farming system while others are complex and incompatible.

It has been reported that Institutional factors particularly the credit component, overall market environment, frequency of extension visits, and proximity of farm to formal

markets are important determinants of agricultural technology adoption (Gong and Beck, 1992; Alson and Reading, 1998; Bisanda and Mwangi, 1996; Nkonya *et. al.* 1997; Mkenda, 1997; Msuya 1998; Ntege-Naneenya *et al.* 1997; Regassa *et al.* 1998; Harris and Bhattacharyya, 1998). Some commodities such as improved maize require high dose of fertilizer and chemical input, which are not affordable by small-scale farmers without credit facilities. Farmers with access to credit have a higher probability of adopting capital-intensive technologies (Bisanda and Mwangi, 1996). Frequency of extension visits also has positive influence on technology adoption (Alson and Reading, 1998). This is because through extension services, farmers are exposed to innovations. Social status such as leadership position in rural set up has been reported by Obinne and Jojo (1991) to influence adoption of improved cassava production. Lack of market and market promotions for certain varieties may be a decisive factor to adopt or dis-adopt the crops in question (Minde and Mbiha 1993; Harris and Bhattacharyya 1998). It is therefore worthy studying the existing market and market systems in relation to adoption of sorghum and pearl millets.

Resource endowment factors such as farm size and geographical location such as proximity to formal market had positive influence on adoption of improved cassava and wheat production technologies in Nigeria, Tanzania, Ethiopia and Tennessee (Obinne and Jojo 1991; Mwanga *et al.* 1999; Regassa *et al.* 1998; Roberts *et al.* 2002).

Demographic characteristics such as household size, income, education level, and farming experience has also been reported to affect adoption of improved varieties and fertilizer (Bisanda and Mwangi, 1996; Nkonya *et al.* 1997; Mwanga *et al.* 1999).

Sometimes the characteristics of the research package may not be appealing for farmers to adopt. Such technologies need to be refined to conform to the farmers' criteria. Evidence from a maize study in the northern zone of Tanzania revealed that farmers' perception of technology characteristics example profitability, riskiness of use, compatibility with other practices, technical soundness, relevance to farmers needs and complexity of the innovation are key elements in adoption, (Nkonya *et al.* 1998; Hainsworth and Eden-Green 2000; Gong and Beck, 1992). In that study, demand for hybrid maize was higher than composite maize although the later can be recycled. Mkenda, (1997) reported a number of attributes influencing the probability of adopting SUA 90, a bean variety in Morogoro region. These include technology characteristics namely palatability, yield, cooking time, seed colour, and seed size.

From the review above, it can be concluded that different studies identified different sets of factors that influence adoption of innovations. The variations are due to diverse socio-economic, geographical and environmental circumstances under which different farming communities operate, methodology used and the type of technology studied.

2.7 Methodologies Employed in Adoption Studies

Both probability and purposive sample surveys are used in adoption studies. Large samples are normally used especially when rigorous econometric analyses are involved. Formerly multivariate linear regression analysis was the common analytical tool for determinants of adoption but currently the linear probability models (LPM) and cumulative distribution functions (CDF) are becoming popular (Bisanda *et al.*

1998; Kaliba and Marsh, 1999; Feder, *et al.*, 1985; Ntege-Naneenya *et al.*, 1997). This is probably because most models used in adoption studies fail to meet the statistical assumptions necessary to validate the conclusions based on the hypothesis being tested (Feder, Just and Zilberman, 1985; Ntege-Naneenya *et al.*, 1997). CDF models take into consideration of non-linear characteristic, which is typical in adoption data. Also in the non-linear models parameters are estimated using the Maximum Likelihood Estimation (MLE) approach in order to yield parameters that are asymptotically efficient and consistent. Although LPM is the simplest, it has limitations. Estimated probabilities for LPM may fall outside the 0-1 bounds. It also suffers non-normality and heteroscedasticity problems (Gujarati 1995).

CDFs include Probit and Logit probability models as suggested by Gujarati (1995). Probit and Logit models measure the relationship between the strength of stimulus and the proportion of cases exhibiting a certain response to the stimulus. These models are appropriate tools in situation where there is a dichotomous output that is thought to be influenced by levels of some independent variable(s). These models are useful in estimating the strength of stimulus required to induce a certain proportion of responses, such as the probability of adoption resulting from farming experience. The models are quiet appropriate analysing cross sectional data with binary dependent variable. In some cases it they have been used to analyze time-series-cross-section data (Nathaniel and Jonathan, 1997).

The difference between the two models is that Logistic curve has flatter tails than probit curve. Probit curve approach the axes quickly than logistic curve. A logistic

estimate of a parameter multiplied by 0.625 gives a fairly good estimate of probit model (Gujarati, 1995). Choice between the two models is that of mathematical convenience and ready availability of computer software.

Nkonya *et al.* (1998), in their study, used probit model and applied a two stage Heckman's procedure to analyse factors affecting adoption of improved maize in Northern Tanzania. The result from the probit model showed that farming experience influences adoption. In central Tanzania, Kaliba *et al.* (1998) used probit model to analyse factors affecting adoption of improved maize, and realized that household wealth, education level, Agro ecological zone, and variety type significantly influenced adoption.

Logit model has been widely used in wheat and maize studies. For instance, in Southern highlands of Tanzania, a logistic regression model was used to analyse factors affecting adoption of improved wheat (Mwanga *et al.* 1999).They found that household size; farm size and extension contact had significant influence on adoption of improved wheat varieties. The same model was used in maize study in Uganda and wheat study in Ethiopia by Ntege-Nanyeenya, *et al.* (1997) and Regassa *et al.* (1998) respectively. Using the model, Ntege-Nanyeenya, *et al.* (1997) found that education, farmers' group and land tenure had statistically significant effect on adoption of Improved maize. The logistic model is also applicable in analysis of land conservation technologies. For example Logit regression model was used to analyse the factors influencing adoption of soil conservation in Tanzania (Kalineza *et al.*1999; Senkondo

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et al. 1998). It was also used in Tennessee by Roberts *et al.* (2002) to determine factors affecting the location of precison farming technology.

The third model is the Tobit model. This model is also known as censored regression model because some of observations on regressand are known. This model has been used by several scientists in analysis of farmer's perception of a given technology (Bisanda *et al.* 1998; Kaliba and Marsh, 1999). Advantage of Tobit model over the rest is that it can further be dis-aggregated to determine the effect of change in the i^{th} variable on change of probability of adopting modern technology. Unfortunately this model is not easily accessible since it is not embodied in popular software like SPSS. In southern highlands maize study, Bisanda *et al.* (1998) used Tobit model to analyse factors affecting proportion of land allocated to improved maize and discovered that extension contact, agro ecological zone and livestock units were significantly associated with adoption of improved maize varieties. Using Tobit model Kaliba and Marsh (1999) realized that age, education, and factors related to household income influenced both demand for health care and improved health care system.

CHAPTER THREE

METHODOLOGY

This chapter describes the methodology used in study and is divided into three main sections. Section one describes geographical location and socio-economic profiles of the study area. Section two presents survey design indicating sampling procedures, data collection and analytical methods. Section three presents conceptual framework of the study and model specification.

3.1 Study Area

3.1.1 Location

This study was conducted in Dodoma region in central Tanzania. Dodoma region shares border with Arusha on the North and North East, Tanga and Morogoro on the East, Iringa on the South and Singida region on the West. Dodoma region lies between 4° 49'- 7° S latitude and between 35° 55'- 36° 56' E longitude (URT, 1997). It has an area of 41,311 km^2 covering the central plateau of Tanzania mainland. It rises gradually from 830 m.a.s.l in Bahi swamp to 2,000 m.a.s.l in highlands of Kondoa North. Average altitude is 1040 m.a.s.l. Figure 3.1 shows the location of Dodoma region in Tanzania.

The region has five administrative districts namely Dodoma urban, Dodoma rural, Kondoa, Mpwapwa, and Kongwa (Figure 3.2). There are 26 divisions, 136 wards and 453 villages.

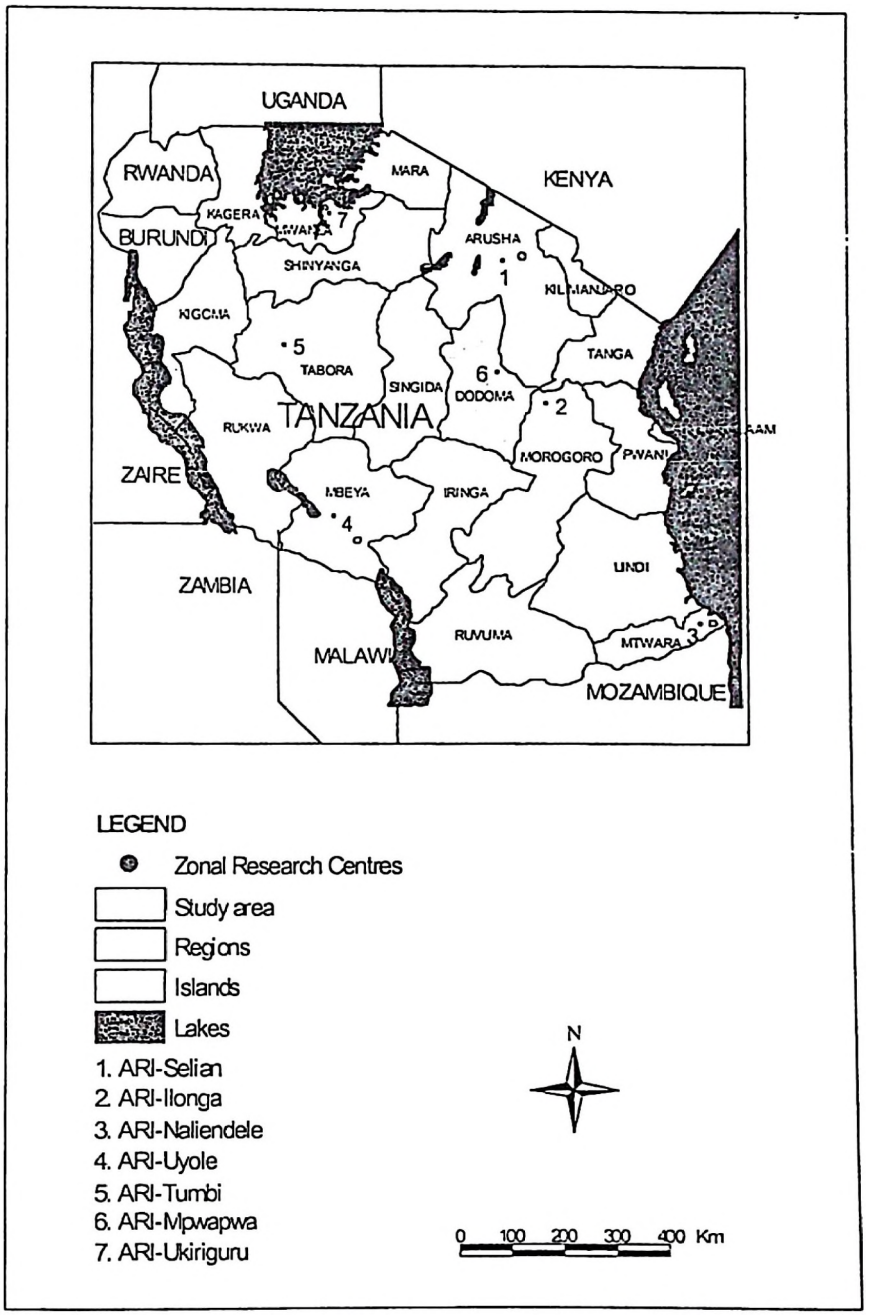

Figure 3.1: Map of Tanzania showing the location of Dodoma region

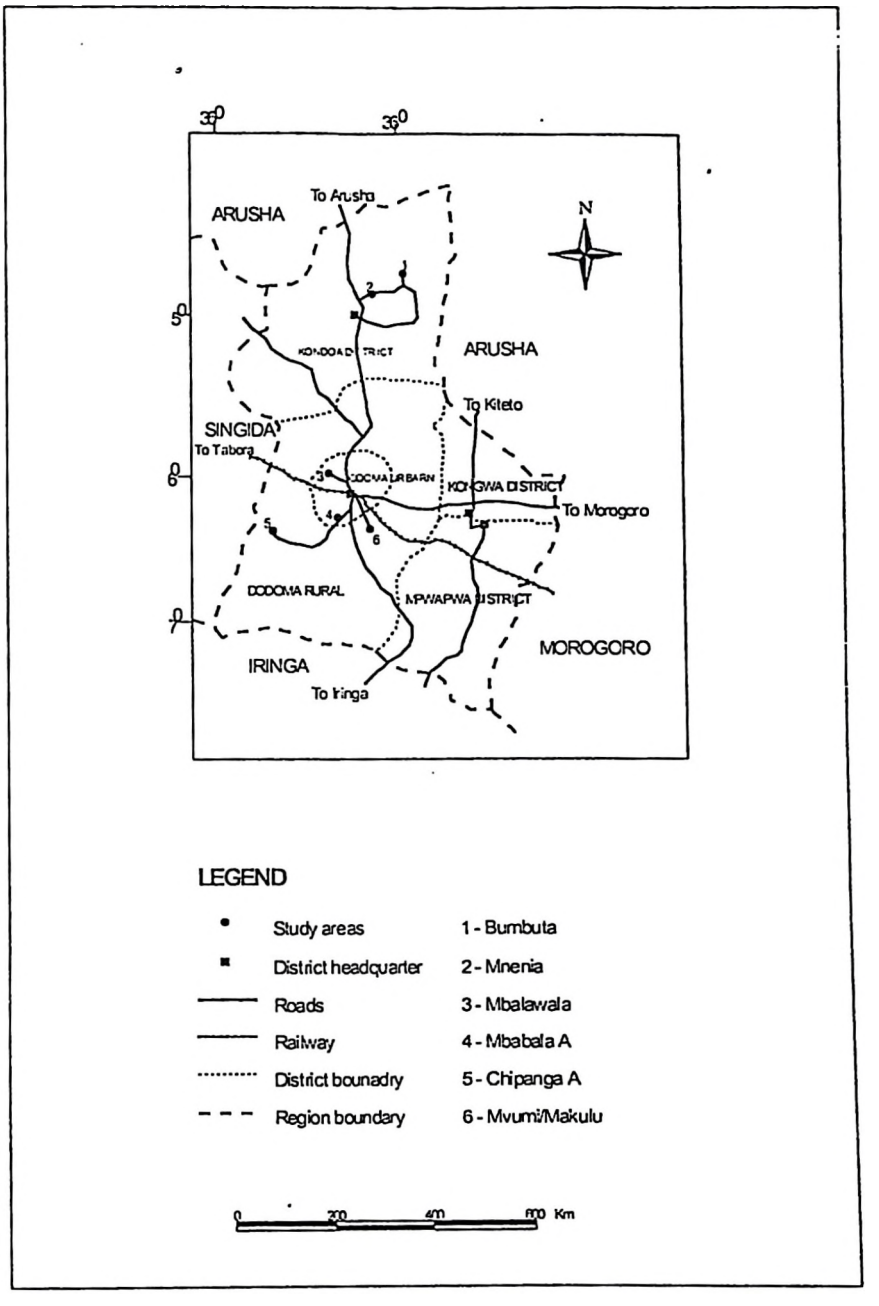

Figure 3.2: Map of Dodoma region showing the study area.

This study was undertaken in six villages of Mvumi-Makulu and Chipanga-A in Dodoma Rural District, Mbalawala and Mbabala-A in Dodoma Urban district, and Bumbuta and Mnenia villages in Kondoa district.

3.1.2 Population

According to the census of 1988, the population of Dodoma was 1.2 million (5.3 % of national population). Population growth rate is 2.4% as compared to national growth rate of 2.9%. Dodoma region is sparsely populated with population density of 30 people per km^2 (URT, 1995). Ethnic groups found in Dodoma region include the Wagogo, Warangi, Wanguu, Wazigua, Wakaguru, Wasagara, Wafyomi, Wabarbaig, Wambulu, Watatoga, Watonga, and Wamasai.

3.1.3 Climate

The climate of this area varies from sub-humid to Semi-arid type and is generally defined as dry to dry humid, with temperature ranging from 8° C to 39° C (URT 1997a). Wet season starts in December to April/May. The area has unimodal rainfall pattern ranging from 450-800 mm with an average of 538 mm per annum. About 85% of rainfall is received from December-March. Distribution of rainfall is erratic and very unreliable. Available literature shows that out of every five-year cycle, Dodoma region experience a drought at least once (Mwenda, 1993). Dry season start from May to November. The landform is savannah plains of medium altitudes with protruding hill ranges dominated by

medium textured sandy soils. The soils have moderate fertility but severely affected by water and wind erosion.

3.1.4 Farming system

The dominant farming system in Dodoma is agro-pastoral system. However, high proportion of the population has no cattle, but they may have small stocks e.g. goats and sheep. According to Azaria (1992), the region is divided into three crop zones based on rainfall reliability. The first one is rainfall reliable zone where maize, sunflower and groundnuts are recommended. This zone receives between 700 mm to 1000 mm of rainfall and includes parts of Mpwapwa and Kondoa Districts (URT 1997a). The second zone has a moderate rainfall reliability and is receiving about 550. Maize, groundnuts and sunflower are recommended for this zone. The areas include Central and southern parts of Kondoa, whole part of Kongwa district and part of Mpwapwa and central Dodoma. The third zone is the low rainfall and low reliability zone receiving less than 550.The main crops include sorghum, pearl millet and simsim. These areas includes Masai steppe in the North-East of Kondoa, Southwest part of Mpwapwa, and Southern part of Dodoma Rural district.

Livestock categories found in Dodoma includes cattle, goats, sheep, pigs and poultry. Dodoma herd contribute at least 10% of national cattle herd (Mwenda, 1993; URT 1997a). This study was undertaken in the third zone because of the dominance of sorghum and pearl millet. Dodoma Rural is basically an agricultural district growing variety of crops and keeping livestock. Sorghum, millet, maize, paddy, groundnuts, pulses, grapes and oil seeds are some of the major crops. In Kondoa district, over 90% of

people live in the rural areas engaged in agriculture and livestock keeping. About 70% of the total area of the district is potential for agriculture. Maize, finger millet, sorghum, pearl millet and oil crops are some of the crops grown. The district has earthen road network of 1276 km. Some of the roads are not passable during wet seasons.

3.2 Methodology

This study was carried out in three stages: preliminary survey, informal survey and formal survey. The preliminary and informal surveys were carried out in November and December 2000 respectively. The formal survey was carried out in April 2001.

3.2.1 Preliminary survey

The preliminary survey was done for three major reasons. To familiarize with the study area, discuss with stakeholders involved in promotion of sorghum and pearl millet and selection of the study districts and villages. The institutions visited include, ARI-Ilonga, District Agricultural and Livestock Development Officers, Bihawana Farmers Training Centre, Diocese of Central Tanganyika (DCT), World vision International Chipanga division and Msimba Foundation Seed Farm. These institutions were the key players in sorghum and millet development. Guided discussions and physical observation were the main tools of data collection. The key informants were heads of institutions mainly Ilonga Sorghum and Millet Research programme, Msimba Foundation Seed Farm, Sorghum breeder in DANIDA supported Seed project, DALDOs, Bihawana Farmers Training Centre (FTC), Makutopora National Service, sorghum and millet millers,

input-stockists Village Extension workers (VEOs) and DCT. The main criteria for key informants were the knowledge on evolution of sorghum and pearl millet in the village and willingness to share information. Secondary data were collected from Sokoine University Library and SADC/ICRISAT centre.

In consultation with Sorghum and pearl millet researchers, and DALDOs, purposive and random sampling techniques were used to select districts, villages and farmers. Three districts were selected purposively from Dodoma region. These include Dodoma rural, Dodoma-urban and Kondoa. These districts were selected due to the fact that improved sorghum and pearl millet varieties have been introduced. These districts form the main sorghum and pearl millet farming system.

From each district, two villages were purposively selected to include one in which sorghum and millets research activities have been carried out and one village with no direct research interventions. The respondent farmers for informal survey were purposively picked to representation of entire village, to include both sexes and different age groups in order to capture user differentials in adoption. An entire list of households' heads was prepared during the introductory visit with the help of Village Agricultural Extension Officers (VAEOs) and Village Executive Officers (VEOs). From this list farmer samples were picked depending on number of households in the village.

3.3.2 Informal survey

The aim of informal survey was to collect qualitative information and help to structure the questionnaire for subsequent formal survey. The main activities during this survey included (i) key informant interviews (ii) group interviews (ii) wealth ranking and market survey. The Survey was conducted in six selected villages of Dodoma region from 6th to 19th of December 2000. These villages were Mnenia and Bumbuta in Kondoa district, Chipanga and Mvumi-Makulu in Dodoma Rural District and Mbabala and Mbalawala in Dodoma urban district. Focused group interviews were held for two days in each village with full participation of farmers. A checklist was used to guide discussions (Appendix 3.2).

During the discussions, a variety of PRA tools were used including historical trend of events, matrix ranking, pair-wise ranking and wealth ranking. During the group interview, farmers were requested to bring with them sample of varieties of sorghum and pearl millets that they were growing for identification purpose.

Wealth ranking was done in each of selected villages. The aim was to determine the proportion of farmers falling under different wealth groups. This was an important exercise because it facilitated in assessment of adoption differences across wealth groups. During the wealth ranking exercise farmers were divided into two groups, a group of men and a group of women. Each group drew up list of wealth indicators they consider to be important in classifying households in their village into wealth categories. While in the same groups, farmers were requested to suggest the possible number of wealth groups available in the village. Later, men and women groups came together and

presented their findings. They also reached consensus with regard to number of wealth groups. Finally the sample names of household heads on manila cards, were read and the farmers grouped each card to the appropriate wealth group. The cards were counted and percentage calculated.

Rapid market survey was conducted in Majengo central market in Dodoma municipality, Kondoa town market, Mpwapwa town market and Kongwa town Market. The aim of the survey was to collect market information on sorghum and millets. A sample of traders was purposively picked on condition that they should be dealers of sorghum and or pearl millet. The urban traders were informally interviewed using a checklist. The focus was on position of sorghum and pearl millet in grain market.

3.2.3 Formal survey

A formal survey was conducted to complement and quantify some of the findings of the informal survey. A proportionate sample of household heads was used to select individual respondents based on percentage of wealth group distributions in each village. The aim of proportionate sampling technique was to capture wealth group's differentials in adoption of improved varieties. Forty household heads were picked for questionnaire interview in each village, out of which at least 25 percent were females headed households. This is because female farmers are the key actors in farming activities. Male-headed households were randomly picked from a pre-established list of sorghum and millet's farmers. A total sample of 240 sorghum and pearl millet farmers were therefore interviewed. Table 3.1 shows distribution of household heads by gender and district.

Table 3.1: Distribution of household head by gender and district

Gender	Kondoa		Dodoma-Rural		Dodoma-Urban	
	n	%	n	%	n	%
Male	60	75	59	73.8	60	75
Female	20	25	21	26.3	20	25
Total	80	100	80	100	80	100

Source: Survey data (2000/01)

During the formal survey, a semi-structured questionnaire was designed, pre-tested and used to collect data from individual households (Appendix 3.1). The questionnaire was tested by interviewing several households in the sorghum and millet based farming system. Modified version of the questionnaire was used to solicit information from farmers.

The enumerators who administered the questionnaires under went a preparatory training before embarking on the fieldwork. This was necessary in order to avoid unnecessary mistakes in data collection. Every evening the questionnaires were inspected and necessary amendment made before moving to next village. Interviews were done at farmers homestead and where necessary on-farmers' fields.

3.2.4 Data cleaning and analysis

Data from individual households were entered and cleaned by use of SPSS. The data analysis included qualitative and quantitative analyses. Descriptive analysis mainly frequency distribution, cross tabulation, comparison of means, was done. The aim was

to summarize the data in order to facilitate scientific interpretation. Descriptive analysis mainly frequency distribution, cross tabulation, comparison of means was used for summarizing the formal survey data.

Regression analysis was carried out to establish effect-cause relationship among the variables. In this study, Cumulative Distribution Functions (CDF) specifically logit model was used to determine the influence of a number of pre-indicated variables on adoption of improved sorghum and pearl millet technologies. Choice of independent variables was based on literature review, preliminary survey and socio-economic theory governing the adoption of innovations.

3.2.5 Data limitation

A number of technical limitations were encountered during data collection. The first technical problem was over expectation material gain by farmers from the researchers. In five out of six villages the farmers were in demand for financial allowance before participating in focused group discussions. This is probably due to some NGOs providing financial support to participating farmers during stakeholders meetings.

The second problem was that due to frequent famines and subsequent relief aids, the data provided by farmers in most cases could be underestimated to attract charity aids and donor's attention. The third problem was lack of transparency on the side of sorghum and millet traders with respect to prices and quantities stocked. The fourth problem was that the output prices do not reflect reality because between 1998-2000, the donor community supplied maize at highly subsidized price of T sh 70 instead of market price of T sh 80 to 100. This might have caused price distortion because maize

is a close substitute to sorghum and pearl millet. The fifth problem was that during the survey period, floods swept some bridges and car hijacking was quite rampant in Dodoma region. For safety reasons it was therefore necessary for the study team to leave the village before sunset even if some issues were not fully discussed. The sixth and final limitation was the confusion on variety names. Hunger relief missions delivered seed aids without providing the correct name for a particular variety. For instance Okoa, a pearl millet variety, was confused with Tegemeo a sorghum variety popularly known as "Kusila". Likewise Uwele china and Uwele Bombay both local pearl millet varieties were confused with Okoa. The problem was minimized by providing the enumerators with the right samples for improved varieties

3.3 Conceptual Framework

The conceptual framework for this study is presented in figure 3.3. The conceptual framework was constructed based on "Sustainable Rural livelihoods: Framework" by Carney (1998); Woolcock (2000) and Isham (2000).

Livelihood may mean different thing in different societies. In this study a definition adopted by Department for International Development DFID is used. "A livelihood comprises the capabilities, assets (Including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future while not undermining the natural resource base (Carney, 1998).

Shocks in the context of this definition refer to drought, floods and local practices in which assets exist and which affect livelihoods (Carney, 1998). This study was carried out in semi-arid area of Tanzania where rainfall is unreliable and unevenly distributed. Due to shocks in the form of frequent famines resulting from drought farmers in these areas are subjected to uncertainty situation. When economic decisions are to be made under such circumstances, livelihoods approach emphasises building on what the farmer already has in terms of capital assets.

3.3.1 Capital Assets

The capital assets are mainly in form of natural capital, social capital and human capital used by farmers as copping strategies. These are types of assets upon which individual draws to build their livelihoods. Natural capital refers to natural resource stocks from which resource flows useful for livelihoods are derived e.g. land, water, wild life, biodiversity and environmental resources (Carney, 1998). Social capital refers to social resources (networks, membership of groups, relationships, and access to wider institutions of society upon which people draw in pursuit of livelihoods (Carney, 1998;Woolcok, 2000; Isham, 2000). Human capital refers to skills, knowledge and ability to labour and good health important to the ability to pursue different livelihoods strategies.

3.3.2 Improved technology and the conceptual framework

Improved sorghum and pearl millet technologies may enter the conceptual framework through two points. The first entry is through capital assets, because improved seeds are

3.3.2 Improved technology and the conceptual framework

Improved sorghum and pearl millet technologies may enter the conceptual framework through two points. The first entry is through capital assets, because improved seeds are developed from genetic biodiversity, a form natural capital. Second is through human capital in form of improved practices (skills and local knowledge). In Tanzania, improved seeds can be accessed through formal or informal seed system. A rational farmer will always choose the production and consumption alternative that maximizes their utility. The farmers will therefore decide to adopt appropriate strategies that combine improved seeds of early maturing varieties and improved practices and management skills with their existing knowledge in order to increase production. Increased production will improve household food sufficiency, food security, and increase income, which in turn may be used to improve household livelihoods i.e. increased farmers' capacity to buy improved seeds and acquire improved production skills. Availability of credit increases farmers' capacity to purchase inputs that in turn increases the production. Efficient seed supply systems will ensure timely availability of seed at affordable prices. Access to input and output markets have significant influence on production. Unless there is assured market, farmers tend to produce at subsistence level.

From the conceptual framework, it is clear that farmers may decide to adopt the improved technologies or plant a larger area as a strategy to improve production. Farmers' decision towards this strategy is influenced by several factors. This study seeks to identify the factors that influence farmers' decision to adopt or disadopt the improved technical varieties.

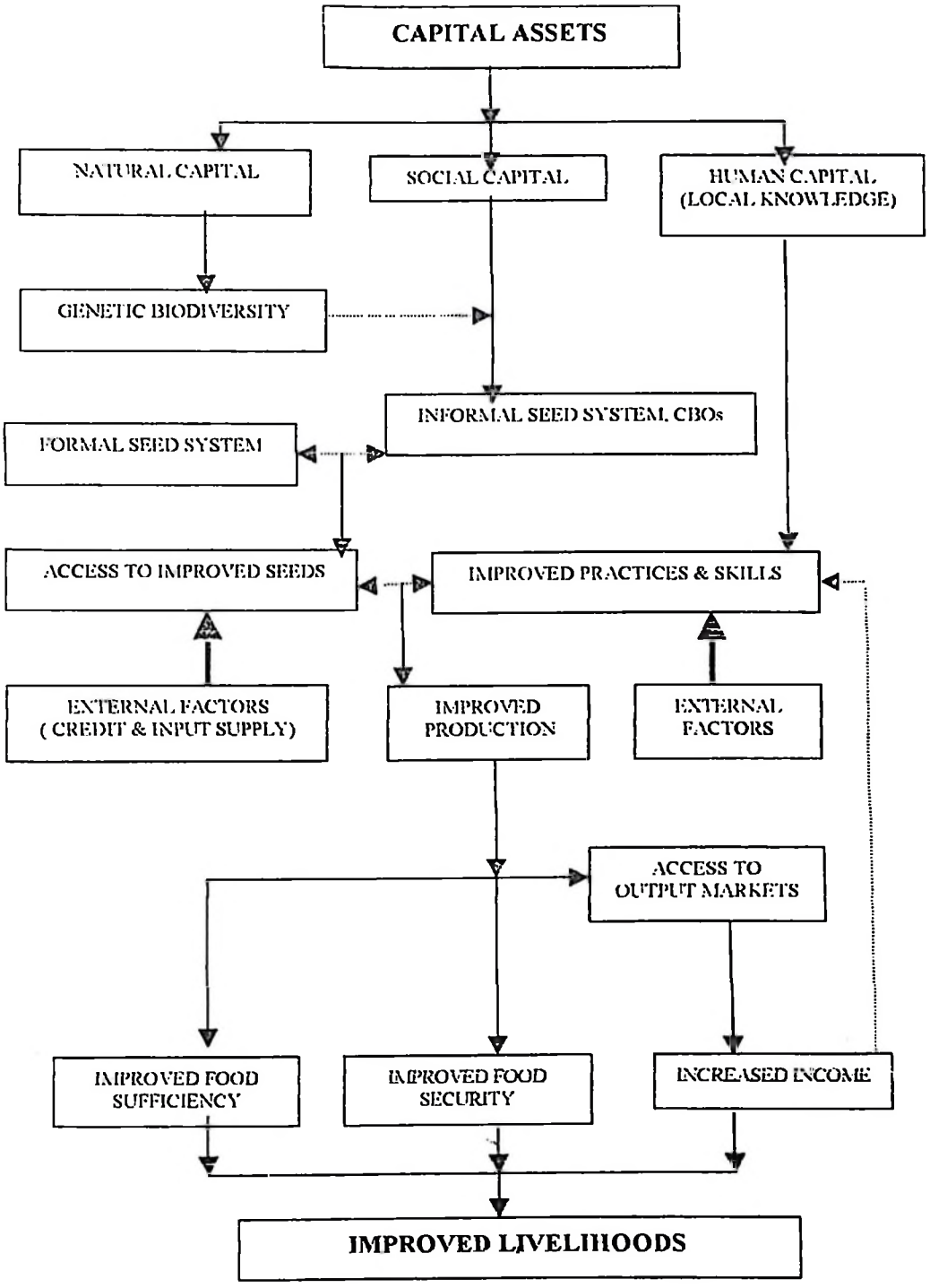

Figure 3.3: Conceptual frame work
Source: Modified from Carney (1998); Woolcock (2000) and Isham (2000)

The external factors in the model suggest the determinants of adoption i.e. access to credit and input supply, output market, and seed development and supply system. Determinants of adoption are determined depending on the local surroundings, type of technology, population involved and socio-economic environment. Experience from Bisanda and Mwangi (1995) show that adoption takes place in a step - wise manner. Farmers tend to adopt improved seed before the agronomic practices. In this study only the adoption of Pato a (sorghum variety) and Okoa a (pearl millet variety) was subjected to the model. Agronomic practices were analysed using descriptive statistics.

3.4 Specification of Logit Model

In this study two Logit models were estimated, one for improved sorghum varieties and the other for improved pearl millet varieties. A number of variables were included in the model as follows. Dependent variable was adoption of (whether or not farmer has adopted improved sorghum). In this study, an adopter of improved sorghum and or pearl millet is any farmer who was having at least quarter an acre under Pato and or Okoa by 1999/2000 seasons respectively.

Logit Model specification proposed by Gujarati, (1995) was employed in estimation of the model. The model is specified as:

$$P_i = E(Y = 1/X_1) = 1/(1+e^{-\beta_0 + \beta_i X_i}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where P_i is the probability of adopting improved technologies. Y is dependent dummy variable. Whereby Y = 1 if respondent has adopted improved technologies and zero otherwise. Xi stands for variables that affect adoption. The terms B_0 and βt are elasticity.

The B_0 is an intercept and has got no practical meaning while βi is the log-odds in favour of adopting the improved technology and e is the random error.

For estimation purposes, the model is transformed using natural logarithm as follows:

$$\text{Ln}(P_i/(1-P_i)) = Zi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots \beta_{25} X_{25} + e \ldots\ldots\ldots\ldots 2$$

Where: (Pi) is the probability to adopt improved variety divided by the probability of not adopting (1-Pi). β is the coefficient of probability to adopt and X_1 to Xn is a series of independent variables considered to influence farmers' decision to adopt improved varieties (Table 3.2). P_i ranges from 0-1 and is non- linearly related to Zi. For this reason ordinary least square (OLS) cannot be used to estimate parameters. Therefore, the model was estimated using maximum likelihood (MLE) method. Multiple correlation matrix was used to test for multicollinearity.

3.5 Factors Influencing Adoption of Improved Sorghum and Pearl Millets

The factors hypothesized to influence the adoption of improved sorghum and pearl millet are listed under Table 3.2. The factors are grouped into five major groups, namely: farmers' demographic characteristics, socio-economic factors (physical capital, human capital, and social capital), geographical and environmental factors, Institutional factors and finally technology characteristics and farmers' perception on technology characteristics.

Table 3.2: The list of factors affecting adoption

Variable	Variable label	Expected Sign	The theory and logic behind
(A) Farmers' demographic characteristics:			
X_1 = EXPRE	Sorghum and millet farming experience (years)	+	Experienced farmers are likely to try innovation than inexperienced ones.
X_2 = GENDER	Sex of household head (1= Male, 0 = Female)	+ or -	Depending on culture, male-headed households adopt differently from female-headed households. Female farmers have less command of resources than males. Gender-neutral crops may have no gender differentials in adoption.
X_3 =AGE1	Age of the household head	+ or -	Aged farmers may have more resources to access improved technologies, but risk averseness increase with age.
X_4= HHDSIZE	Number of people in the house hold	+	To increase food security, large households are expected to adopt high yielding technologies to increase household food sufficiency. They also have more labour than small households.
(B) Socio-economic factors:			
	Physical capital:		
X_5 = FARSIZE	The total land owned	+	The large-scale farmers have more freedom in allocating land to new crops. They also have access to information and credit since land is used as collateral.
X_6 =TLU	Livestock units owned	+	Livestock stands for wealth in agro-pastoral society. In general terms, rich farmers are better placed in terms of risk bearing ability, access to information, extension services, resources, and commercial orientation.
X_7 =LNHHWEAL	Value of non livestock items (Wealth)	+	Affluent households are expected to adopt faster than poor households due capacity to acquire technology.
X_8 =NFINCOME	Availability of non farm income	+ or -	A household with diversified livelihood strategies may or may not adopt technologies on inferior commodities.
X_9 =HHOE	Use of hand hoe	-	Primitive land preparation methods may hinder adoption but may not have effect for non-labour intensive technology.
X_{10} =PLOUGH	Use of ox-plough	+	Being superior to hand hoe, the use of ox-plough is expected to promote adoption of labour intensive technologies.
	Human capital:		
X_{11} = LITERACY	Capacity to read and write	+	A literate farmer has higher capacity to grasp new ideas and are likely to attend training.
X_{12}= FTRAIN	Farmers' attendance to farmer training course	+	Farmers' training is a key element in exposing farmers to new information and subsequently adoption.
X_{13} =FEDUYRS	Number of years in formal school	+	The higher someone go in academic ladder, the more exposure to innovations he/she gets, and the more livelihood opportunities becomes available.
	Social capital:		
X_{14}= SEEDS2	Community based sorghum seed source.	+	CBOs and DCT have initiated on-farm sorghum and pearl millet seed production complementing the role of formal seed supply
X_{15}= SEEDP2	Community based pearl millet seed source.	+	CBOs and DCT have initiated on-farm sorghum and pearl millet seed production complementing the role of formal seed supply

Table 3.2:Continued

(C) Geographical and environmental factors:

X_{16} DISTRIT$_1$	Kondoa district	+	The lower areas of Kondoa have got very conducive environmental conditions for production of millets and sorghum with potential market in northern Tanzania
X_{17} DISTRIT$_2$	Dodoma Urban district	-	Being centrally located and trading centre, Dodoma Urban was expected concentrate on more economically viable off-farm activities than inferior commodities like sorghum and pearl millet
X_{18} DISTRIT$_3$	Dodoma Rural district	+	Given the relatively good infrastructures, Many NGOs, CBOs, and research coverage, Dodoma Rural is expected to adopt innovation faster than other districts.
X_{19} = PROXIMI	Distance to nearest research station (Km)	+	Proximity to research station is expected to have positive influence to adoption.
X_{20} = PROXIM2	If farmer dwells near the urban centre (Km)	+	Proximity to urban centre has implication to seed source, new information and output market.
(D) Institutional factors:			
X_{21} = EXTFR	Frequency of extension contacts	+	The more visits the farmer gets from extension agent the more informed about the innovations the farmer becomes.
X_{22} =TENURE3	Inherited land	+ or -	Inherited land is governed under customary law hence more secure than the land offered by village government, farmers may or may not decide to exploit its potential using improved technologies.
X_{23} =TENURE4	Land leased	+	The land leased is most secure form of land tenure in which farmers may decide to exploit its potential harmoniously using improved technologies.
X_{24} =TENURE5	Land offer from village government	+	There is no reliable security on land offers by village government, rational producers will there fore employ-improved technologies to exploit its potential as fast as possible.
X_{25} =EXPOSURE	Exposure to research intervention	+	The farmers who are more exposed to research interventions have got higher likelihood of adopting.
(E) Technology characteristics:			
X_{26} = PTMKT	Scores on technology Marketability	+	Farmers' subjective perception on the characteristics of an innovation will influence the decision to adopt. Farmers who are informed on marketability and utilization alternatives of a variety will tend to adopt it faster than non-informed.

Source: Survey data (2000/01)

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter discusses the results of the study. It includes Socio-economic and demographic characteristics of adopters and non-adopters. The chapter also presents the contribution of sorghum and pearl millet in the farming system, the rates and intensities of adoption of sorghum and pearl millet production practices, management of genetic materials and factors influencing the adoption.

4.1 Socio-Economic and Demographic Characteristics of Adopters and Non-Adopters

The results in this study are disaggregated by adoption or disadoption of Pato mainly because information on this variety has been widely disseminated to farming community compared to Okoa.

4.1.1 Age of household head and farming experience

Socio-economic and demographic characteristics of sample household, Pato adopters and non-adopters are shown in Table 4.1. The mean age of household head of adopters was 46 years compared to 51 years for non-adopters. Adopters had 26 years of farming experience that was significantly (5% level) lower compared to 30 years of non-adopters. On average non-adopters had lived longer in the villages of study (41 years) compared to adopters (36 years). Adopters are younger than non-adopters because young farmers are more ready to tackle risk than old farmers. Also young farmers are more mobile; hence have higher chances to access information than old

farmers. Although the old farmers have more farming experience, they are likely to be slow in adopting new ideas because of low education, negative attitude towards change and lack of willingness to change.

Table 4.1: Socio-economic and demographic characteristics of adopters and non-adopters

Characteristics of household head	Non adopters (N=124)		Adopters of Pato (N=116)		t – Statistic
	Mean	SD	Mean	SD	
Age (years)	51	16.47	47	14.44	1.92 **
Household size (number of people living in the household)	5	2.6	6	2.6	2.99 NS
Farming experience (years)	30	17.3	26	14.61	1.99 **
Time lived in the village (years)	41	16.56	36	17.1	2.15 NS
Distance to near by urban centre (km)	36.3	9.54	43	16.04	3.88 ***
Number of years in formal school	3.9	3.5	4.5	3.32	1.4 NS
Number of children (Below 18 years) per household	3	2.19	3.7	2.28	2.71 NS
Frequency of extension contact in 2000	.66	1.23	1.02	1.55	1.96 **
Dependency ratio	1.84	1.53	1.85	1.41	0.04 NS
	Frequency	%	Frequency	%	χ^2 Statistics
Gender:					0.543 NS
Male	34	27.4	89	76.70	
Female	90	72.6	27	23.3	
Age categories:					5.85 *
Young farmers, (20 to 40 years)	45	36.3	45	38.8	
Adult farmers, (41 to 60 years)	43	34.7	52	44.8	
Old farmers (above 60 years)	36	29	19	16.4	
Marital status:					7.52 NS
Single	7	5.6	10	8.6	
Married	91	73.4	94	81	
Widow	14	11.3	9	7.8	
Divorced	4	3.2	2	1.7	
Separated	8	6.5	1	0.9	
Type of marriage for married males:					7.55 ***
Monogamy	80	89.8	69	74.2	
Polygamy	9	10.1	24	25.8	
On-farm work status :					2.15 NS
Full time	119	96	106	91.4	
Part time	5	4	10	8.6	
Religious belief:					6.68 **
Christian	70	56.5	84	72.4	
Moslem	48	38.7	28	24.1	
Traditional	6	4.8	4	3.4	

Note: *** = P < 0.01, ** = P < 0.05, * = P < 0 .1, SD = Standard deviation, NS = Non significant

Source: Survey data (2000/01)

4.1.2 Household size

The mean household size in the sample households was about 5.5 persons. This figure is slightly higher than national average mean household size of 5.2, and it is within the regional figure of 5.2 to 5.8 (URT 1997a). Adopters had the mean of six persons while non-adopter had 5 persons per household (Table 4.1), but there were no significant difference between adopters and non-adopters observed. This implies that the adopters have got more family labour than non-adopters. The number of adults (18 to 60 years old) for adopters was significantly (5% level) higher than that for non-adopters but there were no significant differences with respect to number of children below 18 years and old persons above 60 years. The dependence ratio for non-adopters was lower 1.84 compared to that for adopters 1.85 but there were no significant differences observed. Dependence ratio was derived by dividing the sum of elderly persons (above 60 years) plus children (below 18 years) over sum of adults (18 - 60 years) old. This implies that every adult (18 years or above) is supposed to support for at least one dependant from young and or old age categories. This figure is in line with regional profile figure (URT 1997a).

About 77 % of adopters were male-headed while 23% of adopters were female-headed households but there were no significant gender differentials between adopters and non-adopters (Table 4.1). This is because sorghum is more of hunger relief crop than cash crop hence it is gender neutral. However females maintain household food busket. About 81 % of the sample households were married and 8 % were widows. About 25 % of adopters are from polygamous households. Polygamy is common

practice among the agro-pastoralists as it is a source of labour. Widowhood and polygamy practice were the major causes of female-headed households in the study area.

4.1.3 Adopters by location

Location of household relative to urban centres has implication for access to input, and output markets and information. Distribution of adopters and non-adopters by district is presented under Table 4.2. Dodoma urban had significant (1%) higher number of adopters 46 % compared to Dodoma Rural 30 %, and Kondoa 24 %. Dodoma Urban is having advantage of being centrally placed, hence farmers have access to inputs and output market and communication infrastructure than other districts.

Table 4.2: Distributions of adopters and non-adopters by district.

	Kondoa		Dodoma rural		Dodoma Urban		Total	
	N	%	n	%	n	%	n	%
Adopters	28	24	35	30	53	46	116	48
Non-adopters	52	42	45	36	27	22	124	52
Total	80	33	80	33	80	33	240	100

Source: Survey data (2000/01)

4.1.4 Access to social and human capital by adopters and non-adopters

Table 4.3 shows the access to social and human capital by adopters and non-adopters. Social capital was estimated by determining the participation of household in labour

sharing groups, seed multiplication groups, and on-farm research groups. The results show that higher proportion of adopters participates in on-farm research activities.

Human capital in terms of formal education, farming experience and participation of household in other training also influence adoption. Large proportion of adopters attended farmers training sessions and field days (Table 4.3).

4.1.5 Educational characteristics

Education has got positive influence on adoption of new technologies especially in terms of accessing of information. About 76% of sample household heads were literate implying that they can read and write, out of these 18% were females. About 79% of adopters were literate but there were no significant difference between adopters and non-adopters with respect to literacy. About 60% of sample household heads had attended primary school. About 16% to adult education, 3% secondary school and only 1% of sample households had been to tertiary institutions. Majority of adopters 64.7% had been to primary school at different levels. The sample mean number of years in formal school for household head was 4 years. Adopters had on average higher number of years in formal school (4.5 years) compared to non-adopters (3.9 years) but there were no significant differences observed.

Table 4. 3: Social and human capital by adopters and non-adopters

Characteristics of house hold head	Non adopters (N=124)		Adopters of Pato (N=116)		χ^2 - statistic
	Frequency	%	Frequency	%	
Social capital :					
Membership to community seed multiplication group					11.21ns
Yes	5	4	2	17.2	
No	119	96	96	82.8	
Ethnicity					15.92 ***
Wagogo	69	55.6	84	72.4	
Warangi	51	41.1	28	24.1	
Wahehe	0	0	2	1.7	
Wamasai	2	1.6	0	0	
Wanyamwezi	0	0	2	1.7	
Wanyaturu	2	1.6	0	0	
Participation in on-farm research groups					6.48 **
Yes	12	9.7	25	21.6	
No	112	90.3	91	78.4	
Human capital:					
Attendance to farmers training					18.21 ***
Yes	12	9.7	37	31.9	
No	112	90.3	79	68.1	
Educational level					8.74 NS
Primary school	70	56.5	75	64.7	
Adult education	21	16.9	17	14.7	
Secondary School	3	2.4	4	3.4	
College	0	0	3	2.6	
Madrasa	0	0	1	0.9	
Attendance to field days					9.19 ***
Yes	14	11.4	31	26.7	
No	109	88.6	85	73.7	
Exposure to research and farmers training centre					21.62 ***
More exposed	44	35.5	76	65.5	
Less exposed	80	64.5	40	34.5	
Literacy					1.84 NS
Literate	89	71.8	92	79.3	
Illiterate	35	28.2	24	20.7	

Note: *** = P < 0.01, ** = P < 0.05, * = P < 0 .1, SD = Standard deviation, NS = Non significant

Source: Survey data (2000/01)

4.1.6 Adopters by ethnicity

Ethnicity and culture are among the factors that affect uptake and adoption of improved technologies (Hainsworth and Eden-Green 2000). Different ethnic groups assign different values on certain crops. Also taste and preference differs across different ethnic groups. If a technology focuses on crop of interest to a particularly ethnic group, the likelihood of adoption by that group is fairly high. The dominant

ethnic groups encountered during the focused group discussion were Wagogo and Warangi. About 64% of sample households were from Wagogo group, 33% from Warangi group. Others were Wahehe, Wanyamwezi, Wamasai, and Wanyaturu constituting about 0.8% each. Abut 72% of adopters were Wagogo and 24% Warangi. This is because the two groups form the majority of population in Dodoma region. The numbers of adopters were significantly (1% level) different across the ethnic groups.

4.1.7 Livelihood groups

During the informal survey, farmers were requested to identify and describe the livelihood groups within their communities. According to farmers' criteria, presented under table 4.30, about 91 % of the sample households fall under "poor" livelihood group. This implies that majority of sample households are living under extreme poverty conditions. Table 4.4 shows the distribution of adopters and non-adopters by livelihood groups established by farmers.

Table 4. 4: Distribution of adopters and non-adopters by livelihood groups

Livelihood groups	Non adopters		Adopters		Total	
	n	%	n	%	n	%
Poor	0	0	0	0	0	0
Average rich	6	5	6	5	12	5
Better off	1	1	8	7	9	4
Total	7	6	14	12	21	9

Source: Survey data (2000/01)

4.2 Household Resource Allocation

4.2.1 Land resource and land acquisition methods

The mean farm size was 2.63 hectares per sample household; adopters had 2.83 hectares that is slightly higher but not significantly different from 2.43 hectares for non-adopters (Table 4.5). The farms are fragmented into small plots. The sample mean number of plots was three, ranging from one to seven. The mean number of plots (3.5 SE 0.12) for adopters was slightly higher than non-adopter (2.6 SE 0.11) but there were no significant differences observed. Majority of households (30.4 %) had 3 plots. As a result of villagisation, people are settled in villages while their original fields are far away from the village. It takes several hours walk to original fields. As a result farmers can attend very small fields of between 0.1 to 0.8 hectares of sorghum and millets. This situation allows farmers to test new technologies on some of their plots before they can plant on larger land areas as a risk minimizing strategy.

Table 4. 5: Resource and assets ownership by adopters and non-adopters

Characteristics of household head	Non adopters (N=124)		Adopters of Pato (N=116)		t – Statistic
	Mean	SD	Mean	SD	
Number Tropical Livestock units (TLU)	4.31	10.20	9.1	26.44	1.53 ***
Number of cows	7.07	12.01	13.76	23.98	1.33 **
Number of plots	2.6	1.19	3.5	1.32	5.54 NS
Farm size (hectares)	2.43	6.54	2.83	10.4	0.99 NS
Non-livestock household wealth (value of selected items in T sh.)	87888	203756	1360 81	320548	1.38 **
Agricultural credit value ever obtained in Tshs.	30950	42830	5549	5740	1.67***
Amount of sorghum sold in 2000 (kg)	270	277.5	376.7	538.14	0.57 *
Number of adults (Above 18 years)	2.3	1.07	2.59	1.3	1.92 **
Number of ox-ploughs	1.44	1.1	1.44	0.9	0.02 NS
Number of Machetes (Panga, nyengo)	2.06	1.09	2.56	1.34	2.94 **
Number of hand hoes	2.79	1.54	3.34	1.89	2.44 *
	n	%	n	%	χ^2 Statistics
Use of agricultural credits					3.4 *
Yes	9	7.3	17	14.7	
No	115	92.7	99	85.3	

Note: *** = P < 0.01, ** = P < 0.05, * = P < 0 .1, SD = Standard deviation, NS = Non significant

Source: Survey data (2000/01)

Land acquisition

In Tanzania, all land is publicly owned and vested in state. But individuals have got user right (usufruct, (MoA 1995). There are three major tenure systems, these are: customary or communal land tenure, Commercial land tenure, and leasehold and right of occupancy. The majority of household owns land under communal system. In this system, the land is utilized by entire agro pastoral community. The land is governed and protected by customary law. Table 4.6 shows the distribution of existing land tenure systems by village. No single household indicated to have leased the land. About 69% of sample household inherited some of their plots, 42% cleared the natural forest, 18% purchased the plots, 10% rented in, 10% were offered land by village government. The existing land tenure system does not attract long-term commitment of resources to improve productivity of land.

Table 4. 6: Land acquisition method by village

Method of land acquisition	Kondoa				Dodoma Urban				Dodoma Rural				Total	
	Mnenia		Bumbuta		Mbabala-A		Mbalawala		Chipanga-A		Mvumi-Makulu			
	n	%	n	%	n	%	N	%	n	%	n	%	n	%
Inherited	31	78	25	63	19	48	24	60	23	58	36	90	158	69
Cleared forest	7	18	14	35	17	43	29	73	25	63	9	23	101	42
Purchased	5	12	10	25	10	25	6	15	9	23	2	5	42	18
Rented in	4	10	6	15	6	15	1	3	4	10	3	8	24	10
Village government offer	3	8	1	3	1	3	3	8	5	13	8	20	21	9

Source: Survey data (2000/01)

4.2.2 Capital

Financial capital in cash or savings is factor-influencing adoption. Adoption of new technology often necessitates purchases of inputs such as improved seed, fertilizer and pesticides. The main sources of financial capital in the study area are off-farm activities and agriculture (both crop and livestock).

About 91 % of adopters and 96 % of non-adopters were fulltime farmers. However, 82 % of adopters and 77 % of non-adopters indicated to have some form of off-farm activities as complementary sources of income but there were no significant differences between adopters and non-adopters with respect to non-farm income opportunities (Table 4.7).

Table 4. 7: Participation in non-farm activities by adopters and non-adopters

Response	Non adopters		Adopters		Total	
	N	%	n	%	n	%
No	29	23	21	18	50	21
Yes	95	77	95	82	190	79
Total	124	100	116	100	240	100

Source: Survey data (2000/01)

Credit is another important source of capital. According to Kashuliza *et al.* (1998), access to credit enables the farmers to invest on technologies that improve productivity and tap the economic opportunities. Results from preliminary survey shows that availability of credit was mainly concentrated in urban centres. For example there are about 18 Savings and Credit Cooperatives (SACCOS) in Dodoma district but 17 of them are operating in the Dodoma urban centre. Results from formal survey shows that only 14.7 % of adopters and 7.3 non-adopters had ever received agricultural credit. The mean credit value ever received for adopters was T sh. 5 549 and was significantly (1% level) lower than that for non-adopters T sh. 30 950. In some cases, sorghum farmers are scared of credit because of bad experience from Kilimo-Sasakawa G 2000 project. According to Village extension workers in the pilot areas, farmers obtained credit worthy between T sh. 50 000 to100 000 in form of seed and fertilizer, but since there was no market for sorghum and millet they were not able to repay the credit. This situation created a group of non-intentional defaulters. The defaulters had to seek money from other sources to repay the credit. Currently there is no formal credit agency-serving farmer in the study area due to collateral barriers. This has limited farmers hire tractors to plough the land, buy seed and other farm inputs. So there is a need for government to initiate a specialized institution lending

money to agricultural sector, and this will facilitate the adoption of improved technologies.

Physical capital in the form of land, livestock and other asset ownership also influence adoption of technologies. Among the agro-pastoralists, cattle are considered to be storage of wealth. The mean number of cows for adopters was 13.8 and was significantly (5% level) higher than that for non-adopters (7.1). Based on the current value of selected household items, the mean non-livestock wealth for adopters of T sh. 136 081 and was significantly (5% level) higher than non-adopters T sh. 87 888. Likewise adopters had significantly (1% level) higher number of Tropical Livestock Units (TLU) of 9.1 than non-adopters 4.3 (Table 4.4). The TLU was calculated based on the tropical animal with live weight 250 kg as suggested by Wiktorsson (1992), Appendix 4.1).

4.2.3 Labour hiring and labour sharing

Human labour is the major resource in smallholder agriculture especially because of dominance of the use of hand hoes as the main tool. According to URT (1997a), there are virtually no officially paid agricultural workers in the region. However the results from this study shows that labour hiring exist among the farmers. About 44% and 23 % of adopters and non-adopters respectively use hired labour. Labour hiring show that it is largely practiced for crops with financial returns mainly maize 26 % and groundnuts (27) (Table 4.8). Household ability to hire labour at critical times can influence adoption positively.

Table 4. 8: Labour hiring and labour sharing by adopters and non-adopters

Characteristics of household head	Non adopters (N=124)		Adopters of Pato (N=116)		χ^2 - statistic
Labour hiring					11.42***
Yes	29	23.4	51	44	
No	95	76.6	65	56	
Participation in labour sharing					3.50*
Yes	42	33.9	53	45.7	
No	82	66.1	65	54.3	

Note: *** = P < 0.01, ** = P < 0.05, * = P < 0 .1, SD = Standard deviation, NS = Non significant

Source: Survey data (2000/01)

4.3 Extension Service

Access to effectiveness of extension service is crucial in uptake and adoption of improved technologies. The number of extension workers per unit of population influence extension delivery. The higher the number of extension workers the more visits that can be paid to farmers in most cases.

4.3.1 Extension visits

Four out of the six study villages had extension workers all with diploma level. The sample mean visit frequencies by extension workers for year 2 000 were 0.84 per household. About 64 % of sample household did not receive any visit by village extension workers. This is probably due to lack of appropriate means of transport and wider coverage per extension worker. Other stakeholders playing active role in promotion of sorghum and pearl millets are DCT, Norwegian Peoples Aid (NPA), International Food and Agriculture Development agency (IFAD) and World Vision International

4.3.2 Extension messages

Together with the number and quality of education of extension workers, the type of extension advice is important in adoption of improved technologies. The extension advice concentrated on advices related to planting, planting date and planting patterns. This was reported by about 40% of sample households. Pest control was another area of importance reported by about 24% of sample household. The use of farmyard manure was reported by 17% of households. Only about 8% of sample household were advised on new varieties (Table 4.9).

Table 4.9: Extension advice given to sample farmers in 1999/2000 by village

Extension message	Kondoa				Dodoma Urban				Dodoma Rural				Total	
	Mnenia		Bumbuta		Mbabala-A		Mbalawala		Chipanga-A		Mvumi-Makulu			
	N	%	n	%	n	%	n	%	n	%	n	%	n	%
Planting date and planting patterns	2	15	11	50	3	60	1	50	10	38	8	40	35	40
Pests and pest control	5	39	2	9	2	40	0	0	9	35	3	15	21	24
Farm yard manure use	3	23	3	14	0	0	1	50	5	19	3	15	15	17
New varieties	1	8	2	9	0	0	0	0	1	4	3	15	7	8
Animal husbandry	11	15	0	0	0	0	0	0	0	0	1	5	3	4
Cassava production	0	0	0	0	0	0	0	0	0	0	2	10	2	2
Past harvest crop handling	0	0	2	9	0	0	0	0	0	0	0	0	2	2
Soil conservation	0	0	2	9	0	0	0	0	0	0	0	0	2	2
Horticulture	0	0	0	0	0	0	0	0	1	4	0	0	1	1
Total	22	100	22	100	5	100	2	100	26	100	20	100	88	100

Source: Survey data (2000/01)

4.3.3 Radio ownership

Radio is a mass media through which farmers can get agricultural information. The major role of mass media is to provide linkages mechanism, create awareness, and sensitise public on various issues. In addition to extension services, radio was used as a proxy for access to information. About 53% of the sample households owned radio receiver, while 59% of adopters and 48% of non-adopters owned a radio receiver. However, there was no significant difference between adopters and non-adopters (Table 4.10).

Table 4.10: Ownership of radio receiver by adopters and non-adopters

Response	Non-adopters		Adopters		χ^2 Statistics
	n	%	n	%	
Yes	60	48	68	59	2.52 NS
No	64	52	48	41	
Total	124	100	116	100	

Note: NS = Non significant

Source: Survey data (2000/01)

4.4 Farming Systems

4.4.1 Soil and land use pattern

Three major soils were found in the study area. Sandy soils were dominant in most of the villages. These are abundantly found on the waterways and valley bottoms. In Dodoma rural and urban districts Wagogo people classifies sandy soils in two types. According to Holtland (1994), these are "Isangh'a" characterized by grey-yellow brown sandy, loam soils found on fields and "Msawawa" which are pure sandy soils deposited on valley bottom and waterways. Other types of soils are reddish-brown sandy clay loam with few sand known as "Nkuluhi" by Wagogo and dark-grey to black clay loam soils with no cracks which are known as "Isanganyika, and "Nyika or Mbuga" soils characterized by black, heavy clay with cracks when dry (Holtland, 1994). The results of this study shows that about 61% of sorghum farmers preferred red clay soils (Nkuluhi) while about 62% of pearl millet farmers prefer sandy loam soils

(Isangh'a). According to farmers, sorghum requires more fertile soils than pearl millet. Table 4.11 shows the farmers preference for soils suitability for sorghum and pearl millet. The preferences are related to soil fertility. The red soils (Nkuhuhi) used for sorghum are more fertile than sandy soils. According to farmers, pearl millet can perform better on poor sandy soil than sorghum.

Table 4.11: Farmers' soil preferences for sorghum and pearl millet production

	Sorghum		Pearl millets	
Soil type	n	%	n	%
Reddish-brown clay soils (Mfinyanzi or Nguluhi)	126	61	25	12
Grey Sandy loam soils (Kichanga or Isangh'a)	49	23	149	74
Grey Sandy clay loam (Tifutifu)	31	15	25	12
Black clay soils (Mbuga soils or nyika)	2	1	3	2
Total	208	100	202	100

Source: Survey data (2000/01)

4.4.2 Use of agricultural inputs

Farmyard manure

URT (1997a) estimates that Dodoma region produces about 1.6 million tones of FYM per annum, but only 6% can be accessed from the night kraal. This is because the rest of FYM is wasted during the daytime free range feeding system. About 58% of sample households indicated to have used farmyard manure at any time. Table 4.12 shows that about 62% and 64% of FYM users are Okoa and Pato adopters respectively.

Table 4.12: Distribution of households using farmyard manure

Use of FYM	Non-adopters		Pato Adopters		Total	
	N	%	n	%	n	%
No	60	48	42	36	102	43
Yes	64	52	74	64	138	57
Total	124	100	116	100	240	100
	Non adopters		Okoa adopters		Total	
No	93	43	9	38	102	42.
Yes	123	57	15	62	138	58
Total	216	100	24	100	240	100

Source: Survey data (2000/01)

Farmyard manure is used mainly for maize 30%, sorghum 28%, pearl millet 26% and horticultural crops 11% (Table 4.13). The mean amount of farmyard manure is 3.9 tonnes per hectare, which is far less than the recommended amount of at least 5 tonnes per hectare (Myaka *et al.* 1999). Due to increased demand for land, coupled with population growth, livestock are pushed away from the villages' peripherals and to marginal areas. So the use of farmyard manure for production purposes is highly limited by transportation from livestock kraals (locate away from the village) to crop fields.

Table 4.13: Farmyard manure use by crops on which it was applied

Type of crop	Number of FYM users	(%)
Maize	43	30
Sorghum	40	28
Pearl millet	37	26
Horticultural crops	15	11
Other crops	7	5
Total	142	100

Source: Survey data (2000/01)

Use of inorganic fertilizers and improved seeds

The use of inorganic fertilizer seems to be a rare practice due to high prices of fertilizer and low precipitation. Only one household reported to have used fertilizer in both sorghum and pearl millet in year 2000.The use of inorganic fertilizer took place mainly between 1972 and 1996 a period when fertilizers were highly subsidized (Table 4.14). Between 1980s and 1996 Kilimo-Sasakawa G 2000 project was operational in the region with emphasis on improved seeds and fertilizer use. This accounts for high use of fertilizers in 1985. The major fertilizers used were CAN, Urea, and SA. According to Heisey and Mwangi (1996), the use of fertilizer in central semi-arid of Tanzania is very low, about 8-10 kg of Nitrogen per hectare as compared to 18-43 kg Nitrogen per hectare in Southern highlands.

Table 4.14: Fertilizer use by crop and year of use

Year of fertilizer use	Sorghum		Pearl millet	
	Number Of users	%	Number of users	%
1972	1	12.5	-	-
1985	3	37.5	-	-
1989	1	12.5	1	50
1992	1	12.5	-	-
1996	1	12.5	-	-
1998	1	12.5	-	-
2000	1	12.5	1	50
Total	8	100	2	100

Source: Survey data (2000/01)

During the study period it was noted that there is generally low use improved seed mainly because of accessibility problems and untimely delivery. With removal of subsidies, the prices of farm inputs continue to be beyond the reach of ordinary peasant. Community seed multiplication is new but a potential source of improved seed to farmers and has positive influence on adoption.

Farmer-to-farmer seed exchange was found to be one of the major sources of seed in the study villages. When larger amounts of seed are required, then some form of agreements is made. In such cases one has to pay for seed or refund the same amount after the harvest. Table 4.15 shows community seed exchange by different wealth categories of the community members. The largest proportion (60%) of those receiving seed lots from fellow come farmers from very poor group. Likewise, seed offer is also highest (58%) in the very poor group. So it implies that seed exchange takes a form of social capital to member of society and it is most likely that it takes place within the same livelihood group.

Table 4.15: Community Seed Exchange by livelihood groups (%) in 1999/2000 season

	Livelihood categories				
Proportion of households	Very Poor	Poor	Average	Better off	Total
Received seed lot from other households.	78 (59)	40 (31)	6 (5)	6 (5)	110 (100)
Offered seed lots to others	53 (58)	31(34)	2 (2)	6 (6)	92 (100)

Note: ( ) = percentage

Source: Survey Data (2000/01)

4.4.3 Farm equipment and tools

In the study area, there was significant use of Draft Animal Technology (DAT). According to farmers about 90% of fields in Bumbuta village were cultivated using ox-plough. Result from a study by Maiseli *et al.* (1999) shows the potential of integrating ox weeding in the maize based farming systems. But in sorghum and millet based system ox weeding is not yet a popular practice among the farmers probably due to random planting and intercropping. Row planting is a prerequisite for ox weeding. Results from formal survey shows about 13% of sample households own at least a pair of oxen, and 14.2% owns at least one ox-plough. About 26% of sample households indicated to use plough in land preparation and 10% used ox-furrow technology in planting. Most of these (87%) come from Kondoa district, 11% from Dodoma rural and 2% from Dodoma urban. About 49% of adopters and 51% non-adopters use ox-plough in land preparation. This difference is because there is little insistence on oxenisation technology associated with sorghum and pearl millet technology transfer unlike the case of maize. However hand hoe continues to be the major tool in land preparation and is used by 73% of sample households. Only about 1% of sample household use tractor in land preparation (Table 4.16).

Table 4.16: Method of land preparation by district

Method of land Preparation	District / Number of respondents							
	Kondoa		Dodoma Urban		Dodoma Rural		Total	
	N	%	N	%	N	%	n	%
Tractor	0	0	2	3	1	2	3	1
Hand hoe	22	31	65	95	68	91	155	73
Ox-plough	48	69	1	2	6	8	55	26
Total	70	100	68	100	75	100	213	100

Source: Survey data (2000/01)

4.4.4 Staple food crops

The most important food crop is pearl millet followed by, sorghum, and maize (Table 4.17.). According to farmers, pearl millets are not very popular in Bumbuta and Chipanga villages of Kondoa and Dodoma Rural Districts respectively because these villages are located close to breeding sites for dangerous pests such as quelea quelea and locust. Other crop that is important in just localized areas is groundnuts in Kondoa, Dodoma rural and Dodoma urban. Cowpea is important in the rest of districts except Kondoa. Sweet Potatoes were considered important in all villages except in Mvumi- Makulu.

Table 4.17: The six most important food crops by district and villages

	Kondoa District		Dodoma Rural		Dodoma Urban	
Crop priority	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
1	Pearl millet	Pearl millet	Pearl millet	Sorghum	Pearl Millet	Pearl millet
2	Sorghum	Sorghum	Ground nut	Pearl millet	Sorghum	Sorghum
3	Maize	Maize	Maize	Maize	Maize	Maize
4	Sweet potato	Cassava	Sorghum	Rice	Cow pear	Ground nuts
5	Cassava	Cow peas	Cassava	Ground nuts	Sweet potato	Cassava
6	Bambara nuts	Sweet potato	Bambara nuts	Cow peas	Bambara nuts	Bambara nuts

Source: Survey data (2000/01)

4.4.5 Place of sorghum and pearl millet in the system

Farmers' adoption of new varieties depends on how they rank the importance of that crop. Results from preliminary survey shows that respondents ranked pearl millet as the most preferred food crop followed by sorghum and maize. Sorghum ranked the second important food crop in four out of six village and first in one village. Maize ranked the third important food crop, in all the six villages.

Table 4.18 Shows land allocation patterns in year 2001. Pearl millet was cultivated by majority (63%) of the sample households. Maize take the second place, cultivated by 56% of the sample households and is allocated 0.67 mean numbers of plots. Sorghum takes the third place and is currently cultivated by about 48% of sample households and is allocate about 0.6 mean number of plot.

Table 4.18: The current uses of field plots

Crops	Mean plot number allocated	n	% Of farmers growing
Pearl millets	0.77	151	63
Maize	0.67	134	56
Sorghum	0.60	114	48
Ground nuts	0.40	91	38
Bambara nuts	0.11	25	10
Rice	0.09	22	9
Cassava	0.092	22	9
Sunflower	0.079	18	8
Simsim	0.038	9	4
Fallow	0.033	8	3
Vegetables	0.025	6	3
Cow peas	0.017	3	1
Rented out	0.008	2	1

Source: Survey data 2001

4.4.6 Cash crops

The most important cash crops in Dodoma are groundnuts, simsim, sunflower and Bambara nuts. Table 4.19 shows the six most important cash crops as prioritized by respondents during the study. Oil crops and pulses are currently the major source of cash income to households in the study area. Others are Finger millet, cowpea and tomato. Grapes are of second Importance in Dodoma rural and Dodoma Urban. Pearl millet and sorghum does not feature as cash crop except in Chipanga. In two of the surveyed villages (Bumbuta and Chipanga) simsim was ranked first. In the other two villages (Mvumi-Makulu and Mbalawala) groundnuts ranked first, while sunflower and tomato ranked first in Mnenia and Mbabala-A village respectively.

The priorities are different across the villages probably because of soil, environmental factors and market reasons. In areas with suitable soils, and good accessibility,

groundnuts and sunflower are cultivated in large quantities. Sunflower and groundnuts are grown in every district as cash crops and part retained for domestic uses. Dodoma region is famous for tomato production mainly in urban and peri-urban areas. That is why in villages closer to urban centre example Mbabala-A, tomatoes are famous because they give good economic returns. Simsim has got ready markets and it performs very well in Bumbuta and Chipanga villages. It is bought mainly by wholesale traders from Dar es Salaam.

Table 4.19: The six most Important Cash crops by District and Villages

	Kondoa District		Dodoma Rural District		Dodoma Urban District	
Crop priority	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
1	Sunflower	Simsim	Ground nuts	Simsim	Tomato	Ground nuts
2	Pigeon Peas	Finger millet	Grapes	Rice	Grapes	Bambara nuts
3	Onions	Sunflower	Simsim	Ground nuts	Sunflower	Cassava
4	Simsim	Cow peas	Sunflower	Finger millet	Ground nuts	Sweet potato
5	Finger millet	Beans	Castor oil	Pearl millet	Simsim	Pigeon Peas
6	Cow peas	Ground nuts	-	Sorghum	-	-

Source: Survey data (2000/01)

4.4.7 Cropping calendar

As indicated earlier, Dodoma experience short rain seasons. Because of this, labour peak is observed immediately after on-set-of rains. Planting, cultivation and weeding should be done on the first two months starting from mid November to mid February.

The recommended planting time for central plateau of Tanzania is November and December (Myaka *et al.* 1999), but according to Holtland (1994) most of planting takes place before the onset of rains. While the scientific recommended time of planting intends

to capture as much rains as possible, the farmers rationale for dry planting focus beyond that. Dry planting is a risk avoiding technique, which is necessary due to short and erroneous pattern. Also, dry planting enables the seedlings to make optimal use of N-flush, which take place after the first showers (Holtland 1994). About 76% of sorghum farmers and 75% of pearl millet farmers plant within the recommended time of planting (November to December, (Table 4.20). Time of planting has implication on adoption of new varieties as the farmers plan the planting time so as to capture most of rainfall and avoid risks. Those varieties with growth characteristics, which coincide with farmers planting calendar, have higher likelihood of being adopted than the rest.

Table 4.20: Time of Planting for sorghum and pearl millet farmers

	Sorghum		Pearl millet	
Planting period	N	%	N	%
Before recommended time	0	8	0	9
Within recommended time	0	8	0	9
After recommended time	0	16	0	16
Total	193	32	0	34

Source: Survey data 2001

4.5 Crop Management Practices

The crop management practices have got bearing on adoption of new varieties. The varieties that fit well in the farmers' management system such as intercropping have got higher likelihood of been adopted.

Intercropping sequence

About 70% of sample households indicated to practice sole cropping in some plots while 77% indicated to practice intercropping in some of their plots. Table 4.21 shows the distribution of intercropped crops. The recommended crops for intercropping with sorghum and pearl millet are grain legumes particularly cowpea and pigeon pea. Contrary to this recommendation, about 38% sorghum farmers and 36% pearl millet farmers used other cereals for intercropping. Only about 36% of sorghum farmers and 34% pearl millet farmers used recommended intercropping legumes such as pigeon pea. About 26% of sorghum farmers and 30% of pearl millet farmers used other crops for intercropping. These results show that some of farmers have not adopted the recommended grain legumes for intercropping.

Table 4.21: Distribution of intercropped crops with sorghum and pearl millet

	Sorghum		Pearl millets	
Crop	Number of respondents	%	Number of respondents	%
Cereals	0	38	33	36
Recommended legumes	31	36	33	34
Other crops	22	26	27	30
Total	53	100	93	100

Source: Survey data (2000/01)

Table 4.22 show distribution of spacing used by farmers in the study area. For intercropping purposes wider spacing is required. The recommended spacing for sorghum and pearl millet is 30cm between plants x 75 cm between rows for single seed per hill and 60cm between plant x 75 cm between row for two seeds per hill (Myaka *et al.* 1999). Majority (79%) and (73%) of sample households have adopted the recommended spacing 30 cm between plants in sorghum and pearl millet

respectively. Only 10% and 11% of sample households have adopted the recommended spacing of 75 cm between rows for sorghum and pearl millet respectively. Majority of households 50% prefer larger spacing in both crops. The plant spacing ranges from 45 cm to 120 cm between row, and from 10 cm to 90 cm between plants. The mean spacing was 77 cm and 35 cm between row and between plants respectively. This implies that the farmers have generally abide to the recommended spacing between plant but not the recommended spacing between rows.

Table 4.22: Distribution of the spacing (cm) used by farmers

Between rows	Sorghum		Pearl millet	
	N	%	N	%
Below 75	0	0	0	39
75 (Recommended)	16	10	17	11
Above 75	16	50	17	50
Total	167	60	34	100
Between plants:	N	%	N	%
Below 30	199	120	Na	Na
30 (Recommended)	132	79	112	73
Above 30	331	199	112	27
Total	662	398	153	100

Na = not available

Source: Survey data (2000/01)

Seed rate

When planting using dibbling methods, recommended seed rate for sorghum and millet is 4-6 kg / ha (Myaka *et al.* 1999). However, sample farmers are normally not concerned with kg per hectare but rather with number of seeds per hill. Sorghum had lower mean number of 5.8 seeds per hill (which is equivalent to 8.5 kg/ha) as compared to 7.2 seeds

per hill (which is equivalent to 4 kg/ha) for pearl millets. The results shows that farmers have adopted the recommended seed rate for pearl millet but they are using a larger than the recommended rate for sorghum.

4.5.1 Crop rotation

Table 4.23 shows the distribution of households practicing the crop rotation. About 22 % of sample households practice rotation on sorghum fields and 27% on pearl millet fields.

Table 4.23: Distribution of households practicing crop rotation

Response	Sorghum		Pearl millets	
	N	%	N	%
YES	52	21.7	55	27.4
NO	151	62.9	146	72.6
Total	203	100	201	100

Source: Survey data (2000/01)

Table 4.24 shows crop rotation sequence for both sorghum and pearl millet fields. Un- expectedly 33% of sample farmers rotate sorghum with pearl millet, 31% with maize and only 9% with groundnuts. A more or less similar sequence is observed in pearl millet fields where 32% of sample farmers rotate pearl millet fields with sorghum, 30% with maize and 28% with groundnuts. The results in Table 4.24 indicate that, the farmers are either not well informed on appropriate rotation sequence or they have interest other than management of soil fertility. Immediate benefits from cereals seem to be of more interest to farmers than soil fertility.

Table 4.24: Crop rotation sequence

Sorghum fields			Pearl millets fields		
	n	%		n	%
Sorghum → pearl millet	17	33.3			
Sorghum → Maize	16	31.4	Pearl millet- → sorghum	18	31.6
Sorghum → Ground nuts	9	17.6	Pearl millet → maize	17	29.8
Sorghum → Sunflower	8	15.7	Pearl millet →Ground nuts	16	28.1
Sorghum → Pigeon peas	1	2	Pearl millet → Sunflower	6	10.5
Total	51	100	Total	57	100

Source: Survey data 2001

4.5.2 Weed control

Table 4.25 shown the weeding regime for sorghum and pearl millet fields. About 68% of sample households practice two weeding regimes per season, this is as per recommendation. The first weeding takes within two weeks after planting, and the second weeding 30-46 day after planting. About 19% are practicing single weeding due to labour shortage while 30% practice three times weeding regime depending on the intensity of weeds. Among the noxious weeds observed in the field is striga (witch weed). Although Striga plants were observed in the field, there was very little mention except in villages where sensitisation workshops have taken place mainly Chipanga-A and Mvumi-Makulu in Dodoma Rural district. Since the common practice is rotation cereal by cereal it does not help to reduce the problem. Farmers in Kondoa District reported that during colonial era, it carried a corporal punishment if a striga plant (*Striga asiatica*) locally known as (Kidori) was found on some one's field. This experience might have caused farmers to close their mouths and take low profile in striga campaign. Shifting cultivation is the only strategy used by farmers to combat striga problem, but as opportunities for shifting

cultivation decline, deliberate efforts should be made to amplify awareness on striga problem and provide tools and strategies for addressing the striga problem.

Table 4.25: Weeding regimes for sorghum and pearl millet fields

	Sorghum		Pearl millet	
Frequencies	N	%	n	%
Twice	163	68.2	163	68.2
Once	46	19.2	46	19.2
Three times	30	12.6	30	12.6
Total	209	100	216	100

Source: Survey data 2001

4.5.3 Pest Control

About 88% of sample households indicated to have suffered crop loss in 1999/2000 seasons. The major cause of field crop loss was the insect pests and was reported by 62% of sample households. Armyworm, stalk borers and green stinkbugs were the common insect pets. Bird attack mainly quelea quelea was reported by about 32% of sample households (Table 4.26). Insect pest problem is exaggerated by the fact that farmers do not use any pest control measure. Secondly, it was noted that unless given free chemicals, farmers are unlikely to afford agro-chemical control, a situation, which calls for integrated pest management technology and innovative means such as botanicals.

Table 4.26: Major causes of field crop losses in sorghum and pearl millet

Source of loss	N	%
Insects pests	129	62
Birds attack	48	23
Vermin	17	8
Wind shedding	8	4
Theft	3	2
Diseases	2	1
Total	207	100

Source: Survey data (2000/01)

4.5.4 Post harvest handling

Head load mostly by women was the major means of transport used by 60% of sample households. Other means of transport are ox-carts, bicycles, and donkeys with 13% each. Only 1% of households used vehicles as a result of high transport charges. Table 4.27 shows the major means of transport for farm produce.

Table 4.27: Major means of transport for farm produce

Means of transport	N	%
Head loads	144	60
Oxcarts	32	13
Donkey	32	13
Bicycle	30	13
Vehicle/trailer	2	1
Total	239	100

Source: Survey data (2000/01)

The most common grain storage facilities in the study area polythene bags 51% and locally made granary (idong'a) 16%, Table 4.28).

Table 4.28: Post harvest storage methods

Storage method	N	%
Bags (polythene)	120	51
Granary (vilindo or Idon'ga)	39	16
On the Floor	26	11
Calabash	18	8
Raised platforms	15	6
On the roof	11	5
Drums	8	3
Total	214	100

Source: Survey data (2000/01)

According to farmers in the study area, local varieties are more tolerant to storage pests than improved varieties. About 68% of sampled households indicated to have practiced seed treatment. Ash or lime is the major treatment for both sorghum and pearl millet grains used by about 50% of sampled households. About 23% of sorghum farmers and 19% of pearl millet farmers use commercial storage chemical mainly actelic dust. Botanicals mainly *Azadracta spp.* (muarobaini and mijohoro) are also used to treat the grains (Table 4.29)

Table 4.29: Grains treatment method

	Sorghum		Pearl millet	
Method of treatment	N	%	n	%
Ash/lime	70	50	60	50
Storage chemicals	31	23	23	19
Traditional herbs	23	17	21	18
Airtight guards	12	9	12	10
Smoke	2	1	4	3
Total	138	100	120	100

Source: Survey data (2000/01)

4.6 Household wealth and social status

4.6.1 Sources of household cash Income

In the study area, households depend on both farm and non-farm sources of cash income. The farm sources of income are cash crops, mainly oil crops and pulses. The non-farm income sources include; Needle work, handicrafts, pottery, salt works, selling forest products and in some cases fishing. Some farmers, mainly young people, have temporarily migrated to other areas especially Morogoro, Tanga and Tabora in seek for employment.

4.6.2 Household wealth rank and social status

A wealth ranking exercise was carried out in all the six villages with the aim of identifying the differences in adoption between the livelihood/wealth groups. Through men and women, group discussions indicators generally acceptable in the village were identified.

Table 4.30 shows the profile of farmers' wealth indicators in Dodoma region. According to farmers the main wealth indicators are: Farm size, number of cattle, quality of house, shop ownership, household food security, ownership of oxen plough and milling machines. The indicators differ between villages depending on the prevailing economic conditions. In Mnenia, Mbalawala, Bumbuta and Mbabala–A, farm size was the main criterion probably because crop farming to them is major source of livelihood. In Chipanga-A number of cattle was the main criterion since the nature of land allows free ranging for large herd of cattle. In Mvumi-Makulu shop

ownership is the main criterion because of several prosperous shop owners found in the village; the villagers consider shop ownership, as been a profitable venture.

Table 4.30: Farmers' Wealth Indicators in Dodoma Region by District and Village

Priority	Kondoa		Dodoma Urban		Dodoma Rural	
	Mnenia	Bumbuta	Mbabala-A	Mbalawala	Mvumi-Makulu	Chipanga A
1	Farm size	Farm Size	Farm Size	Farm size	Ownership of shop	Number of cattle
2	Quality house	Quality house	Ox-plough	Number of cattle	Food security	Milling machines
3	Food security	Number of cattle	Number of machine	Quality house	Ownership of vineyard	Ownership of shop
4	Number of livestock	Milling machine	Milling machine	Shop ownership	Milling machines	Employment off-farm income
5	Oxen Implements	Motor vehicle	Ownership of shop	Improved Cow	Number of cattle	Number of goats
6	Oxen pairs	Shop owner-ship	Ox-cart	Ox--plough	House quality	Farm size
7	Milling machines	Ox- cart	Vineyard-yard	Milling machine	Dairy cow	Technical skills
8	Shop owner Ship	Kiosk	Quality house	Pottery	-	House quality
9	Sewing machine	Tea room	Number of goats	Local brewing	-	Number of chicken
10	Crops Stockist	Number of goats	-	-	-	Pottery

Source: Survey data (2000/01)

Table 4.31 shows existing wealth groups and percentage distribution of households in the four identified groups.

Table 4.31: Percentage distribution of wealth groups by location

Wealth Group	Kondoa		Dodoma Urban		Dodoma Rural	
	Mnenia (n = 120)	Bumbuta (n =100)	Mbabala-A (n= 120)	Mbalawala (n = 122)	Mvumi-Makulu (n= 120)	Chipanga - A (n= 138)
Better off	1	1	12	1	Na *	3
Average rich	11	4	6	3	1	3
Poor	54	20	15	10	98	10
Very poor	34	75	67	86	1	84
Total	100	100	100	100	100	100

Note: Na = not available, * = Group one for Mvumi-Makulu could not be determined from the random sample used.

Source: Survey data (2000/01)

The result of wealth ranking exercise shows that in general over 68% of households in each of four of the six villages (Bumbuta, Mbalawala, Mbabala-A and Chipanga-A) are very poor. Mbabala-A had most of the better off households about (12%) because it is located within the Dodoma municipality where there are array of economic activities. Chipanga-A had about 3% households in better off group mainly the large-scale livestock keepers (matajiri ng'ombe) as are popularly known. According to farmers criteria majority of households in the sample villages are poor. To enhance adoption to such groups it is necessary to provide an enabling environment that will enhance uptake and adoption of improved technologies such as improved package for sorghum and pearl millets, which will eventually improve their livelihoods.

4.7. Evolution of different sorghum and pearl millet in Dodoma region

An exercise to capture important events that had influence on the households' livelihoods, and forces that enhanced the diffusion of different sorghum and pearl

millets in the study area was carried out using historical timeline, a PRA tool. The results are presented under Table 4.32 and Table 4.33. This is an aggregate of six separate timelines carried out in each village. Most of the local varieties for both sorghum and pearl millet existed even before 1939. Improved varieties diffused to the local communities largely through hunger relief aids pathway. New varieties were introduced following frequent famines. It was not possible to capture the origin of local varieties because none of the participating farmers could remember events before 1939. By 1970, Dobbs was the only improved sorghum variety available to farmers. Improved varieties diffused to the central zone farming systems after 1970. During 1972-76 Lulu and Serena were introduced in the region under the pressure of popular policy "Agriculture for Life or death" identified by political slogan (kilimo cha kufa na kupona).

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Table 4.32:Historical events and evolution of sorghum and pearl millet varieties in Dodoma 1939-1970

Year	Event	Cause	Livelihood Strategies	Introduced or existing Sorghum	Introduced or existing Pearl Millet
1939	Famine (njaa ya makopa) or Njaa ya John[1].	- Drought - World War II - Rust disease on pearl millet	Relief aid from government (dry cassava). Migration to Tabora and Tanga. Selling livestock. Construction of granaries (Vilindo) for pearl millet one per division. Consumption of wild finger millet seeds, orange dog larvae and porridge from Baobab tree seeds were.	Langalanga Udo, Ikorobo, Lugugu Chingwala, Luhu and Hembahemba were local varieties. Dobbs Introduced as improved variety.	Uwele Kienyeji, Uwele nywele, Uwele Buruma
1946-49	Famine (Njaa ya Hambaya)	Drought 1946 - Rinderpest 1949	- Relief Aids Yellow Corn, garden peas. - Migration to Tanga and Tabora. - De-stocking, - Cassava production - Granaries were built to store pearl millet	Dobbs	Uwele Buruma Uwele nywele Uwele Mwezi mmoja
1950- 55	Famine (Njaa ya Nkumbi or (njaa ya mau mau)	Red Dessert Locusts Drought Army Warms Cattle rustling	- Dry cassava food aid, Chief farms for cassava and sugarcane - Wild Finger Millet - Migration to Kilosa, Tabora	Mabukula (White)	Uwele Kiboko Uwele Ubabaza Uwele mwezi 1 (umoja)
1956	Gully Erosion	Overgrazing/ overstocking	Compulsory migration to down stream for livestock keepers	-	-
1959 - 62	Famine (Njaa ya Kuponi, Njaa ya Manoma)	- Drought - Grasshoppers (Senene)	- Food Aid: Milk, Yellow Flour, Garden Peas, Yellow corn from USA. Irrigated gardening, - Emphasis on oxenisation- migration to Kilosa	Dobbs	
1969-70	Famine (Njaa ya Michele or Njaa ya Mvujee)	- Drought - Army worms - Ujamaa policy	- Food aid: Rice cowpeas, dry cassava from government. - Grapes Introduced as cash crops. - Short term maize- katumbili		

Source: Survey data (2000/01)

[1] Mr. John was a DC during that time and was responsible for food aid.

Table 4.33: Historical events and evolution of sorghum and pearl millet varieties in Dodoma 1972-1999

1972-74	Famine 1974 (Njaa ya Machele or Njaa ya bulga)	- Drought and implementation Villagization policy.	- Food aid (Yellow Flour (Yanga), Cassava -Vegetable and fruits production -Introduction of Grapes. -Ujamaa farms -(Kilimo cha kufa na kupona policy). -Migration to Kilosa and Dar es Salaam -Sugarcane production -Begging (omba omba). -Chinese experts brought in Mvumi and Bihawana FTCs - Farmers Training Centre (FTCs) established	Serena and Lulu	Uwele-China Uwele muda mfupi from India.
1980-84	Famine (Njaa ya Ndoma Kwi? (Where Shall I go? 1984)	- Drought - Price hiking - Hyper Inflation - Economic sabotage - Cholera outbreak	Begging, tomato production, introduction of grinding machines. Operation nguvu kazi. - Row planting and use of FYM. Irrigated agriculture insisted. - Seeds from wild finger millets consumed - Food aids mainly cassava flour - Rural – urban migration	Sandala, Lulu Tegemeo	Bombay from India
1986-88	Famine (Njaa ya (HADO)	-Drought - Eviction of Livestock from HADO areas.	- Agro forestry, - Zero grazing and Improved livestock	Serena, Lulu and Tegemeo	Uwele muda mfupi
1995-99	Famine (Njaa ya Elnino~97/98)	- Elnino~ floods - Pests (Striga, Green stinkbugs, Quelea quelea Grasshoppers (Senene)	- Food aids: maize, cow pea, to target groups - Introduction of Kichiri-a green peas like plant. - Credits from SASAKAWA G 2000	PATO, Weijita, Macia, SRN 39, SAR 29, P 9405,P 9406 and Tegemeo	Okoa

Source: Survey data (2000/01)

4.7.1 Inventory of different types of sorghum and pearl millets

During the study 10 improved varieties and 23 local sorghum varieties were identified. There are 10 local pearl millet varieties and only one improved pearl millet. Table 4.34 and Table 4.35 show an inventory of sorghum and pearl millets ever grown in Dodoma region respectively. Shibe, a pearl millet variety is a quite newly released variety, it did not feature in the study villages. The two tables show that there is a higher concentration of varieties in Mvumi – Makulu and Chipanga than in the rest of the villages. It is worth noting here that local sorghum and pearl millet varieties may be the same, but they bear different names depending on ethnicity.

Table 4.34: Inventory of sorghum varieties reported to have been grown at any time by study village

Sorghum type	Village					
	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
Local sorghum						
Uhemba	√					
Langalanga	√	√				
Udo	√	√				√
Ikorobo	√	√				
Ibiwa		√				
Bangala		√	√			
Luhu		√				
Lugugu			√	√	√	√
Chingwala				√		
Mtika				√		
Mgali				√		
Hembahemba			√	√		√
Weijita			√	√		
Chipuputa					√	
Magaji					√	
Ngowe						√
Sandala			√	√		
Mabukula			√			
Ndagumo			√			
Ng'onje			√			
Sanyaji			√			
Sandala				√		
Mhumputa			√			
Improved sorghum						
Pato	√	√	√	√	√	√
Lulu	√	√	√	√	√	√
Tegemeo	√	√	√	√	√	√
Serena	√	√	√	√	√	√
Dobbs	√		√	√		√
SRN 39			√	√		
P 905			√	√		
P 906			√	√		
Macia			√	√	√	
SAR 29			√	√		

Source: Survey data (2000/01)

Table 4.35: Inventory of pearl millet varieties reported to have been grown at any time by village

Type of pearl millet	Village					
	Mnenia	Bumbuta	Mvumi - Makulu	Chipanga – A	Mbabala – A	Mbalawala
Local:						
Uwele China	√		√		√	
Uwele Bombay	√					
Uwele Kienyeji	√	√	√	√	√	
Uwele Muda mfupi	√	√				
Uwele nywele					√	
Uwele mwezi mmoja (umoja)				√		√
Buruma			√	√		√
Uwele Ubabaza				√		
Uwele sandawi	√		√			
Uwele Kiboko			√			
Improved:						
Uwele Okoa	√	√	√	√	√	√

Source: Survey data (2000/01)

4.8 Priorities and preference for different sorghum and pearl millet

4.8.1 Farmers' preferences on sorghum and pearl millets varieties

In each village the farmers were requested to indicate and prioritise the criteria they use when selecting for sorghum and pearl millet varieties. Table 4.36 shows the first six selection criteria for sorghum and pearl millets. These criteria were then used to assess farmers' preference for different varieties and result are presented under Table 4.37.

Table 4.36: Important selection criteria for sorghum and pearl millet by location

	Kondoa District		Dodoma Rural District		Dodoma Urban District	
Priority	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
			Selection criteria for sorghum:			
1	Drought tolerance	Drought tolerance	Draught tolerance	Drought tolerance	Drought tolerance	Drought tolerance
2	Time to maturity	Time to maturity	Grain yield	Time to maturity	Grain yield	Time to maturity
3	Grain taste	Grain taste	Head size	Grain yield	Grinding ease	Grain storability
4	Grain yield	Grain yield	Grain size	Marketability	Grain taste	Grain yield
5	Digestion time	Grain storability	Time to maturity	Grain storability	Head size	Grinding ease
6	Amount of bran	Digestion time	Grain taste	Grain taste	Grain storability	Head size
			Selection criteria for pearl millets:			
1	Grain storability	Grain yield	Grain taste	Digestion time	Drought tolerance	Drought tolerance
2	Drought tolerance	Time to maturity	Grain storability	Porridge quality	Grain yield	Time to maturity
3	Grain taste	Drought tolerance	Grain yield	Marketability	Porridge quality	Grain taste
4	Digestion time	Grain taste	Grain size	Brewing quality	Head size	Grain storability
5	Grinding ease	Grain storability	Time to maturity	Grain taste	Grain taste	Grain yield
6	Suitability for plao	Brewing quality	Drought tolerance	Grain storability	Grain storability	Grinding ease

Source: Survey data (2000/01)

Results from the formal survey shows that about 51% of sample households prefer Pato and 28% prefer Tegemeo both improved sorghum varieties. In three of the six villages Pato ranked first and second in two villages. In Chipanga village where local varieties had higher priority Pato ranked sixth (Table 4.37).

Table 4.37: Priority list for six most important sorghum and pearl millet by villages.

	Kondoa District		Dodoma Rural		Dodoma Urban	
Priority	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
			Priority list for sorghum			
1	Pato	Pato	P9405	Lugugu	Macia	Pato
2	Uhemba	Ibiwa	P9406	Chingwala	Chipuputa	Lugugu
3	Lulu	Bangala	Pato	Mtika	Pato	Tegemeo
4	Langalanga	Lulu	Macia	Sandala	Lugugu	Luiu
5	Udo	Tegemeo	Bangala	Mgali	Tegemeo	Ngowe
6	Ikorobo	Langalanga	Lugugu	Pato	Magaji	Hembahemba
			Priority list for pearl millet			
1	Uwele Bombay	Uwele kienyeji	Okoa	Uwele kienyeji	Uwele kienyeji	Okoa
2	Uwele kienyeji	Uwele mfupi mnene	Uwele China	Uwele Buruma	Uwele china	Uwele mwezi mmoja
3	Uwele mfupi mnene		Uwele kiboko	Okoa	Uwele nywele	Uwele buruma
4	-	-	Uwele kienyeji	Umoja	Okoa	-
5	-	-	Uwele buruma	Ubabaza	-	-
6	-	-	Uwele sandawi	-	-	-

Source: Survey data (2000/01)

Similar results were obtained during PRA using pair wise ranking. About 45% prefers Uwele kienyeji a pearl millet landrace and 28% prefers Okoa, which is an improved pearl millet. Table 4.38 shows farmers preferences for different varieties based on the first choice.

Table 4.38: Farmers' preference for different varieties

Sorghum			Pearl millet		
Variety	n	%	Variety	n	%
Pato	103	51	Uwele kienyeji	92	45
Tegemeo	57	28	Okoa	58	29
Lugugu	16	8	Uwele Bombay	33	16
Langalanga	16	8	Uwele Kiboko	9	4
Uhemba	6	3	Uwele China	8	4
Macia	2	1	Uwele muda mfupi	3	1
Mbangala	2	1	Uwele umoja	2	1
Total	202	100	Total	205	100

Source: Survey data (2000/01)

The above preference is based on the farmers' criteria in all the six survey villages. The large head size, grain yield was the most important attributes of Pato followed by short time to maturity, high grain yield and drought tolerance. For Okoa, grain size, head size, and time to maturity were the most important characteristics. Porridge and brewing quality were special attributes of pearl millet that were not considered for sorghum.

4.8.2 Farmers' perception of improved varieties

Farmers' perception of characteristic of an improved variety is very important aspect for it to be adopted. Farmers' perception on technology characteristics was assessed by scoring method. This was done by requesting farmers to score the selected characteristics of a variety as they perceive it. The score ranged form zero to ten. The values of scores shows to what extent the farmer is in favour of the attributes of the characteristic involved. Table 4.39 shows the farmers' perception of characteristics of improved sorghum and pearl millet. Overall, Okoa scored 86% hence is perceived suitable than (Pato 76%). This is because Okoa is preferred for food.

Table 4.39: The mean scores for Pato and Okoa as per farmers' perception

Characteristics	Mean Scores (%)	
	Pato	Okoa
Head size	91	94
Time to maturity	90	88
Grain yield	91	88
Drought tolerance	85	86
Grain size	85	94
Grain Taste	75	77
Prolonged digestion	65	47
Grinding ease	67	68
Grain storability	50	66
Amount of bran	47	-
Porridge quality	-	82
Brewing quality	-	67
Overall score	76	86

Source: Survey data (2000/01)

4.8.3 Future plans with respect to area under improved varieties

Table 4.40 shows the farmers' plans with respect to improved sorghum varieties. About (44%) of sample households indicated their plan to increase the area under Pato. The reasons for this plan are: Pato is high yielding (53%), early maturity (28%), large head size (5%) and good taste (5%). Only one household intends to reduce the area under Pato because of poor taste.

Table 4.40: Farmers' future plans with respect area under improved varieties

	Pato		Local sorghum		Okoa		Local pearl millets	
Plan	n	%	N	%	n	%	n	%
To Increase	104	43.9	24	10.1	20	8.4	44	18.6
To Reduce	1	0.4	43	18.1	1	0.4	40	16.9
No change	11	4.6	96	40.3	2	0.8	99	41.8
About to start	70	29.5	-	-	110	46.4	54	22.8
None	51	21.5	74	31.1	104	43.9	-	-
Total	237	100	237	100	237	100	237	100

Source: Survey data (2000/01)

Farmers also gave reasons as to why they will not increase area under Pato. The reasons identified include; labour shortage (20%), seed availability (20%), and pests' attacks (10%) and soil fertility problems (10%). Those who are about to start growing Pato are doing so because they perceived it as being high yielding (45%), short-term variety (19%) but seed availability 24.6%, impede their intentions. Those with no plan at all says seed are not available 30%, or are not informed yet 21%, or they are not interested in production of sorghum 14%.

A high percentage of households (46%) had an intention to start growing Okoa mainly because they perceive Okoa as being drought resistant (14%). Unlike in the case of sorghum, larger proportion of households intends to increase the area under local pearl millet in order to meet the increasing food demands 26%, to preserve the local varieties 17%; resistance to pests attacks 13% and capacity to recover from moisture stress.

4.9 Awareness, adoption and rate of adoption for improved varieties

About 88% of sample households were aware of improved sorghum varieties and only 48% were aware of improved pearl millets. Despite the good figure on awareness on improved sorghum, by April 2001 only about 48.8 % of sorghum farmers were adopters of Pato, 36 % Tegemeo, and 4% were growing Macia. About 1% of sample households were growing Lulu, 0.8% were growing Serena, less than 1% were growing SRN29, 3.3% were growing P9405, 3.3% were growing P9406 and 1.3% were growing SAR39. Only about 9.6% of pearl millet farmers were planting Okoa

and no sample farmer was found to grow Shibe due to seed supply problems (Figure 4.1). The differences observed in awareness and adoption data supports the decision theoretical model (Van de Ban and Hawkins, 1996). Decision to adopt takes place when the farmers are fully aware of the technology. We therefore reject the hypothesis that the adoption rates are reasonably high. The adoption percentage for improved sorghum (48.8%) in central Tanzania is relatively high compared to that of improved maize (28%) between 1974 to1994 (Kaliba *et al.*1998; Moshi *et al.* 1997).

4.9.1 Adoption rates

Logistic curve is the common procedure for assessing the rate of adoption. It captures the historical trend of adoption over a given period. The logistic curve is constructed using data on the proportion of farmers who have adopted an improved technical innovation over a given period (Appendix 4.5). This proportion involves the cumulative percentage of adopters less the percentage of non-adopters. According to CIMMYT, (1993) adoption increases rapidly as it approaches maximum level.

Figure 4.1 shows the trend of adoption of the most popular improved varieties in Dodoma region. In this study, logistic curve estimation figure above 0.75 is termed high, from o.5 to o.75 is medium while below 0.5 is low rate of adoption. The logistic curve estimation results show that between 1995-2001 the annual average rate of adoption for Pato was 0.56. From 1983-2001 Tegemeo was adopted at a rate of 0.79, from 1999-2001 Macia was 0.53 and from 1995 – 2001 Okoa was 0.46. Tegemeo has

the highest rate because it has been in the field for the past eighteen years and favoured than the other two improved varieties, Serena and Lulu. The adoption rate for Pato is medium because of short period of six years in the field since it was released and not much has been done to ensure availability of seeds to farmers. Despite its short period since it was released, Macia is peaking up at a high rate because of its good attributes of being short term, white grains and good palatability. Okoa has the lowest rate due to failure of the formal seed distribution system in responding to farmers' demands.

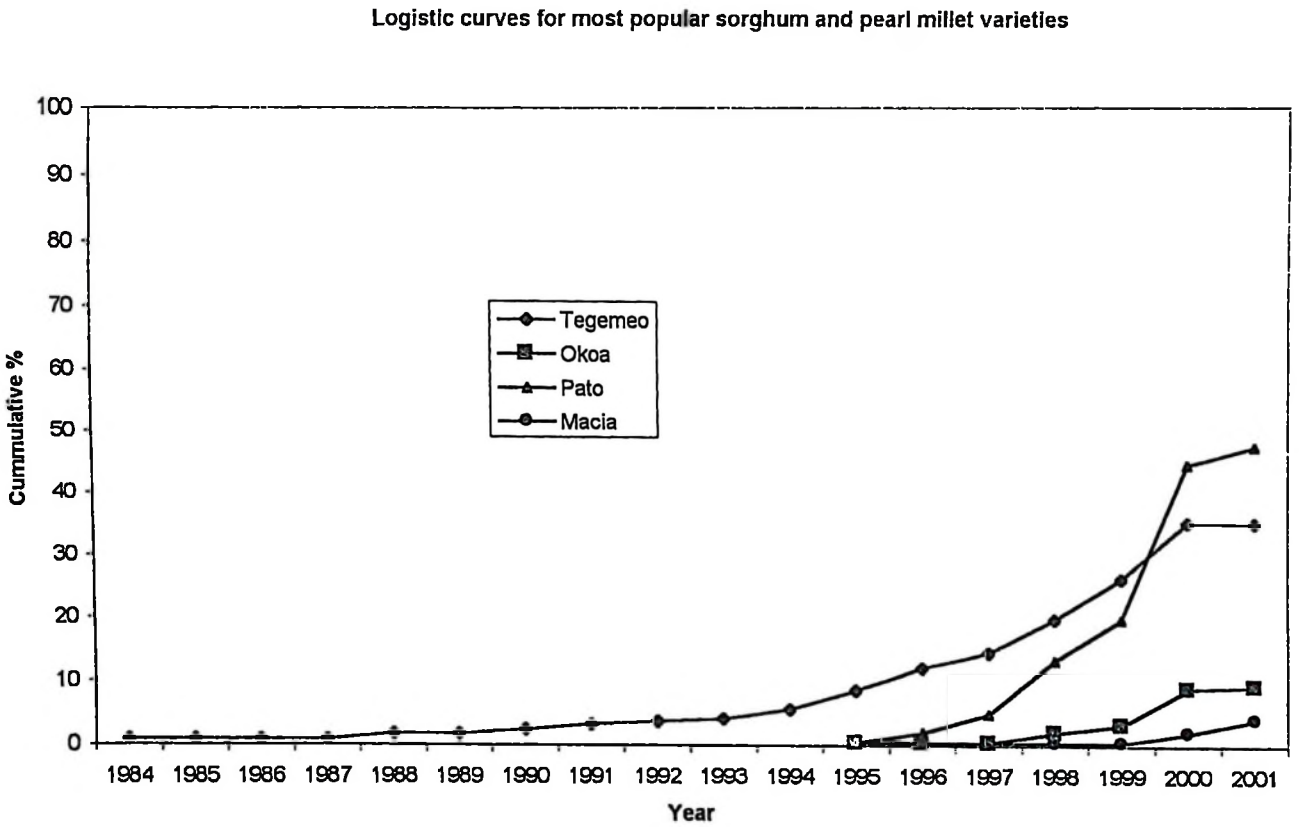

Figure 4.1: Adoption trends for most popular varieties

Overall assessment shows that in recent years (1998-2000) there has been a drastic increase in the rate of adoption for all varieties. This is explained by combined efforts by donor community e.g. on-farm research trials, Norwegian Peoples Aid (NPA), Community based seed production system and extension department. The results on adoption trends follows the adoption curve model (Rogers, 1983; CIMMYT, 1993).It also reflect utility maximization model (Upton 1976). Since the rates of adoption for improved varieties are generally low, we reject the hypothesis that Adoption is independent of combined efforts from various stakeholders in technology development and dissemination. The low rates of adoption can be explained by the fact the efforts by the stakeholders in promoting the improved sorghum and pearl millet are still minimal. The input market is not yet efficient enough to timely avail the inputs to farmers at affordable prices and there is very little done in implementing the policy on promotion of the two crops. For instance evidence from the work done in central Tanzania by SasakawaG2000-Kilimo shows Tanzania could enhance uptake and adoption of improved sorghum and pearl millet technology by providing enabling environment to farmers. For example availability of credit facility to purchase inputs, effective extension service and reliable output market.

4.9.2 Variety turn over rates

The weighted average turn over rate is an indicator that shows the rate at which the farmers are replacing their varieties with new ones. This index is constructed by multiplying the number of years the variety has been in the field by the area planted to

each variety (Regassa *et al.* 1998). In Tanzania, the areas planted to each variety sounds unrealistic due to lack of product market. However the number of years the variety has been in the field, save the purpose. Serena and Lulu have been in the field for 31 years, Tegemeo 18 years, Pato six years and Macia two years. It took 13 years before Tegemeo was released to replace Serena and Lulu, and 12 years for Pato to replace Tegemeo. Therefore turn over rates for sorghum varieties are quite low as it takes between 10 years and 13 years before a new variety is made available (Appendix 4.3). These figures surpass the global variety turn over rate of seven years. This comparatively low varietal turnover reflects the poorly developed seed industry, ineffective extension service and research in delivering new varieties. For instance, during institutional visits it was realised that there is only one active breeder in the NSMIP because of transfer of scientists to other programmes. It is therefore very important to recruit more scientists to manage the programme. Together with recruitment of scientists, there is a need to improve the entire seed development process.

4.9.3 Discontinuation of improved varieties

Failing to meet the farmers' expectations, some varieties were discontinued. There was no respondent indicating to have discontinued the use of Pato, Macia, P9405, P9406, or SRN39. (P9405, P9406, or SRN39 are experimental materials that are not yet officially released) The most disappearing varieties were Lulu 24%, Serena 24% and Dobbs 0.8% which accounts for all farmers who ever grown the variety up to 1997. About 20% of sample household which have tried to grow, indicated to have disadopted Tegemeo. The

main reasons for discontinuing varieties as given by farmers include poor taste, availability of superior substitutes and poor storability (Table 4.41). The table shows about 50% of household that rejected Dobbs did not like the red colour and 50% did not enjoy the taste and it's causes of constipation. Serena was considered to have a bitter taste, causation of constipation, availability of superior variety (Tegemeo) by about 44%, 16%and 13% of respondents respectively. Lulu was discontinued mainly because of poor palatability, availability of superior variety (Tegemeo), and poor storability by 40%, 22% and 15% respectively. Tegemeo was rejected because of poor palatability high susceptibility to bird attack, poor storability, and lack of market (Table 4.41). The results shows that superior varieties substitute the inferior one, this supports the technological change model based on technical efficiency (Fagerberg, 1991).

Table 4.41: Reasons for discontinuing improved varieties

Reason	Varieties									
	Lulu		Dobbs		Serena		Tegemeo		Total	
	n	%	n	%	n	%	n	%	n	%
Causation of constipation	-	-	1	50	9	16	-	-	10	7
Undesirable colour	-	-	1	50	5	9	-	-	6	4
Not palatable	17	40	-	-	24	44	6	14	37	26
Availability of superior variety	12	22	-	-	7	13	7	17	26	18
Poor storable	8	15	-	-	2	4	4	10	14	10
Too much bran	3	6	-	-	2	4	2	5	7	5
Not marketable	5	9	-	-	-	-	2	5	7	5
Susceptible to bird attack	3	6	-	-	-	-	6	14	9	7
Others	7	13	-	-	4	7.2	15	36	26	18

Source: Survey data (2000/01)

4.9.4 Intensities of adoption

The intensity refers to concentration of use of technology by users. Intensities of adoption of improved varieties are presented under Table 4.42. The results show that the current areas under different sorghum and pearl millet varieties are generally low (less than 1 hectare). Mean areas under Pato and Tegemeo have been steadily increasing between 1995 and 2000 and during 1999/2000 the area exceeded that under local varieties. Of interest to note is the decline of area under local varieties. This indicates adoption of improved varieties by farmers.

Area under Okoa has never exceeded that of local pearl millet during the study period. This is due to unavailability of seeds and higher preference by farmers for local pearl millet as compared to improved varieties.

Table 4.42: Mean area (ha/household) under different varieties over time.

Varieties	Year				
Sorghum:	1995/96	1996/97	1997/98	1998/99	1999/2000
Local	0.19	0.19	0.18	0.15	0.13
Pato	0.012	0.023	0.08	0.12	0.21
Tegemeo	0.1	0.11	0.16	0.20	0.21
Macia	-	-	-	0.0004	0.004
Lulu	0.03	0.025	0.019	0.015	0.009
Serena	0.03	0.011	0.006	0.0008	0.0004
Pearl millets:					
Local	0.88	0.92	0.94	0.92	0.91
Okoa	-	0.81	0.76	0.88	0.71

Source: Survey data (2000/01)

Area under Pato also increased total production and productivity also has increased between 1995/96 (Table 4.43). For example between 1998/99 and 1999/2000 Pato

production and yield increased from 89.52 to 131.37 ha and 229Kg/ha to 523.4 kg/ha respectively. This is an indication of good performance of Pato. The district aggregate data for land productivity is presented under Appendix 4.6.

Table 4.43: Mean total yields per household and land productivity for different varieties across the years

Varieties	Year				
	Mean total yield (Kg) per house hold				
Sorghum:	1995/96	1996/97	1997/98	1998/99	1999/2000
Local	137.47	130.67	86.61	85.89	76.48
Pato	2.77	14.79	59.9	89.52	131.37
	99.33	91.12	112.18	131.74	134.51
Tegemeo					
Macia	-	-	-	-	0.42
Lulu	24.47	22.92	11.30	3.6	2.23
Serena	-	13.46	1.32	0.28	0
Pearl millets:					
Local	607.8	540.15	389.13	473.06	499.28
Okoa	-	200	950	459.38	584.04
	The land productivity (Kg/hectare planted)				
Sorghum:					
Local	270.1	180.78	610.38	653.13	514.78
Pato	0	3.76	97.36	229	523.4
	949.57	824.39	687.4	694.86	693.35
Tegemeo					
Macia	-	-	-	-	494.19
Lulu	684.01	564.19	562.6	425.95	421.25
Serena	1070.67	551.77	382.53	329.45	0
Pearl millets:					
Local	727.16	650.9	492.49	566.27	597.43
Okoa	-	164.74	1194.29	896.24	856.09

Source: Survey data (2000/01)

4.10 Management of genetic resources

4.10.1 Major sources of seed in (2000/01)

During the survey respondents were requested to identify their major sources of sorghum and millet seeds. The major source of seed as indicated by majority of farmers was extension service. About 39% of growers of improved pearl millet and 33% of sorghum growers obtained their seed from extension agents. Other sources that were mentioned include selection from previous harvest and other farmers (Table 4.44). The seed sources have strong influence on adoption since they determine availability of improved seed to farmers.

Table 4.44: Major sources of seed by farmers in (2000/01) season

Source	Kondoa				Dodoma Urban				Dodoma Rural				Total	
	Mnenia		Bumbuta		Mbabala-A		Mbalawala		Chipanga-A		Mvumi-Makulu			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
							Sorghum							
Extension	6	35	14	52	7	25	6	27	12	31	7	27	52	33
Own seed	8	47	7	26	4	14	1	4	6	15	8	31	34	21
Other farmers	2	12	3	11	7	25	12	55	3	8	3	11	30	19
Stockists / market	0	0	0	0	7	25	3	14	1	2	0	0	11	7
Hunger relief (NPA)	1	6	3	11	0	0	0	0	5	13	1	4	10	6
DCT	0	0	0	0	0	0	0	0	8	20	0	0	8	5
Research	0	0	0	0	0	0	0	0	1	3	7	27	8	5
Other sources	0	0	0	0	25	89	0	0	36	92	0	0	153	96
Total	17	100	27	100	28	178	22	100	39	184	26	100	159	192
									Pearl millet					
Extension	1	100	2	50	3	38	0	0	0	0	3	50	9	39
Other farmers	0	0	2	50	2	25	0	0	0	0	1	16	5	22
DCT	0	0	0	0	0	0	0	0	3	100	1	17	4	17
Other sources	0	0	0	0	5	63	0	0	0	0	5	83	18	78
Total	1	100	4	100	8	126	1	100	3	100	6	166	23	156

Source: Survey data (2000/01)

Plant genetic resources are vulnerable to extinction (erosion) if they are not continuously used or skilfully stored. Farmers in Dodoma are very keen in management of genetic materials not for sorghum and pearl millet alone but other crops as well. The evidence of this is the existence of local varieties that existed before World War II while Dobbs, Serena and Lulu are phasing out of production system. For those varieties, which farmers perceive to be important, seed selection is carried out carefully. Table 4.45 shows the farmers' seed selection strategies in each study village. For majority of sample households, 78% sorghum farmers and 82% pearl millet farmers, selection of seeds takes place at the threshing ground just before threshing. About 87% of Pato adopters and Okoa adopters indicated to use this procedure. The problem with this method is that it does not take into account the field characteristics of the parent plants. The seed is selected basing on grain quality and head size only.

Table 4.45: Seed selection methods by district and villages.

Selection place	Kondoa				Dodoma Urban				Dodoma Rural				Total	
	Mnenia		Bumbuta		Mbabala-A		Mbalawala		Chipanga-A		Mvumi-Makulu			
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Pearl millet														
On farm at maturity stage	11	30	3	8	5	13	6	16	-	-	2	5	27	14
Post harvest before threshing	25	68	29	83	32	84	30	79	6	100	33	92	155	82
From grain stored for food	1	2	3	9	1	3	2	5	-	-	1	3	8	4
Total	37	100	35	100	38	100	38	100	6	100	36	100	190	100
Sorghum														
On farm at maturity stage	9	28	6	16	5	15	5	16	10	27	5	14	40	19
Post harvest before threshing	22	69	28	74	27	82	26	81	27	73	32	86	162	78
From grain stored for food	1	3	4	10	1	3	1	3	-	-	-	-	7	3
Total	32	100	38	100	33	100	32	100	37	100	37	100	209	100

Source: Survey data (2000/01)

Selection criteria for sorghum and pearl millet were mainly large grain, large head size and fully matured heads to ensure germination. Farmers were much concerned with post harvest qualities and not on field performance of sorghum and pearl millet plants.

4.10.1.1 The Role of traditional seed experts in conservation of genetic resource.

Crop conservation cannot be disassociated from crop usage and the decision to conserve depends largely on its usefulness. During the preliminary survey, it was realized that traditional seed experts (conservators) were important in stopping genetic erosion and increasing on-farm diversity). Local land races are the most conserved compared to improved varieties. This is because the varieties are genetically diverse and often have multiple uses both grain and non-grain uses. Varieties are palatable and well adapted to local methods of processing and cooking. Also farmers are sure of getting-improved varieties from extension but not the local varieties. According Friis-Hansen (1999), varieties have characteristics to minimize risk of crop failure, including drought tolerance and horizontal resistance to pests and diseases. A total of 20 local conservators were identified in the study area (Appendix 4.2). Majority of the conservator 80% were male households heads. The breeder seed for improved varieties is conserved by formal seed breeders at ARI-Ilonga.

4.11 Post Harvest Processing and Utilization of Sorghum and Millet Products

4.11.1 Post harvest processing of sorghum and pearl millet

Post harvest processing of sorghum and pearl millet involves threshing, dehulling and grain grinding. In Tanzania, much emphasis has been on breeding to maximize yield. According to Lazaro, (1999) little effort was directed to processing and utilization research. As a result, the dominant processing techniques are still traditional. Availability of improved processing technology would add value to the sorghum and pearl millet products hence promoting the related enterprises in the rural areas of the region. Threshing is usually done manually by beating sorghum and millet heads on the floor with sticks. Grain dehulling and milling technologies are not readily available in Dodoma. The major means of dehulling the two crops in rural areas is by mortar and pestle. Grinding is also done manually by use of stones. The dominance manual post harvest limits the adoption of improved sorghum and pearl millet.

4.11.2 Other uses of sorghum and pearl millets

Utilities derived from sorghum and pearl millet has influence on adoption of improved varieties. Table 4.46 shows the list of uses other than local brew and porridge at household level. Consumption of sorghum and pearl millet is a crucial issue, not only because they fall under inferior commodities, but also because apart from porridge and local brew, very few sample households know other recipes. Very little work has been done in promotion of consumption of sorghum and pearl millets. There is a need to continue researching on

alternative uses of the two crops both at household level and at commercial level. Farmers, especially female farmers, have the need for training on various recipes of sorghum and pearl millet. This will give them a wider choice of food menu in the houschold.

Table 4.46: Distribution of sample household by known recipes of sorghum and pearl millets in Dodoma region in 2001

Recipe	Yes		No	
	n	%	n	%
Pan cake (Chapatti)	18	7.5	222	92.5
Bread	3	1.3	237	98.8
Pops (Bumunda)	2	0.8	238	99.2
(Plao)	24	10	216	90
Ubwabwa	26	10.8	214	89.2
(Kande)	71	29.6	169	70.4
(Andazi)	3	1.3	237	98.8
(Vitumbua)	9	3.8	231	96.3

Source: Survey data (2000/01)

Cooking taste is another issue, which influence the consumption of sorghum and millet meals. The taste can be improved by proper processing. Proper dehulling technique is important to reduce the amount of bran fibres. Some times, consumers preference do change and switch to other substitute commodity provided they could derive more satisfaction out of it. This has been the case, particularly for Dodoma rural areas where pearl millet and sorghum use to be the main food staples but currently there is a tendency of switching to maize meal, hence supporting the utility maximization model (Upton, 1976)

As a follow up, the study posed a question intended to capture the consumption frequency of common grains for a week before the day of interview. The result shows that

maize meal was consumed most frequently, about (5 times a week) as main meal; while pearl millet, had frequency of (1.52 times a week), mainly for breakfast. Table 4.47 show a household preference for main staples, although not conclusive since there is a possibility that this trend is observed at that particular time of the season.

Table 4.47: Consumption of selected types of food preparations by the sample household a week before the study period April 2001

Food preparations type	Mean consumption frequency
Maize (stiff porridge) Ugali	4.83
Pearl millet (stiff porridge) ugali	4.008
Sorghum (stiff porridge) ugali	3.2
Pearl millet porridge	1.515
Sorghum porridge	1.127
Maize porridge	1.071
Rice	0.7155

Source: Survey data (2000/01)

Other uses of sorghum include the use of sorghum ash as for cooking purposes, source of construction materials and fuel, medicine for cattle and human beings and source of mechanical structures used as mixers for local brew.

4.11.3 Contribution of sorghum and pearl millets in household livelihoods

When farmers were requested to quantify the contribution of various commodities in livelihoods of households they came up with three main areas of contribution. These are contribution for regular household food supply, household food security during famine times, and sources of financial income. These have got direct influence on uptake and adoption of improved varieties. Comparisons were made between crops

including sorghum and pearl millets using scoring method.

Table 4.48 shows the contributions of various crop in daily household food supply. In all the six villages, pearl millet ranked first in terms of food supply. It contributes between 20% and 50% of household regular food supply. In Mnenia village it contribute about 50% in food supply. Sorghum contributes between 0% and 20%. Sorghum ranked first in Chipanga by contributing 28%.

Table 4.48: Percentage contribution of different commodities in household food supply (%) by villages.

Crop	Kondoa District		Dodoma Urban		Dodoma Rural	
	Mnenia	Bumbuta	Mbabala- A	Mbalawala	Mvumi - Makulu	Chipanga - A
Pearl Millet	50	40	30	25	20	28
Ground nuts	10	-	10	5	14	16
Bambara nuts	10	-	10	10	11.5	-
Sorghum	20	8	20	15	14	28
Cow pea	6.7	-	5	-	6	-
Maize	10	24	20	15	11.5	20
Finger millet	-	12	-	-	-	-
Beans	-	8	-	-	-	-
Pigeon pea	10	8	-	-	9	-
Rice	-	-	-	-	-	8
Cassava	3.3	-	-	15	11	-
Sweet potato	-	-	-	15	3	-
Total	100	100	100	100	100	100

Source: survey data (2000/01)

Contribution of sorghum and pearl millet in household food security is presented under Table 4.49. Owing to their drought resistance, the two crops are very useful during crop failure resulting from drought. In four of the six villages, pearl millet ranked first in this aspect. These are Mnenia (44%), Mvumi-Makulu (43%), Chipanga-A (40%), Mbabala-A (35%) and Mbalawala (55%).

Table 4.49: Percentage contribution of various commodities in household food security during famine periods by village.

	Kondoa District		Dodoma Rural		Dodoma Urban	
Commodity	Mnenia	Bumbuta	Mvumi-Makulu	Chipanga – A	Mbabala – A	Mbalawala
Sorghum	10	12	11	40	25	10
Pearl millet	44	24	43	40	35	55
Maize	7	12	6	20	20	25
Cassava	10	12	40	-	20	10
Finger millet	23	28	-	-	-	-
Cow pea	3	-	-	-	-	-
Pigeon Pea	3	-	-	-	-	-
Total	100	100	100	100	100	100

Source: Survey data (2000/01)

In terms of financial income, the two crops have got very little contribution. This is due to the fact that the two crops have no well-established commercial market in Tanzania. Internal market is very small, not even the strategic grain reserve (SGR) is willing to buy and stock the two crops. Table 4.50 shows the contribution of various commodities in household income. The results presented here are perceptions of farmers and were obtained by scoring method. Sorghum and pearl millets did not come up as a source of income in two and three villages respectively. In Mnenia, simsim, pigeon pea, and finger millets were among the first three with contribution of about 10% each. In Bumbuta village, simsim and pigeon pea were among the first two with contribution of about 32% each, followed by finger millet with contribution of about12%. In Mbabala-A, tomato contributed most (30%)to household income, followed by grapes 15%. In Mvumi-Makulu and Mbalawala, groundnuts contributes most in household income by 30% and 20% respectively while in Chipanga-A, livestock was the first source of income contributing about 20%.

Table 4.50: Percentage contribution of different commodities in household income in Dodoma region

	Kondoa District		Dodoma Urban		Dodoma Rural	
Crops	Mnenia	Bumbuta	Mbabala-A	Mbalawala	Mvumi Makulu	Chipanga-A
Sorghum	3.3	-	10	5	-	5
Pearl millet	-	-	10	20	-	12
Maize	3.33	-	-	5	-	-
Ground nuts	3.33	8	15	30	20	8
Bambara nuts	-	-	10	15	-	-
Cassava	3.33	-	-	10	-	-
Sweet potato	-	-	-	15	6	-
Onions	13.33	-	-	-	-	-
Finger millet	10	12	-	-	-	-
Pigeon pea	10	32	-	-	-	-
Simsim	10	32	-	-	11	4
Sugar canes	-	-	-	-	8	-
Cow pea	3.33	-	10	-	-	-
Sunflower	4.0	8	-	-	6	-
Dairy cattle	-	-	-	-	14	-
Local livestock	-	-	-	-	-	20
Fishing	-	-	-	-	-	4
Salt work	-	-	-	-	3	4
Hired labour	-	-	-	-	-	8
Local brew	-	-	-	-	3	12
Forest products	-	-	-	-	6	-
Hand craft	-	-	-	-	-	4
Rice	-	-	-	-	-	16
Green gram	-	8	-	-	-	-
Tomato	-	-	30	-	6	-
Grapes	-	-	15	-	17	-
Total	100	100	100	100	100	100

Source: Survey data (2000/01)

4.12 Output and Input Markets

4.12.1 Output market

Market as an institution has considerable influence on adoption of improved technologies. Input and output markets are key factors in production of agricultural products. For example, using interventions and Tegemeo variety promoted by SASAKAWA-G2000 during early 1980's, farmers in the study area had bumper harvests. According to key informants, lack of market was dis-incentive and hence farmers decided to produce at

subsistence level. Before trade liberisation, public sector through government parastatals and primary cooperatives had monopoly in output marketing, seed and other input supply. National Milling cooperation was the main marketing agency for sorghum and pearl millet. Following trade liberisation in Tanzania during mid 1980s, the public parastatals and primary cooperative unions have failed to withstand competition and hence the private sector dominates input supply and marketing of agricultural produce. However, unlike other grains such as maize, the market for sorghum is not well established. Figure 4.2 shows the current marketing chain for sorghum and pearl millet. The figure shows that there are two main output outlets. These are farmers, local traders and urban traders. Farmers sell the produce to their fellow farmers. These are the local consumers. They can also sell to village traders or urban traders who visit the rural areas during harvesting season. In most cases farmers are price takers since there are very few buyers.

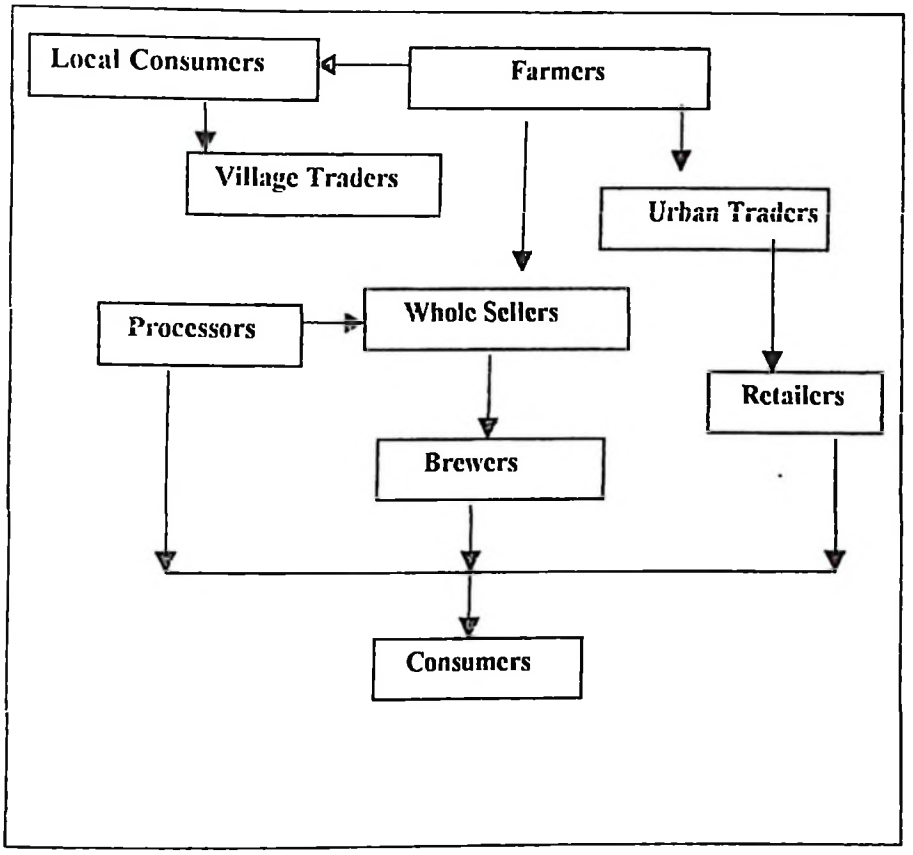

Figure 4.2: Sorghum and pearl millet marketing chain

4.12.1.1 Output stockists in Dodoma

During the study, output-stockists were identified. One stockist is based at Mvumi-Makulu dealing with sorghum, pearl millet, maize and groundnuts. The second is based in Dodoma town centre, dealing with cereals including sorghum and pearl millet. This dealer stocks the crops within the village godowns and re-sales the crops to farmers during food shortage. The stockist was also an agent for Chibuku, Power Foods and some pearl millet traders from Dar es Salaam and Zanzibar. The third one was a well-established company based in Dares salaam, stocking maize, grain legumes and oil seeds but not sorghum and pearl millet.

Others include owners of grain milling machines who plays the role of cereal stockists.

It is a very common practice to find small amount of stocks of maize and pearl millets.

4.12.1.2 Village traders

Village traders typically deal with small quantities (200 to 500 kg) and collect the harvest from household to the village market and open markets (mnadani). Some traders tend to purchase the produce and store the stock at milling machine to take advantage of milling facility. In most cases village traders were found to deal with pearl millet, which is less risky in terms of storability and is more marketable in the village than sorghum. Village traders can sell their stock to urban traders or directly to wholesalers who are occasionally involved in transporting the grains.

4.12.1.3 Urban traders

In the market places, traders were found to sell the two crops. Male traders dominate this business with stock ranging from 200-2000 kg of either sorghum, or pearl millet and in some cases both. Two improved varieties were found in the market. These were Pato and Okoa sorghum and pearl millet varieties respectively. Urban traders sell their stock to wholesaler who visit the market place for fast delivery of grains. Urban consumers get their needs from urban traders but the amount demanded is quite small. The most selling was finger millet sold by 23 traders and found in all town markets except Kongwa. About 18 traders sold pearl millet out of which 17 traders sold Uwele kienyeji. About 15 trader sold sorghum mainly Langalanga and Lugugu with seven and five traders respectively. There was only one trader for each Pato and Okoa varieties found in

Dodoma- Majengo market. Table 4.51 shows the distribution of urban traders and type of sorghum and pearl millet marketed.

Table 4.51: Number of urban traders and type of sorghum and millet sold in Dodoma Region December 2000.

	Dodoma Majengo market		Kondoa town market		Mpwapwa Town Market		Kongwa town Market		Total
	F	M	F	M	F	M	F	M	
Sorghum:									
Langalanga	0	3	0	2	0	2	0	0	7
Lugugu	0	5	0	0	0	0	0	0	5
Pato	0	1	0	0	0	0	0	0	1
Udo	0	0	0	2	0	0	0	0	2
Total	0	9	0	4	0	2	0	0	15
Pearl millet:									
Uwele Kienyeji	0	4	1	5	1	6	0	0	17
Okoa	0	1	0	0	0	0	0	0	1
Total	0	5	1	5	1	6	0	0	18
Finger millet:	1	9	1	5	0	7	0	0	23

Note: F = Female trader, M = Male trader
Source: Survey Data (2000/01)

4.12.1.4 Whole sellers

Since the sorghum and pearl millet business is not lucrative, rarely few sellers and commission agents are involved. In Dodoma town one trader was involved in wholesale of the two crops and was supplying Chibuku and one food processor in Dar es Salaam.

4.12.1.5 Destination of sorghum and pearl millet

The main destination for sorghum and pearl millets were Dar es Salaam, Arusha, Moshi and Zanzibar. Since only small volumes are transported, the traders use buses to ferry the grains. The common package for the two crops is polythene bags weighing 100 kg.

4.12.1.6 Competing products

Maize, rice and wheat are the major competing product for sorghum and pearl millet in rural areas. For instance some farmers in Kondoa showed their preference to wheat flour as compared to sorghum and pearl millet in preparing confectionery or pancakes (chapatti). Rice is substitute for the two crops especially in urban areas. In Chipanga-A, the rice was posing strong competition to sorghum because the farmers had some flooded irrigation facility for rice.

4.12.1.7 Categories of consumers

The commercial uses of sorghum and pearl millet in the study area is limited to local brew. In Kondoa district local brew industry is not very much developed due to Islamic culture. Utilization knowledge was needed in order to increase the utility of the two crops.

Preliminary survey results show that all households in rural areas consume sorghum and millet, but the two crops are less consumed in urban areas. However, Pearl millet is said to be suitable energy source for hyperglycaemia victims. The majority of the farmers consumes local brew from the two crops.

4.12.1.8 Sales of sorghum and pearl millets

About 23.8% and 20% of sample households indicated to have ever sold sorghum and Pearl millet respectively (Table 4.52). However, only 14% sold either of the two crops in the past one year (2000) implying serious market problems. According to the key informants in the study area, interventions by SASAKAWA G2000 led to huge marketable surpluses, but there was no market. So past experience confirms the problem is market

and not inadequate surplus. Once there is market, production will improve gradually. The sales figure appear high because it is only 23.8% and 19.9% of households that have ever sold sorghum and or pearl millet.

Table 4.52: Number of household who have ever sold sorghum and pearl millet

Sale status	Sorghum		Pearl millet	
	n	%	n	%
No	182	76.2	189	80.1
Yes	57	23.8	47	19.9
Total	239	100	236	100

Source: Survey data (2000/01)

4.12.1.9 Volume of grains sold and retained food reserved by sample households

Table 4.53 shows the amount of grain sold and that reserved from 1999 to 2000.The amounts of sales and reserved appear to increase for both crops, however in year 2000, the mean sales per household is still very low, 333 kg and 323 kg for sorghum and pearl millet respectively. More sales come from sorghum than from pearl millet whereas reserves are more on pearl millet than sorghum implying the typical household food security strategy in the study. The results show that in the two seasons, the marketable surplus is increasing.

Table 4.53: Volumes of sales and retention of sorghum and pearl millet 1999 to 2000 (Kg)

	Strategy	Amount (kg)	
		Sorghum	Pearl millet
Sales:	1999	308.88	270.286
	2000	333.381	323.273
Retained:	1999	468.93	468.44
	2000	475.154	547.882

Source: Survey data (2000/01)

4.12.1.10 Prices and pricing mechanism

The mean filed price for sorghum and pearl millet in 1999 and 2000 are presented under Table 4.54. Pearl millet sold at T sh. 126 in 1999 and T sh. 123 in 2000. Sorghum sold at T sh. 123 in 1999 and T sh108 in 2000. Field prices for pearl millet are higher than those for sorghum but they all exceed the price of maize, which sells for between 80 and 100 T sh. per kg. The price difference between the two crops and maize is caused by relief aid, which is offered free of charge or sold at highly subsidized prices. The price differential between the two crops and maize, cause market distortion and render sorghum and pearl millet uncompetitive. Basing on prices and taste, the rational consumers would obviously go for maize and not sorghum or pearl millet. The impact of food aid should there fore be re-examined because it has made the food market less predictable. It lowers returns to farmers hence discouraging the adoption of improved sorghum and pearl millets. World Bank (2001) suggests that in order to address the food market problem, food aid should be used sparingly.

Table 4.54: The mean field prices for sorghum and pearl millet in 1999 and 2000 in (T sh./Kg)

Year	Sorghum price	Pearl millet price
1999	110.532	126.0863
2000	108.353	123.0654

Source: Survey data (2000/01)

Figure 4.3 presents prices for various milling grains in Dodoma for period from 1997-2000. The price trend shows that during that period rice had the highest price followed by finger millet. The maize prices have continuously been lower than sorghum prices and more consistent except on early 1999. This is probably due market distortion purposively encouraged by government. Importers are dumping the maize from abroad and by so doing; the sorghum cannot compete with maize. Currently, maize importers are enjoying a grace period on import tax. Since the prices of maize are lower than those of sorghum automatically the consumer goes for maize. The prices of sorghum reflect the real domestic cost of production. In order to promote production of sorghum, there is a need to manipulate the prices of sorghum and pearl millet from supply side by commercialising the two crops to the extent that maize prices are higher than sorghum and pearl millet.

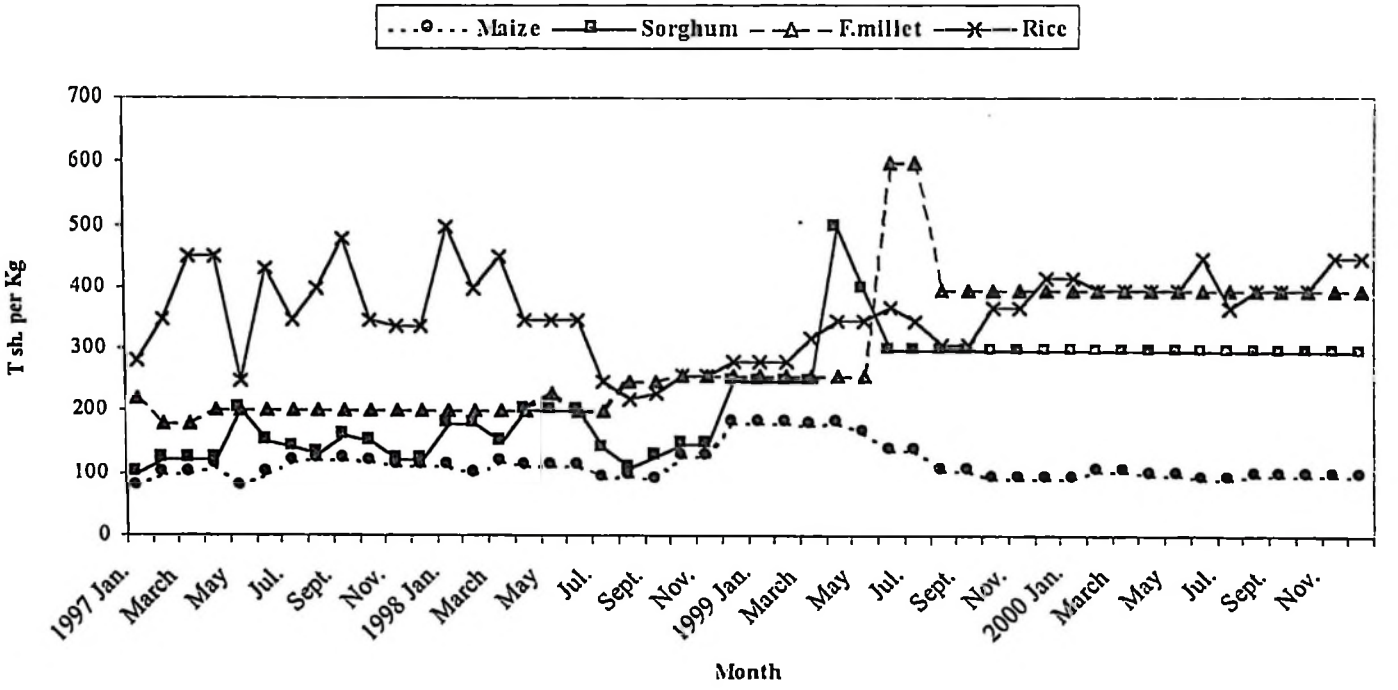

Figure 4.3: Consumer prices for various grains in Dodoma central market 1997-2000

4.12.1.11 Market problems

Low marketability opportunities and high input prices are the major bottlenecks in production of sorghum and pearl millet. According to farmers, the market problem is more serious for sorghum than for pearl millet because the later has more utility in the household. Farmer to farmers market channel is used for pearl millet but not for sorghum. The only time when there are market opportunities is during famine periods. Table 4. 58 Shows farmers perception with respect to market problems.

Table 4.55: Farmers perception on accessibility to market

Perception	Sorghum		Pearl millet	
	n	%	n	%
Minor problem	15	6.3	19	8.1
Normal problem	23	9.6	39	16.7
Major problem except during famine periods	178	74.5	150	64.1
No opinion	23	9.6	26	11.1
Total	239	100	234	100

Source: Survey data (2000/01)

Market constraints reported by stockists

The stockist suffers from low capital outlay and lack of credit facility to finance their business. There is lack of market for sorghum and pearl millet. There are high taxes imposed on crop through village levies and city tax. The government's efforts in seeking for external markets for sorghum and pearl millets are lacking. There is unnecessary bureaucracy of Strategic Grain Reserve (SGR) and other buyers of grains for relief food during famines.

4.12.2 Input markets

Sorghum and pearl millet input demand by farmers is low. This is because farmers have got no culture of buying inputs for these crops. Most people cannot afford to buy external inputs; hence they resort to local technology and seed recycling. The use of purchased seeds and fertilizer is very limited. Packing materials are probably the main inputs purchased by the farmers. Most of farmers use local seeds. Since most of stockists are located at district headquarters, it is therefore difficult for farmers living in remote areas to access the agricultural inputs even if they are willing to purchase. In most cases the seeds are delivered very late to capture the unreliable rains. The existing stockists are hesitant to stock sorghum and pearl millet seeds because buyers are not readily available.

4.13. Factors Affecting the Adoption of Improved Sorghum Varieties

Adoption of improved sorghum and pearl millet varieties was analysed using logit analysis model. The model predicts the probability of these factors in influencing farmers' varietal adoption. An improved variety in this model refers to Pato, a sorghum variety and Okoa a pearl millet variety.

4.13.1 Logistic model estimates

Maximum Likelihood Estimation (MLE) method was used in estimating the adoption parameters. Table 4.56 and Table 4.57 indicate that, about 84% and 61% of the total variations in sorghum and pearl millet farming households, are explained by respective

logistic models. These results are reasonable for cross-sectional data. In sorghum model, figure for correctly predicted adopters and non-adopters were 88% and 93% respectively. In pearl millet model, the figure for correctly predicted adopters and non-adopters were 54% and 99% respectively. Both sorghum and pearl millet models, Chi-square indicates that the parameters included in the model are significantly different from zero at the 1% level. The variables farming experience, literacy and vicinity to nearby agricultural research station were removed from the model to take care of multicollinearity. Farming experience showed multicollinearity with the age of household head. Literacy showed multicollinearity with number of years in formal school. Vicinity to research institution showed multicollinearity with the exposure to research intervention.

Table 4.56: Parameter estimates of logistic models for factors influencing the adoption of improved sorghum in Dodoma region

Explanatory Variable	Description of the variable	Parameter estimate for sorghum (Pato)	
		β coefficient	Wald statistics
Intercept		- 8.5027	5.8927**
TLU	Number of Tropical Livestock Units owned	0.549	4.1731**
AGE1	Age of the head of household (years)	- 0.1076	8.9183***
HHDSIZE	Number of people in the household	0.3026	5.5222**
FARSIZE	Total farm size (acres)	0.0032	0.0040 NS
PROXIM2	Distance to the near by town centre (Km)	0.1098	4.3578**
FEDUYRS	Number of years in formal school	- 0.4519	8.8790***
FTRAIN	If farmers attended agricultural training	0.7094	0.7495 NS
SEEDS2	If farmer's source of seed is CBOs	1.8484	3.7458*
NFINCOME	If farmer has non farm source of income	1.6942	2.7858***
EXPOSURE	If farmer's location is extensive or less researched	6.5731	14.2361***
EXTFR	Number of visits by extension staff in 1999/2000	-0.0227	0.0098 NS
DISTRICT3	If farmer is based in Dodoma rural district	-3.2791	4.9606**
TENURE3	If farmer inherited the land	0.5708	4.7909*
TENURE5	If farmer received land from village government	2.0582	3.8266**
OXPLOUGH	If farmer's method of land preparation method was ox plough	4.0556	5.1480**
HHOE	If farmer's method of land preparation is hand hoe	3.0127	4.9825**
PTMKT	Farmer's perception on marketability of Pato (score)	9.1430	0.610 NS
R^2	Coefficient of determination	83.7%	
Model Chi-square		162.181***	
Sample size		240	

Note: *** Indicates significance at 1%level, ** Significance at 5%level, * Significance at 10% level.

Source: Survey data (2000/01)

4.13.2 Sorghum model parameter estimates

Parameter estimates for improved sorghum model are presented under Table 4.55. Of the socio-economic factors, the physical assets variables that were significant include Tropical Livestock Unit, availability of off-farm sources of income, use of ox plough and hand hoe in land preparation. Significant human capital variable was number of years in formal school while the only significant social capital variable was community-based source of sorghum seed. Among the farmer's characteristic factors only age of the head of household and household size were significant. As expected, the age of household head negatively influenced the farmers' decision to adopt Pato because risk aversion increase with age. Household size has positive and significant impact on adoption of Pato because large households have possibility of more labour to till the land, sowing and weeding in time, and scarring the birds. Un expectedly, the numbers of years in formal school, influenced the decision to adopt Pato negatively. But Survey results on Table 4.1 on education characteristics showed that larger proportion of adopters was literate compared to non-adopters. The explanation for negative influence is that as one goes higher on academic ladder the possibilities of getting a more lucrative livelihood opportunity than sorghum farming increases, but the sample mean was very low (4 years). This implied most of adopter had primary school level of education and they rarely went beyond standard four.

Institutional variables that were significant include exposure to research intervention inherited land, and land given by village government. Unexpectedly frequency of extension visits was insignificant and influenced the decision to adopt Pato negatively.

In case of extension contacts, the data shows extension had no impact on adoption because the extension workers did not visit farmers frequently. It was also observed that frequency of contact alone is not enough unless accompanied by appropriate extension messages. Only about 8% of sample farmers had received extension advice on improved varieties.

Except variable for Dodoma rural district and proximity to urban centre all other geographical and environmental variables included in the model were insignificant. Despite the fact that Dodoma Rural has been researched extensively other districts are better placed to influence decisions in favour of Pato. These results suggest that farmers in Dodoma Rural are less in favour of sorghum because it is an inferior crop and farmers have substitutes e.g. rice and maize. The result from informal survey revealed that in Dodoma rural there are off-farm income generating activities e.g. salt works, local brew, handcrafts, forest products and fishing (Table 4.50). Lack of market for sorghum is an obvious reason rendering sorghum to be of less importance. The results suggest that at district level, there are insufficient efforts put on sorghum development by different local authorities.

Farm size influenced adoption positively but non-significantly because all categories of farmers adopt Pato; secondly the mean farm size of 2.63 hectares per household was so small. Lack of significance because farmers with small farms tend to practice intensive farming. Attendance to farmers training was positive but insignificant. Marketability had positive though insignificant impact on adoption of sorghum

because the rational farmers produces not for domestic use only, but surplus for market. The informal survey results showed that sorghum and pearl millets are largely food crops but the model results imply that there is perceived potential for Pato marketing.

Wealth ranking results showed that livestock is an important wealth indicator in Dodoma hence TLU has significant positive influencing on adoption of Pato. Distance to urban centre had positive and significant impact on adoption indicating that in remote areas there are no lucrative business ventures as compared to peri-urban centres. Both rented land and offer from village government had positive and significant effect on adoption. The results from sorghum model shows that farmer's characteristics, Socio-economic (physical, human and social capital) and demographic factors, institutional factors, geographical and environmental factors, and farmer's perception on technology characteristics have significant influence on adoption of improved sorghum varieties.

4.13.3 Pearl millet model parameter estimates

Parameter estimates for pearl millet model are presented under Table 4.57.

Among explanatory variables that lacked significant influence on adoption of Okoa were age of household head, distance to the nearby urban centre, number of years in formal school, farmers' attendance to agricultural training, availability of off-farm source of income, frequency of extension visits, location by Dodoma Urban District,

gender of the household head, Land tenure by clearing the natural forests, and transformed non-livestock wealth value. Unexpectedly, number of years in formal school, availability of non-farm income, and transformed value of non-livestock wealth had negative influence on decision to adopt Okoa. However, community based seed source of pearl millet, distance to nearest urban centre, farm size, and household size were key explanation factors for adoption of Okoa a pearl millet variety in Dodoma region.

These results suggest that community based seed system has positive and very significant impact on adoption of pearl millet which is acceptable because the formal seed system is inactive with respect to pearl millet seed supply. Household size had significant but negative impact on adoption of pearl millet. The farm size had positive and significant impact on adoption of Okoa. Distance to urban centre had significant but negative impact probably because farmers close to town have wider alternative livelihood opportunities such as labour selling, petty trade, and more attractive commodities mainly vegetables.

In summary, the pearl millet model results show that farmer's characteristics, socio-economic factors (physical and social capital) have significant influence on adoption of improve varieties.

Table 4.57: Parameter estimates of logistic models for factors influencing the adoption of improved pearl millet in Dodoma region

Explanatory Variable	Explanation of the variable	Parameter estimate for pearl millets (Okoa)	
		β coefficient	Wald statistics
Intercept		3.9212	1.1008 NS
AGE1	Age of the head of the household	-0.0032	0.0161 NS
HHDSIZE	Number of people in the household	-0.4730	5.3635**
FARSIZE	Total land owned (acres)	0.923	4.5374**
PROXIM2	Distance to from farm to nearest urban centre (Km)	-0.1324	8.4259***
FEDUYRS	Number of years in formal school	-0.0120	0.0103 NS
FTRAIN	If farmer has attended agricultural training	07485	0.9275 NS
SEEDP2	If farmer's source of seed was (CBOs in 1999/2000)	8.7645	24.0064***
NFINCOME	If farmer has non-farm source of income	-0.7222	0.9871 NS
EXTFR	Number of visits by extension worker	0.2975	1.4719 NS
DISTRIT2	If the farmer is based in Dodoma Urban district	0.0609	0.0050 NS
GENDER	Sex of the head of household	1.5531	2.1710 NS
TENURE4	If farmer cleared natural forest to get land	0.2674	1.0823 NS
LNHHWEAL	Transformed non-livestock wealth for selected items (T sh)	-0.1998	0.517 NS
R^2	Coefficient of determination	61.2%	
Model Chi-square		82.923***	
Sample size		240	

Note: *** Indicates significance at 1%level, ** Significance at 5%level, * Significance at 10% level.

Source: Survey data (2000/01)

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study was aimed at determining the rate, extent and factors influencing the adoption of improved technologies for production of sorghum and pearl millet in Dodoma region. The findings of this study show that farmers adopt technologies that meet their expectation in production. Farmers' expectations include varieties with short time to maturity, good taste, high yields and white grains. The evidence from this study shows that while some improved varieties e.g. Pato and Okoa are adopted some are abandoned e.g. Serena and Lulu. For these reasons, annual rates of adoption for improved sorghum variety Pato and pearl millet Okoa are 0.56 and 0.46 respectively. These figures are generally low but they are higher than that of improved maize (0.28) in central Tanzania reported by (Kaliba, 1998).

The possible factors attributing to these low rates are unavailability of market for Sorghum and pearl millet, failure of formal seed system to meet farmers' demand and lack of knowledge on product utilization techniques that would help farmers to maximize utilities of sorghum and pearl millet. In view of these results, the hypothesis that the rates of adoption for improved varieties are reasonably high is rejected.

The adoption of management practices of sorghum and millets is largely influenced by climate. For this reason, farmers have adopted recommended planting time and weeding regime. Although intercropping is practiced, it does not involve the

recommended crop combinations. Farmyard manure is used by about (58 %) of sample households, but when used is at low rates. Inorganic fertilizer is a rare phenomenon in sorghum and pearl millet based farming system.

Intensity of adoption is determined by area under different varieties. Results shows that more land is being allocated to improved sorghum than to local sorghum. In 1999/2000 season the intensity of Pato was 0.21 hectares per household compared to local sorghum (0.13) hectares per household. Okoa, the only improved pearl millet variety that is currently found in the study area had 0.71 hectares compared to 0.91 hectares per household for local pearl millet. The possible reason for difference between Pato and Okoa is time difference. Pato was released on 1995 while Okoa was released in 1999. The high rate of intensity for Pato compared to local varieties is attributed by the utility that the famers gain from consumption of the variety in terms of taste, colour, suitability for local brew and local recipies. Okoa has lower intensity than local varieties mainly because farmers gain higher utility by consuming local varieties. Based on the results, we fail to reject the hypothesis that the rational farmers will always invest more land to those varieties that will maximize utility.

The results of the study identified number of years in formal school, number of livestock units, market opportunities, family size, location relatively to urban centres, exposure to research intervention and seed source as the main factors influencing the adoption of improved sorghum.

Family size, seed source and location relative to nearby town centre influenced adoption of improved pearl millet. These results strongly support the hypothesis that the adopters of new technical innovations are characterized by specific socio-economic, environmental, institutional and demographic characteristics of farmers' circumstances and the prevailing micro and macroeconomic environment.

The farmers in Dodoma region are highly vulnerable in terms of livelihood security. Dodoma being a semiarid with unfavourable weather conditions, adoption of improved technologies in production of sorghum and pearl millet is one of the strategies to absorb the shock. This is because sorghum and pearl millet are relatively drought tolerant crops. However, the study shows that adoption of improved sorghum and pearl millet need to be complemented with micro-processing industries to improve the farmers' livelihoods significantly.

5.2 Recommendations and Policy Implications

Based on the empirical findings from this study the following is a set of recommendations for stakeholders of agricultural sector:

5.2.1 Research

Research plays a major role in genetic diversity. Therefore, there is a need to improve the variety development process particularly for pearl millet. Currently there are only

two improved varieties. Farmers need a large basket of varieties from which selection can be made as a way to diversify solutions to their needs. Breeding work should target the end users, such as commercial varieties for brewers, pop sorghum for confectionery, fodder varieties for livestock keepers, and varieties for food industry. Research should maintain the local varieties as they have desirable traits lacking in improved varieties. Entomologists and weed scientists should extend the research work to remote and less researched areas e.g. the lower Kondoa plains. Sorghum and millet improvement program in collaboration with agricultural engineers should work hard to come up with appropriate post harvest processing technology for small-scale rural farmers that may add value to sorghum and pearl millet products. Results from this study show that farmers have very few options to utilize sorghum and pearl millet. Therefore food technologists should embark on sorghum and pearl millet post-harvest processing and utilization program to promote their consumption. Research should develop user-friendly teaching materials e.g. fliers and leaflets as a way to disseminate information about research outputs. Research should perform proper targeting of their with respect to socio-economic and demographic differences e.g. wealth groups, literacy level and location. In order to achieve the above, the government should invest on human capital (skills and education), by recruiting more scientists to run the NMSIP.

5.2.2 Agricultural support services

The findings from this study show that farmer-extension contacts are not enough and that farmer lack information on new varieties. More effort is required to reach more farmers particularly in remote areas, with appropriate information on improved sorghum and pearl millet technologies. The extension service should strengthen the advisory role to farmers with relevant demand driven messages. Research centres should target linkages with existing farmers' training centres that are focal points for farmers' training. User-friendly training materials e.g. fliers, leaflets and booklets should be availed to farmers. Extension service should encourage farmer-to-farmers interactions by providing fora e.g. organizing exchange visits. Extension should also encourage use of non-traditional extension methods e.g. drama and songs to promote promote production of improved sorghum and pearl millet beyond subsistence level.

5.2.3 Seed industry

The Ministry of Agriculture and Food Security (MAFS) should encourage private sector to participate in sorghum and pearl millet seed supply and informal seed sector should be facilitated to complement these efforts. Community based seed system is viable and potential source of improved seed. Government and other stakeholders should therefore support this system. New approaches should be sought to promote the adoption of improved seeds, for instance, "seed fairs" may form a fast way to disseminate the improved varieties through seed exchange. TOSCA should ensure that informal seed system does not affect the management of genetic resources.

Above all, there is need to put into place a policy on small grains and review seed distribution policy.

5.2.4 Sorghum and millet commercialization

The National Sorghum and Millet Improvement Programme, in Eastern and Central zonal research centres should involve private sector and processors in research on the two crops in brewing, food and animal feed industries.

5.2.5 Strategic Grain Reserve (SGR)

In semiarid areas, sorghum and pearl millet are food security crops. The reserve should consider stocking the two crops along with maize in order to improve the intensities, and rates of adoption for improved sorghum and pearl millets. Once the reserve becomes an outlet for sorghum and pearl millet, it will heighten the farmers' perception on marketability for the two crops.

5.2.6 Market Development Bureau (MDB)

Market development bureau of Ministry of Cooperatives an Marketing should look for external markets to encourage export of sorghum and pearl millet. Marketing promotions are required to encourage local consumption of sorghum and pearl millet products.

5.2.7 Areas of further research

(i) Farmers' perception on attributes of a given technology is key element to uptake and adoption. Research on modelling farmers' perception will be useful.

(ii) There is a need to study the performance of Community Based Organisations involved in seed system (CBOs) since they are potential and viable approach but new in Tanzanian context. The study should focus on capacity of CBOs in management of genetic resources.

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APPENDICES

Appendix 3.1: Questionnaire for formal survey

QUESTIONNAIRE FOR: FACTORS INFLUENCING THE ADOPTION OF IMPROVED TECHNOLOGY FOR PRODUCTION OF SORGHUM AND PEARL MILLET IN DODOMA REGION IN CENTRAL TANZANIA

A: BASIC INFORMATION:

QUESTIONNAIRE NUMBER. ..... ENUMERATOR'S NAME.....

DATE OF INTERVIEW ..... TIME OF INTERVIEW. .....

1. VILLAGE ..... 2. WARD .....

3. DIVISION ..... 4. DISTRICT .....

5. WEALTH GROUP UNDER WHICH THE HOUSE HOLD FALL (.....)
I = BETTER OFF, II = AVERAGE RICH, III = POOR, IV = VERY POOR
(To be obtained from the wealth ranked list of the head of households in the village)

6. Distance from the residence to the nearest urban centre (km) .....

7. The status of the road network in the informant's village to urban centre? ....
1 = Very poor roads (passable in dry seasons with difficulties), 2 = Poor roads(passable during dry seasons only), 3 = All weather roads.

8. Name of the farmer (head of household) .....

9. If married male, what is the number of spouses (wives): .....

10. Ethnic group/tribe (.....)
1 = Mgogo, 2 = Mrangi, 3 = Msandawi, 4 = Mkaguru, 5 = Mhehe 6, = Mbarbaig, 7 = Mmasai, 8 = Mfyomi, 9 = Mmbulu, 10 = Mtonga, 11= Others(specify).....

11. Religion: (.....) 1= Christian, 2 = Moslem, 3 = Traditional, 4 = Others (specify .....)

12. Leadership position in the society: (.....)
1. Political leader (specify) .....
2. Traditional leader (specify).....
3. Religious leader (specify).....
4. Employee (specify).....
5. Others (specify).....

B: HOUSEHOLD CHARACTERISTICS

13. How long have you lived in this village? .....(years)

14. When did you start farming as an independent household? (Farming experience) .....(year)

15. Have you participated in Labour sharing groups? (.....) 1 = Yes, 2 = No

16. Have you ever attended any Agricultural Training? (.....) 1 = Yes, 2 = No

17. Have you participated in on-farm research trials? (.....) 1= Yes, 2 = No

18. If yes which group (Programme) .....

19. Have you participated in seed multiplication activities? (.....) 1 = Yes. 2 = No

20. Have you attended farmer's field days organised by research, NGOs or Extension? (.....)
1 = Yes. 2 = No

21. What is the number of people currently living within your household? (.....)

22. For each member please indicate the following characteristics:

	Characteristics	Household member characteristic								
		e.g.	1	2	3	4	5	6	7	8
I	Status in the household	3								
II	Age (years)	45								
III	Sex: 1= Male 2 = Female	2								
IV	Work on household farm	2								
V	Literacy level	3								
VI	Education level	1								
VII	Main occupation	3								
VIII	Marital status	2								

Characteristics key:

I. Status in the household: 1 = Head of household, 2 = First Wife of household head, 3 = Second wife of household head, 4 = Daughter of household head, 5 = Son of household head, 6 = Relative, 7 = Employee.

IV. Work on household farm: 1 = Full time, 2 = Part time, 3 = Don't work on farm.

V. Literacy: 1 = Can read and write, 2 = Cannot read and write well, 3 = Schooling.

VI. Education level: 1= Primary School, 2 = Secondary School, 3 = College, 4 = University, 5 = Adult Education, 6 = Pre-School child & Nursery school.7 =None

VII. Main occupation: 1 = Farming, 2 = Charcoal making, 3 = Petty trade, 4 = Schooling, 5 = Hired labour, 6= Masonry, 7 = Carpentry, 8= others (specify) .....

VIII. Marital status: 1= Single, 2 = Married, 3 = Widow, 4 = Divorced, 5 = Separated.

23 . What is the total number of years in formal education (circle).(Total .....)

Years in Primary school 1 2 3 4 5 6 7 8
Years in Secondary school 1 2 3 4 5 6
Years in the college 1 2 3 4 5
Years in University 1 2 3 4 5 6 7 8 9

24. Please provide the following information with respect to livestock ownership

Type	Number
Cows	.....
Bulls	.....
Goats	.....
Sheep	.....
Pigs	.....
Chicken	.....
Donkey	.....
Others (specify)	.....
None	--------- (Tick)

25. Please indicate type, number and value of assets owned

Asset	Number	Current value (T sh.)
Radio		
Knapsack sprayer		
Sewing machine		
Bicycle		
Vehicle		
Milling machine		
Ox-plough		
Shop/kiosk		
Machete {Hango, panga}		
Hand hoe		
Pairs of oxen		
Ox-cart		

26. Do you hire labour for your farm operations? (.....) 1 = Yes, 2 = No....

27. If yes for which crop operation (s)?

Crop	Operation (s)
.....	.....
.....	.....

28. Apart from farming, What are your other sources of income? Please rank them in the order of their importance:

Activity	Rank (Prioritise them)
Dairy cattle keeping	
Charcoal selling	
Fishing	
Needle work (kufuma)	
Fine art (Drawing)	
Photographing	
Masonry	
Carpentry	
Pottery	
Weaving (Kusuka)	
Salaried employment	
Casual labour	
Business (specify)	
Remittance from members of family	
Others (specify)	

C: FARM SIZE AND LAND ALLOCATION PATTERNS

29. How many plots of land (fields) do you own .....

30. Please provide the following information with respect to your farm last season (1999/2000)

Plot no.	Location	Area (acres)	Method of acquisition	Topography	Current use	Variety of sorghum or pearl millet	Cropping pattern	
							Mono (Tick)	Inter crop (crop)
1								
2								
3								
4								
5								
6								

Key to farm allocation patterns:

Location: 1 = Around home stead. 2 = Away from residence area(name the place.....)

Method of acquisition: 1= Purchased . 2 = Land lease (Hati miliki). 3= Inherited. 4 = Cleared natural forest 5 = Given by village government. 6 = Rented in 7= Other (specify) .....

Current use: 1 = Sorghum. 2 = Maize. 3 = Rice. 4 = Pearl millet. 5 = Grazing. 6 = Rented out. 7 = Fallow. 8. Others (specify) .....

Topography(ecological niche): 1= River bank(korongoni) 2 = Flat plateau. 3 = High slope. 4 = Medium slope. 5 = Valley bottom. 6 = Temporary swamps. 7 = Irrigated area.
Varieties: 1=Pato, 2 =Tegemeo, 3=Macia. 4 = Lulu. 5 =Serena. 6 =Serere 17. 7 = Okoa. 8 = Shibe

31. What is the relative importance of **crops grown for food** this season?(2000/2001) Please rank your **crops'** enterprises according to order of their importance:
I) ....ii) ..... iii) .....
iv) ..... v) ..... vi) .....

32. What is the relative importance of **crops grown for cash income** this season? Please rank your **crops'** enterprises according to order of their importance:
I) .... ii)..... ..... iii) .....
iv) ..... v) ..... vi) .....

D: PRODUCTION OF SORGHUM

33. Are you aware of improved sorghum varieties? (.....) 1 = Yes. No =2

34. Which variety of **sorghum** (Mtama) that you are currently growing? .....
..... , ..., ...

35. Have you ever grown any improved sorghum variety? (.....) 1 = Yes. 2 = No.

36. If yes please **name** them and indicate the source and year you started cultivating each of them

VARIETY	YEAR started cultivating	SOURCE of seed	CURRENT USE 1 = Still used 2 = Discontinued	YEAR Discontinued	REASONS for discontinue'discontinue
Pato					
Tegemeo					
Macia					
Lulu					
Serena					
Serere 17					
Dobbs					
SRN 29					
P 9405					
P 9406					
SAR39					

37. If you have grown any of improved variety above this season 2000/2001,
Where did you get the SEED ? (.....)
1. = Other farmers. 2. = Extension worker. 3. = Researchers.
4. = Market. 5. = DCT. 6. = TFA.
7. = TANSEED. 7. = Through Hunger relief food and seed aid.
8. = Farmers' seed multiplication group. 9. = Own seed from last season harvest.
10. = Parents. 11 = Stockist. 12 = Others sources specify .....

38. Name **any** of the sorghum variety you prefer most and give reasons for your preference.
Sorghum type Reasons
1..... i ..... ii .....
iii .....

39. Regarding the sorghum variety use and seasons. please provide the following information

	95/96	96/97	97/98	98/99	99/2000
Area under Local variety (Acres) named.....					
Area Under **Pato** (Acres)					
Area Under **Tegemeo** (Acres)					
Area Under **Macia** (Acres)					
Area Under **Lulu** (Acres)					
Area Under **Serena** (Acres)					
Area Under **Serere 17** (Acres)					
Yield for Local sorghum (bags) named.....					
Yields for **Pato** (bags)					
Yields for **Tegemeo** (bags)					
Yields for **Macia** (bags)					
Yields for **Lulu** (bags)					
Yields for **Serena** (bags)					
Yields for **Serere 17** (bags)					

40. What is your future plans concerning the total area under **Pato?** (.....)
1 = Increase 2 = Reduce 3 = No change. 4 = About to start
Please give reasons: ..... , ...

41. Do you have any plans for **other improved Sorghum** varieties? (.....)
1 = Increase 2 = Reduce 3 = No change. 4 = About to start
Please give reasons: ....

42. What is your future plans concerning the total area under **local sorghum?** named..... (.....)
1 = Increase 2 = Reduce 3 = No change.
Please give reasons: ..... , ...

43. What was your means of land preparation in sorghum fields last season?
1= Tractor, 2 = Hand hoe, 3 = Ox-plough

44. When did you plant sorghum last season? (Date ...../ Month.....).

45. What was the method of sorghum planting?(....) 1= Dibbling,
2 = Broadcasting 3 = Others (specify) .....

46. If Dibbling , What was sorghum-planting procedure? (....) 1 = Row planting 2 = Random

47. If row planting, the spacing between the rows was (cm)..... and between plants was cm .....

48. If planting was by dibbling, how many seeds per hill? .....

49. What crops are inter cropped with sorghum ? ....
.....

50. Do you currently practice crop rotation in sorghum fields? (.....)
1 = Yes 2 = No

51. If yes, indicate the sequence being used. (..... ....)

52. Which soils do you prefer for sorghum? (.....)
1 = Kichanga (sandy), 2 = Tifutifu, 3 = Mbuga, 4 = Mfinyanzi (Clay).
5 = Others (specify) .....

E: PRODUCTION OF PEARL MILLET

53. Are you aware of improved pearl millet varieties? (.....) 1 = Yes, 2 = No.

54. Which variety of **pearl millet (Uwele) that you are currently growing?** .....

55. Are there any improved pearl millet that you have ever grown? (.....) 1 = Yes 2 = No

56. If yes, please **name** the improved variety and indicate the source and year you started cultivating each of them

VARIETY	YEAR started cultivating	SOURCE Of seed	CURRENT USE 1 = Still used 2 = Discontinued	YEAR Discontinued	REASONS for discontinue
Okoa					
Shibe					
Other					

57. If you have grown any of improved variety above **this season 2000/2001.**
Where did you get the SEED ? (.....)

1. = Other farmers 2.= Extension worker 3. = Researchers
4. = Market 5.= DCT 6. = TFA
7. = TANSEED 7. = Through Hunger relief food and seed aid
8. = Farmers' seed multiplication group 9. = Own seed from last season harvest
10. = Parents, 11 = Others sources specify .....

58. Concerning the use of **pearl millet varieties,** please provide the following information

Year	95/96	96/97	97/98	98/99	99/2000
Area under Local varieties(Acres)					
Area under Okoa (Acres)					
Area under Shibe(Acres)					
Total yield for Local pearl millet (bags)					
Yield for Okoa (bags)					
Yield for Shibe(bags)					

59. What are your future plans concerning the total area under **OKOA?** (.....)
1 = Increase 2 = Reduce 3 = No change. 4 =About to start

60. Do you have any plans for other **improved pearl millets?** (.....)
1 = Increase 2 = Reduce 3 = No change, . 4 =About to start

61. Please give reasons for above answer: ....
..... .
.....

62. What is your future plans concerning the total area under **local pearl millet?** (.....)
1 = Increase 2 = Reduce 3 = No change.

63. Please give reasons for above answer: ....
....

64. Name any **pearl millet varieties** you prefer most and give reasons for your preference.
Pearl millet Variety **Reasons**
..... i ..... . ii ..... . iii .....

65. What was your means of land preparation for pearl millet last season? (.....)
1= Tractor 2 = Hand hoe 3 = ox-plough

66. When did you plant pearl millet last season? (Date ...../ Month.....).

67. What was the method of pearl millet planting? (.....)
1= Dibbling 2 = Broadcasting 3 = Others (specify) .....

68. If Dibbling , What was pearl millet planting procedure? (.....)
1 = Row planting 2 = Random

69. If row planting, the spacing between the rows was (cm).....and between plants was cm .....

70. If planting was by dibbling, how many pearl millet seeds per hill? .....

71. What crops are inter cropped with pearl millets? ...., ...

72. Do you currently practice crop rotation in your pearl millet fields? (.....)
1 = Yes 2 = No

73. If yes, indicate the sequence being used. (....., ... , ...)

74. Which soils do you prefer for pearl millet? (.....)
1= Kichanga (sandy), 2 = Tifutifu 3= Mbuga 4 = Mfinyanzi (Clay)
5. Others (specify).....

F: FARMERS' SUBJECTIVE PERCEPTION ON TECHNOLOGY CHARACTERISTICS

75. If you have ever grown **PATO**, please score the following characteristics or attributes of **(PATO)** as you perceive it basing on the farmers' criteria provided below:

Technology attribute	Perception (scores 0-10) circle your score											Total
Marketability	0	1	2	3	4	5	6	7	8	9	10	
Grain Yield	0	1	2	3	4	5	6	7	8	9	10	
Drought tolerance	0	1	2	3	4	5	6	7	8	9	10	
Time to maturity	0	1	2	3	4	5	6	7	8	9	10	
Grain taste	0	1	2	3	4	5	6	7	8	9	10	
Head size	0	1	2	3	4	5	6	7	8	9	10	
Grains size	0	1	2	3	4	5	6	7	8	9	10	
Grinding ease	0	1	2	3	4	5	6	7	8	9	10	
Grain storability	0	1	2	3	4	5	6	7	8	9	10	
Digestion time	0	1	2	3	4	5	6	7	8	9	10	
Amount of bran	0	1	2	3	4	5	6	7	8	9	10	
Total score												

76. If you have ever grown OKOA millet, please score the following characteristics or attributes of **(OKOA)** as you perceive it basing on the farmers' criteria provided below.

Technology attribute	Perception (scores 0-10) circle your score											Total
Marketability	0	1	2	3	4	5	6	7	8	9	10	
Grain Yield	0	1	2	3	4	5	6	7	8	9	10	
Drought tolerance	0	1	2	3	4	5	6	7	8	9	10	
Time to maturity	0	1	2	3	4	5	6	7	8	9	10	
Grain taste	0	1	2	3	4	5	6	7	8	9	10	
Head size	0	1	2	3	4	5	6	7	8	9	10	
Grains size	0	1	2	3	4	5	6	7	8	9	10	
Grinding ease	0	1	2	3	4	5	6	7	8	9	10	
Grain storability	0	1	2	3	4	5	6	7	8	9	10	
Digestion time	0	1	2	3	4	5	6	7	8	9	10	
Amount of bran	0	1	2	3	4	5	6	7	8	9	10	
Brew quality	0	1	2	3	4	5	6	7	8	9	10	
Porridge quality	0	1	2	3	4	5	6	7	8	9	10	
Total score												

G: CROP MANAGEMENT PRACTICES:

77. Did you use farmyard manure last season? (.....) 1= Yes, 2 = No

78. If farmyard manure was used, to which crops? ....

79. What amount of farmyard manure was applied per acre .....

80. Have you ever used inorganic fertilizer in sorghum production? (.....) 1= Yes, 2= No

81. If yes when (year) .....

82. Have you ever used fertilizer in pearl millet production? (.....)1= Yes, 2= No

83. If yes when (year) .....

84. Which type of fertilizer was used .....

85. How many times do you carry out weeding operations .....

86. What was your common means of transport to bring back the produce? (.....)
1 = Head loads, 2 = Oxcart, 3 = Hired vehicle/tractor, 4= Bicycle

87. Did you experience pre-harvest losses in sorghum and pearl millet last season(.....)?
1 = Yes, 2 = No

88. If yes, Which was the major cause? (.....) 1 = Vermin(s), 2= Birds, 3= Insects, 4= Theft, 5 = Diseases.6=Wind shedding.

89. How do you store your produce? (.....)
1 = Sacks, 2 = Drums, 3 = On the floor, 4= Calabash, 5 = On the roof.

H: MANAGEMENT OF GENETIC MATERIAL

90. What is your main source of seed? (.....)
1 = Select from previous crop. 2 = Purchase. 3 = World vision.
4 = Exchange with other farmers 5 = VEAO 6 = Extension(village office).
7 = Others (Specify) .....

91. If you select seed, how do you select your sorghum seed? (.....)
1= On farm at maturity stage, 2 = Before threshing, 3 = From grain for food.

92. If you select seed, how do you select your pearl millet seed? (.....)
1= On farm at maturity stage, 2 = Before threshing, 3 = From grain for food .
4 = Others specify .....

93. How do you store your seeds (Tick the correct method)

Method of storage	Maize	Sorghum	Pearl millet
Kept together with grains for food			
Kept on separate storage			
Kept in airtight guards sealed with cow dung			
Others			

94. Do you treat your seeds? (.....) 1= Yes. 2 = No

95. If yes how do you treat your seed? (tick the relevant method)

Method of treatment	Maize	Sorghum	Pearl millet
Smoked above kitchen			
Traditional herb			
Treated with lime			
Treated with storage chemicals			
Kept in airtight guards sealed with cow dung			

96. What do you consider to be the main limitation with the use of improved varieties? (....)
1 = Unavailability 2 = High prices 3 = Others explain .....

97. How many times have you offered seed lot to other farmers this season 2000/2001? (....).

98. How many times have you received seed lot from other farmers this season 2000/2001? (....).

I. SOURCE OF INFORMATION ON IMPROVED MANAGEMENT PRACTICES

99. Please provide the following data with respect to your source of information

Management Practice	Source
Improved variety	
Planting methods	
Inter cropping	
Spacing	
Farm Yard Manure use	
Fertilizer use	
Weed management	
Ox-drawn implement	
Pest management	
Disease control Measures	
Storage practices	

Source: 1= Extension , 2 = NGOs , 3 = Other farmers, 4 = Radio, 5 = Traders, 6 = Field day , 7 = Researchers, 8 = Bulletins and Books. 9 = Seminars , 10 = Church (DCT). 11 = leaflets. 12 = Farmers training, 13 = Others (Specify) .....

100. How many times did you sought advice from extension agent for the past 12 months? (.....)

101. What was the advice on? .....

J. MARKETING OF SORGHUM AND MILLET

102. Do you ever sell sorghum from your harvest ?(.....) 1 = Yes. 2 = No

103. Do you ever sell pearl millet from your harvest ?(.....) 1 = Yes. 2 = No

104. Did you sell sorghum or pearl millet last season? (.....) 1 = Yes. 2 = No

105. If yes please provide the following information

Year	Amount Sold		Amount Retained		Farm gate price T sh. per bucket	
	Sorghum	Pearl Millet	Sorghum	Pearl Millet	Sorghum	Pearl Millet
1998/99						
99/2000						

106. What is your view with respect to access to market for sorghum? (.....)
1= Minor problem, 2= Normal problem, 3 = Major problem.

107. What is your view with respect to access to market for pearl millet? (.....)
1= Minor problem, 2= Normal problem, 3 = Major problem.

K: USE OF CREDIT

108. Have you ever obtained credit for agricultural purposes? (.....)
1 = Yes 2 = No

109. How did you use the credit? (.....) 1 = sorghum cultivation, 2 = Pearl millet cultivation,
3 = Sunflower cultivation, 4 = Vine cultivation, 5 = Bought cattle, 6 = Bought goats.
7 = Others (specify) .....

110. What was your source of credit? (.....)
1.= Sasakawa, 2 = DCT, 3 = World Vision , 4 = Neighbour ,5= HPI,
6= SDDP , 7 = Research, 8 = Oil Press project, 9 = Others (specify) .....

111. Year when credit was obtained .....

112. What form of credit? (.....)
1 = Seed, 2 = Fertilizer, 3 = Ox-plough, 4 = Ox-cart, 5 = Cash, 6 = Dairy cattle,
7 = Dairy goats, 8 = Oil press machine, 9 = Others (specify).....

113. Amount or value of credit obtained (T sh.) .....

L .CONSUMPTION OF SORGHUM AND MILLETS

114. What is the most important food for your family .....

115. How often do your family consume sorghum meals? (.....)
1 = Very often 2 = Occasional 3 = During hunger periods 4 = Never consumed

116. How often do your family consume pearl millet meals? (.....)
1 = Very often 2 = Occasional 3 = During hunger periods 4 = Never consumed

117. For the past one week what has been the frequency of consuming the following foods?
Rice .....Times
Sorghum Ugali .....Times
Sorghum porridge ..... Times
Pearl millet Ugali .....Times
Pearl millet porridge .....Times
Maize ugali .....Times
Maize porridge .....Times

118. Apart from Ugali, porridge, and local brew, how else have you ever-used sorghum or millet flour?

I) .....
ii).....
iii) .....

◆◆ THANK YOU VERY MUCH FOR YOUR TIME AND INTEREST ◆◆

Appendix 3.2. Checklist for focused group discussion (FGD)

ADOPTION OF IMPROVED TECHNOLOGIES FOR PRODUCTION OF SORGHUM AND PEARL MILLET IN DODOMA REGION IN CENTRAL TANZANIA

By:
MWANGA, J. N. W.

DEPARTMENT OF AGRICULTURAL ECONOMICS AND AGRIBUSINESS, SOKOINE UNIVERSITY OF AGRICULTURE. P. O. BOX 3007 MOROGORO.

1. Farmers' selection criteria for sorghum and millets (to be listed)
2. Ranking of the selection criteria according to their importance
3. List of local varieties available in the village (Farmers to bring the samples for all varieties they are growing)
4. List of improved varieties available in the village (Farmers to bring the samples for all varieties they are growing)
5. Matrix ranking of each variety
6. Pair wise ranking of the improved varieties
7. Timeline OR HISTORICAL PERSPECTIVE (Which are major events OR CHANGES that farmers can remember?

Events	Year	Reason	Food situation	Dominant Farming system	Livelihood strategies (What & why)	Sorghum Varieties & varieties	Pearl millet varieties & landrace
	19..				Intro. Of new crops/varieties ?	Lugugu?	Uwele kienyeji?
	19..						
	19..						
	19..						
	19..						
	19..						
	19..						
	19..						

8. Management of sorghum and pearl millet
9. Informal seed systems (Community based seed system)
10. Presence of "seed experts" farmers in the village. Are they strong?
11. Major crops grown in village
12. What have been the uses of sorghum?

(A) Vegetative part (B) Grain

13. What has been the source of household food for the past one year?

Source	J	F	M	A	M	J	J	A	S	O	N	D
Sorghum												
Pear millet												
Maize												
Rice												
Cassava												
Groundnut												

14. Importance of (a) sorghum compared to other crops especially cereals (Pair wise ranking)

15. Importance of (a) pearl millet compared to other crops especially cereals (Pair wise ranking)

16. Major income sources

17. Major problems limiting the adoption of improved S&M seeds

Example 1. Matrix ranking

VARIETY	CRITERIA					
	Good for local brew	Good for ugali (stiff porridge)	Good for porridge	Highly marketable	Total score	Rank
PATO						
.....						
.....						
TEGEMEO						
SERENA						
TOTAL SCORE						
RANK						

Example 2. PAIR wise ranking

VARIETY	PATO	TEGEMEO	SERENA	....	.....	LULU	SCORE	RANK
PATO								
TEGEMEO								
SERENA								
.....								
.....								
LULU								

Appendix 4.1: Conversion factors for Tropical Livestock Units.

Livestock categories	Live weight (Kg)	Conversion factor
Indigenous Cattle (TSHZ)	250-300	1
Improved cattle	350-500	2
Donkey	250	1
Goat	30	0.12
Sheep	30	0.12
Pig	150	0.12
Chicken	2	0.12
Duck	2	0.12
Guinea fowl	2	0.12

Source: Survey data (2000/01)

Appendix 4.2: Traditional seed experts (conservators)

Village Name		Crop	Variety preserved
Mnenia	1. Rajabu Omari (M)	Sorghum and maize	Lulu, Serena, Udo Local maize. Yellow grain maize
	2. Mwasinamba Mabruku (M)	Sorghum, Ground nuts, Bambara nuts, Lao lab, Guards Watermelon	Langalanga Erect and creepers different colours
	3. Hawa Salum (F)	Maize Pigeon Pea	Ilonga Composite White and red varieties
	4. Rajab Isangu (M)	Maize	Local Maize, Yellow maize
Bumbuta	5. Hussein Mmondo (M)	Maize Sorghum	Kilima, Illonga and Cargil maize. Lulu, Serena, Udo
Mbabala - A	6. Juliana Mkaka (F)	Pearl millet, Bambara nut Groundnuts Sorghum	Magaji, Local variety Mwezi mmoja Lugugu
	7. John Mzola (M)	Ground nuts Pearl/millet	Mambunga (Large 4 seeded creepers). Uwele Mwezi mmoja, Uwele china
	8. Laurent Tupa (M)	Sorghum Ground nuts	Lugugu Mahobe
Mbalawala	9. Damiani Chazo (M)	Pear/millet Maize Sorghum	Uwele Buruma
	10. Simon Ng'oza (M)	Pear Millet Maize	Uwele kienyji, Local maize
	11. Rock Mligwa (M)	Pear millet Maize Pearl millet	Uwele kienyeji. Local maize Uwele kienyeji.
	12 Chiloti Mwiguti (M)	Sorghum	Lugugu
Chipanga- A	13 Msigwa Ndugu (M)	Pearl millet, Sorghum Rice, Simsim Groundnuts	Uwele kienyeji
	14 Ichapi Ndunu (M)	Rice, Sorghum Sim sim. Pear/Millet	Lugugu. uwele kienyeji
	15. Ndoje Mgogoro (M)	Rice, Sorghum, Ground nuts	Lugugu
	16. Mtinya Makulu (M)	Rice, Sorghum, Sim sim, Ground nuts Pear/Millet	Lugugu. Uwele kienyeji
Mvumi - Makulu	17. Grace Mpali (F)	Pearl millet	Uwele kienyeji, uwele kiboko
	18. Timotheo Ng'ambi (M)	Maize	Local multicolor grains
		Sorghum	Lugugu
		Cassava	Kigoma, kienyeji
	19. Jeremia Sausi (M)	Sorghum Pearl millet	Mhunputa Uwele china
	20. Melina Mwanzije (F)	Sorghum Maize	Bangala Local maize

Source: Survey data (2000/01)

Appendix 4.3:Calculation of weighted varietal turn over rate

Variety	Years. In the field	Years before replacement	Acreage (Acre/household) 2001)	Weighted index
Lulu	31	13	0.023	0.713
Serena	31	13	0.001	0.031
Tegemeo	18	12	0.52	9.36
Pato	6	4	0.52	3.36
Macia	2	-	0.01	0.02

Source: Survey data (2000/01)

Appendix 4.4: Volume of foundation seed delivered to TANSEED (kg)

	Maize				Sorghum		
Year	Katumani	TMVI	Staha	ICW	Serena	Tegemco	Pato
1990	-	-	-	-	-	-	-
1991	-	1400	-	-	350	1060	-
1992	577	700	17140	1900	1000	1300	-
1993	-	250	-	-	-	-	-
1994	-	3000	8000	-	-	-	-
1995	-	-	-	-	-	1150	-
1996	-	-	-	-	-	-	-
1997	-	3000	3000	-	-	-	500
1998	-	3000	3600	-	-	-	-
Total	577	11350	34740	1900	1350	3510	500

Source: Msimba Foundation Seed Farm (2000/01)

Appendix 4.5: Adoption trends for most popular improved varieties

(cumulative %)

Year	Improved Varieties			
	Sorghum			Pearl millet
	Tegemco	Pato	Macia	Okoa
1984.00	.80	.	.	.
1985.00	.80	.	.	.
1986.00	.80	.	.	.
1987.00	.80	.	.	.
1988.00	1.70	.	.	.
1989.00	1.70	.	.	.
1990.00	2.50	.	.	.
1991.00	3.30	.	.	.
1992.00	3.80	.	.	.
1993.00	4.20	.	.	.
1994.00	5.80	.	.	.
1995.00	8.80	. 40	.	.40
1996.00	12.50	2.10	.	.40
1997.00	15.00	5.00	.40	.40
1998.00	20.40	13.80	.40	2.10
1999.00	27.10	20.40	.40	3.30
2000.00	36.30	45.80	2.10	9.20
2001.00	36.30	48.80	4.20	9.60

Source: Survey data 2000/001

Appendix 4.6: land productivity by district in 1995-2000

Crop	Year				
	95 96	96 97	97 98	98 99	99 2000
Mpwapwa district					
Maize					
Area (Ha)	16408	18968	37690	27300	30441
Production (Tons)	21574	18465	39198	28694	36088
Land productivity T/ha	1..3148	0..973	1.04	1.051	1.186
Sorghum					
Area (Ha)	39944	27962	30.814	13000	38565
Production (Tons)	29768	2009	5824	11179	16633
Land productivity T/ha	0.745	0.716	0.189	0.860	0.431
Pearl millet					
Area (Ha)	7772	4284	4111	1200	6930
Production (Tons)	8394	3856	1223	1264	2772
Land productivity T/ha	1.080	0.900	0.297	1.053	0.4
Paddy					
Area (Ha)	361	236	110	190	233
Production (Tons)	387	118	108	38	311
Land productivity T/ha	1.072	0.5	0.982	0.2	1..330
Dodoma Rural District					
Maize					
Area local (Ha)	9690	3491	5839	17756	806
Area improved (Ha)	6195	7085	2747	10875	1794
Area Total (Ha)	7155	10576	8586	28631	2600
Sorghum					
Area local (Ha)	2328	5920	17467	11250	1656
Area improved (Ha)	63540	36382	24119	18354	47126
Area Total (Ha)	65868	42302	41586	29604	48782
Pearl millet					
Area local (Ha)	55915	39598	32340	25468	15092
Area improved (Ha)	7625	11168	6160	6617	13930
Area Total (Ha)	63540	50760	38500	32085	29022
Kongwa district					
Maize					
Area (Ha)	12983	8019	12312	16436	NA
Production (Tons)	42733	28212	38769	36086	NA
Land productivity T/ha	3.29	3.5	3.15	2.15	NA
Sorghum					NA
Area (Ha)	2342	7735	4341	4141	NA
Production (Tons)	5787	19114	10726	9651	NA
Land productivity T/ha	3.5	2	0.9	1	NA
Pearl millet					NA
Area (Ha)	2693	1934	1440	2804	NA
Production (Tons)	5063	4018	1628	3074	NA
Land productivity T/ha	1.88	2.08	1.13	1.1	NA
Kondoa district					
Maize					
Area (Ha)	23579	19997	76434	NA	19997
Production (Tons)	47158	3990	39990	NA	19074
Land productivity T/ha	2	2	0.52	NA	1
Sorghum					
Area (Ha)	18220	19077	19077	NA	19074
Production (Tons)	27332	28617	28617	NA	12104
Land productivity T/ha	1.5	1.5	1.5	NA	0.63
Pearl millet					
Area (Ha)	27277	20174	20174	NA	20174
Production (Tons)	27272	26433	26433	NA	15998
Land productivity T/ha	1	1.31	1.31	NA	0.79

NA = Not available

Source: DALDOs for Mpwapwa, Kondoa, Dodoma rural, Dodoma urban and Kongwa