RELEVANCE AND AVAILABILITY OF AGRICULTURAL TECHNOLOGY IN ETHIOPIAN AGRICULTURE: THE CASE OF SORGHUM, MAIZE AND TEF PRODUCTION IN SELECTED REGIONS

Thesis submitted as partial fulfilment for the M.Sc. degree
Master of Science in Management of Agricultural Knowledge Systems
Wageningen Agricultural University
Department of Extension Science
The Netherlands

July 1990

TESFAYE BESHAH
RELEVANCE AND AVAILABILITY OF AGRICULTURAL TECHNOLOGY IN ETHIOPIAN AGRICULTURE: THE CASE OF SORGHUM, MAIZE AND TEF PRODUCTION IN SELECTED REGIONS.

TESFAYE BESHAH


Advisor: Dr. N. Roling: Senior Lecturer and The Course Committee Chairman of the MSc. Course, MAKS.

Co-Advisor: Ir. P.G.H. Engel: Senior Lecturer

Department of Extension Science: Wageningen Agricultural University, the Netherlands

July 1990
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ACRONYMS

ADDU : Ada District Development Unit
AIDB : Agricultural and Industrial Development Bank
AISCO: Agricultural Input Supply Corporation
AKS : Agricultural Knowledge System
AMC : Agricultural Marketing Corporation
AUA : Alemaya University of Agriculture
CADU : Chilalo Agricultural Development Unit
CD : Community Development
CIAT : Centro Internacional de Agricultura Tropical
CIMMYT: Centro Internacional de Mejoramiento Maíz y Trigo
CIP : Centro Internacional de la Papa
CSA : Central Statistical Authority
EPID : Extension Project Implementation Department
ESC : Ethiopian Seed Corporation
ESTC : Ethiopian Science and Technology Commission
HADP : Humera Agricultural Development Project
IAR : Institute of Agricultural Research
IARC : International Agricultural Research Centre
ICARDA: International Centre for Agricultural Research in the Dry Areas
ICRISAT : International Crops Research Institute for the Semi-Arid Tropics
IFAD : International Fund for Agricultural Development
Acronyms Continued

IITA : International Institute of Tropical Agriculture
ILCA : International Livestock Centre for Africa
ISNAR: International Service for National Agricultural Research
MCTD : Ministry of Coffee and Tea Development
MoA : Ministry of Agriculture
MPP : Minimum Package Project
MSFD : Ministry of State Farm Development
NCIC : National Crop Improvement Conference
NGO : Non-Governmental Organization
PADEP: Peasant Agricultural Development Project
PTD : Participatory Technology Development
RELC : Research and Extension Liaison Committee
R & D : Research & Development
RRC : Relief and Rehabilitation Commission
SORADEP: Southern Region Agricultural Development Project
T&V : Training and Visit System of Agricultural Extension
TAHDU: Tach Adiabo and Hedekti Agricultural Development Unit
WADU : Wollamo Agricultural Development Unit
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Wageningen, The Netherlands

Tesfaye Beshah
Alemaya University of Agriculture
Department of Agricultural Economics
Alemaya, Ethiopia
1

1.0 INTRODUCTION

Ethiopia is predominantly an agricultural country. In order to improve its supply of food and raw materials for agro-industries and maintain a steady flow of foreign exchange, efforts are underway to strengthen its agricultural research and extension organizations. In view of these broad goals, generation and supply of relevant agricultural technologies to the end-users are of paramount importance.

This paper deals with the exploratory exercise of assessing the relevance and availability of agricultural technologies for selected crops with a case study approach. The case study was conducted in and around the research centers of the main research organizations viz., the Institute of Agricultural Research (IAR) and the Alemaya University of Agriculture (AUA). The main thrust of the paper is the comparison of the farmers' practices, problems, and capacities with the offering of research and extension. From the cases, an attempt is made to develop an insight into the state of country's research and extension organizations.

Description of the problem is given in Chapter 2. Chapter 3 deals with the background information on the country's research and extension development and functioning. In Chapters 4 and 5 the conceptual framework and method of data collection are presented respectively. Results and discussions are presented in Chapter 6. The last Chapter contains the implication of the case for national agricultural research and extension.
2.0 DESCRIPTION OF THE PROBLEM

Definition of terms

**Availability**: this refers to the degree to which the research-extension systems make better technology and its complementary inputs available to farmers at a fair price, in sufficient quantity and at the right time.

**Relevance**: this refers to the degree to which a new technology fits into the farmers' socio-economic and agro-ecological environments in order to satisfy their objective(s).


2.1 Statement of the Problem

Agricultural research in Ethiopia is undertaken by universities/colleges, research institutes, user organizations and others such as NGOs and IARCs. The types of research undertaken by the National Research Organizations are mainly applied and adaptive researches.

The major Research Organizations lay claim to several crop
varieties that have been developed and released over time. For instance, the Institute of Agricultural Research (IAR) reported thousands of experiments undertaken, and the release of over 80 varieties of crops and a large number of cropping practices during the past 20 years (IAR, 1989). Similarly, the Alemaya University of Agriculture (AUA) reported 20 high yielding varieties of grain crops and their management practices that were developed by its research centers (Mekonnen, 1988).

This is quite indicative of the efforts that are being pursued by these and other organizations that are involved in the advancement of science and technology in agriculture.

On the performance side, however, these efforts seems to be insignificant as science-based agriculture did not take root in the indigenous farming systems. The situation can be illustrated considering the yield level of some major cereals that have attracted research and extension activities over the years. The average national yield estimate for Sorghum, Maize and Tef (Eragrostis tef) during 1980-86 is 12.85 qt/ha, 15.62 qt/ha, and 8.50 qt/ha respectively, which is very low compared to the research field results (CSA, 1987).

As the national aggregate masks the regional variations and varietal differences etc, the extent of gap between farmers' yield and that of research can be illustrated by demonstrations
carried out on farmers' fields. For instance, in 1986, the yield for lowland sorghum in the Nazret area from farmers' methods and an improved package in farmers' field was 11 and 20 qt/ha respectively (Belayneh, 1989).

In the Eastern administrative regions in the Alemaya area, producers' cooperatives do obtain maize yields as high as 52.7 qt/ha whereas the regional average is 8 qt/ha (Mekonnen, 1988). On the other hand there are substantial differences among the Producers' Cooperatives in adjacent areas that share the major agro-ecological and socio-economic environments.

From these, one may ask for the explanations of the yield gap between the improved practices and the farmers' practices, the reason behind relatively high yield for the producers' cooperative as compared to the regional averages and the causes of the differences among Cooperatives.

Most Researchers assume that a technology produced by a research centre is always relevant to be adopted by farmers in its totality. They rely on grossly simplified (if any) socio-economic factors and their experimental designs to address the bio-technical differences that may impede the use of technologies. Consequently, they blame farmers for not adopting their formula. In practice, farmers' objectives are much more than only yield, the major dependent variable of researcher(s).
They compromise yield with other factors such as risk, labour availability, etc.

Hence, the relevance of technology for some group of farmers does not necessarily imply its relevance to others. Relevance of technology, in a broad sense, goes beyond bio-technical aspects which are very often given high priority by crop/animal scientists. It includes issues such as the fit of the production practices into the farmers' management practices, consumer taste - both household and market, farm development, etc. Therefore, farmers' objectives/choices of a combination of inputs and management practices depend on household's or cooperative's farm structure.

It must be noted that a farm exists within the larger context of political, socio-economic and agro-ecological environments that dictate a particular objective, management practice, etc. The adoption of a given technology depends on its relevance and availability in the farmers' environments. Relevance and availability are affected by the variables associated with four categories of factors affecting adoption. These are farms (agro-ecological factors), farmers (gender, age, affiliation), farmers' opportunities, and characteristics of technologies.

Thus, it is hypothesized that farmers would continue with their practices unless relevant alternative technologies are available
in their environments together with their complementary inputs.

The objectives of the study are: (1) to assess the relevance of the new technologies for Sorghum, Maize and Tef offered by extension, (2) to assess the availability of the relevant technologies and their complementary inputs for Sorghum, Maize and Tef, and (3) to identify factors that affect relevance and availability of technologies for Sorghum, Maize and Tef and their complementary inputs.

The research questions of the study are:

(1) Are the technologies produced for Sorghum, Maize and Tef relevant to the farmers' socio-economic and agro-ecological environments?

(2) Are the relevant technologies for Sorghum, Maize and Tef available to the farmers together with their complementary inputs?

(3) What factors (if any) are mostly affecting relevance and availability of technologies for Sorghum, Maize and Tef and their complementary inputs?

2.2 The Scope and Limitation of the Study

The study pursued an exploratory research methodology, to assess the relevance and availability of agricultural technologies produced by the institutions involved in Sorghum, Maize and Tef
research and development, and the supply of their complementary inputs to the farming community by a case study approach. The measurements employed by the study are qualitative. The case study areas lie around the IAR research centre at Nazret and the Debreziet and the Alemaya research centers of the AUA. The field work lasted for a period of two months, including preparation of detailed field work.

The emphasis of the study is on the interface between research-extension systems and user systems (in this case, farmers). The idea is to compare the appropriateness of the research-extension output in the farmers' environments. In the study, research and extension systems are considered from the point of view of the claim each makes to technology generation and transfer respectively. The research and extension linkage and institutional status of each system is not examined in the study.

Testing cause-effect relationships of the factors involved in relevance and availability is not the objective of the study. In this regard hypotheses and suggestions for improvement are given as an output of the study.

2.3 Significance of the study

Performance of the research and extension systems is an indicator
for the utility of the resources invested in the systems. The performance of research and extension systems is reflected by the degree to which the systems' outputs are adopted by users. Among the factors affecting adoption, technology (the systems' output) is, relatively speaking, lending itself for control by researchers and extensionists more so than farmers, their opportunities and their farms. This study, which is geared towards assessment of the appropriateness of the technologies to users, hopes to shed light on the mechanisms explaining adoption of agricultural technologies in the study areas in particular, and the country in general. Moreover it is hoped that it would help the development of programme-efficient and cost-effective technologies.
3.0 BACKGROUND TO THE STUDY

3.1 The Economy - General

Ethiopia is one of the developing countries which depends on the agricultural sector for economic development. Agriculture contributes 50% of GDP, 90% of exports and employs 85% of the total labour force. Its export items are coffee (60%), followed by hides and skins (13%), petroleum products (8%), vegetables (4%), oilseeds (4%), with the rest being small items. The industrial and service sectors are underdeveloped (Bissio, 1986).

Ethiopia has diverse agro-ecological zones with a total land area of 1,222,900 square Kms. Its climatic types range from equatorial desert to hot and cool steppe, and from tropical savannah and rain forest to warm temperate and cool high lands (ETH. mapping Agency, 1988). The population of Ethiopia is over 48 million with an annual growth rate of 2.9% (projected from July, 1985 estimate, CSA, 1986).

3.1.1 The Agricultural Sector

3.1.1.1 Organization of Agricultural Research

Early Development and Current Mode of Organization

The emergence of agricultural research in Ethiopia is matched with institutions of higher education in agriculture. Ambo (1947)
and Jimma (1952) Junior Colleges of Agriculture were the pioneering higher education institutes in agriculture that undertook agricultural research. The establishment of the College of Agriculture at Alemaya signifies the triumph of agricultural research in Ethiopia. Alemaya, like that of Jimma, was modeled according to the USA's land grant college system, that emphasises the tripartite system of training, research and extension. The College of Agriculture, acted as the national centre of coordination of agricultural research and extension. In 1963, the College administration was transferred from the Ministry of Agriculture to Addis Ababa University. At that time, the Board of Trustees of the University decided that the extension wing of the College be transferred to the Ministry of Agriculture. This marked the separation of research and extension in Ethiopia (Nichola, 1985). Moreover, not only is extension isolated from research but also from the educational influence which directly affects both research and extension. As a result, the land grant system was abandoned.

Between early 1950s and 1970s several research centers or projects were established. Among these are Animal Health Research at Debreziet, Ethiopian Sorghum Improvement Project, Plant Genetic Resource Centre and the Scientific Phytopathological Laboratory. However much these all contribute to the country's agricultural research, the Institute of Agricultural Research (IAR) that was established in 1966, remains the most important
research institute in Ethiopia with a national mandate to do agricultural research. Some of the formerly independent projects are currently incorporated under IAR.

There are also other entities undertaking different levels of research depending on their primary mandates. The Alemaya University of Agriculture (AUA), besides its single most important accomplishment in producing higher level trained personnel for the country, undertakes various kinds of research that are of interest to the scientific community in general and the national agricultural sector in particular. The Ministry of State Farms Development (MSFD), the Ministry of Agriculture (MoA), the Ethiopian Seed Corporation (ESC), the Ministry of Coffee and Tea Development (MCTD), and the Relief and Rehabilitation Commission (RRC) also undertake adaptive research.

3.1.1.2 Organization of Agricultural Extension

Early Development and Current mode of Organization

The Extension service in Ethiopia is said to have its beginning between 1930-31, when the College of Agriculture at HagreHiwot, then Ambo, was established by the Government (Belay, 1959).

Even though its beginning is relatively earlier, its geographic coverage and strength before the 1980's was very limited. Different policies and strategies followed in the late 1950s in
the agricultural sector gave rise to different forms of institutionalization of extension services. Currently the national mandate for agricultural extension is that of the MoA. In addition to MoA, universities are involved in small scale extension activities. In the following paragraphs the profile of agricultural extension typologies are briefly treated.

During the first Five Year Plan (1958-62), the programme of community development (CD) was initiated as a strategy for stimulating popular endeavors to identify and tackle problems of a given community through self-help projects. The programme of CD was concerned with almost all areas of development, using the extension concepts as the communication strategy. Its particular emphasis was in agriculture, rural artisanal development and in social infrastructure and welfare activities. This programme continued until the third Five Year Plan (1968-73).

The other programme where extension has been exercised was the package programme that emerged during the Third Five Year Plan. The typologies of package approaches implemented in Ethiopia since 1960's were formulated as a project.

The first, Comprehensive Package Project was that of Chilalo Agricultural Development Unit (CADU) which was established in 1967, with Swedish Government and multilateral (World Bank) assistance. This project operated in the Chilalo province until
the end of its second phase, in 1975. Thereafter, it was upgraded to cover the whole Arsi Administrative Region.

The second Comprehensive Package Project was initiated in the Wollamo province in 1970 under the Wollamo Agricultural Development Unit (WADU). The first phase of this project extended until 1974.

These projects were directed to the promotion of socio-economic development of the project area and the components of the package that are linked to each other include; agronomic and livestock research, agricultural extension and input distribution such as fertilizer, improved seeds and improved farm implements, plus credit provisions for the purposes of purchasing essential inputs (Schulz, 1976).

The research in this project is mainly adaptive research. During the early days of CADU's project, adaptive research based on wheat material obtained from the experimentation station at Debre-Zeit and agricultural research programmes in Kenya and Mexico yielded promising results (Cohen, 1987;).

There were also other Comprehensive Package Projects initiated in other administrative regions. These were:- Humera Agricultural Development Project (HADP), along the Sudanese border around the Semi-Urban center of Setit Humera; Ada District Development Unit.
(ADDU) in the Debrezeit region East of Addis Ababa; Tach Adiabo and Hedekti Agricultural Development Unit (TAHDU) in the Northwest of Tigray Administrative region and Southern Region Agricultural Development Project (SORADEP) in the vicinity of the town of Awassa-Rift Valley Lake Region, south of Shashamene (Schulz, 1976).

The extension method employed by CADU was the "model farmer" approach until 1975. Farmers who lived in an area of 800 hectares were assembled and asked to nominate five candidates from among whom CADU selected one to serve as the model farmer for the area. Demonstrations and field days have been conducted on the model farmers' land. But the model farmer's approach to extension was criticized both from outside and within CADU itself. Empirical studies concluded that the approach was only partly successful and that it was not the most efficient way of disseminating knowledge (Waktola, 1975).

The second of the Comprehensive package projects, WADU, avoided the "model farmers" approach and instead demonstrated technologies on peasants' farms that were relatively more resource poor. The first line agents were locally recruited 9-12th grade finishers, who had an agricultural background, spoke the local language and understood the local social values. Technology transfer under WADU's approach have been found to be more effective than that of CADU (Ibid).
As early as the 1970's, it was apparent that it would not be feasible to implement the comprehensive package projects through the whole country. Hence, the Minimum Package Programme (MPP) was initiated in Ethiopia with a claim to address the problems of the lower income bracket farmers and also with greater reliance on peoples' participation.

The MPPs were designed to cover large areas so that as many farmers as possible could be reached for extension, input supply, credit provision and marketing services. Thus, the Extension Project Implementation Department (EPID) was created in 1971 to provide peasant farmers production and to carry out the minimum package programme started in 1970.

The basic unit of development was the MPP areas which contained about 10,000 farm families and extended 5 Km on either side of a 75 Km stretch of an all-weather road. MPP-I adopted CADU's grain technology and also applied its extension methodology (Schulz, 1976).

The programme relied on the impact of fertilizer since this was considered the one innovation that could have a notably large impact on yield. Although the minimum package concept worked well in the limited areas of its operation under MPP-I (1971-74), certain shortcomings became apparent as the programme was extended to more farmers. (Nicolla, 1985).
At the termination of MPP-I in 1974, there was a plan to undertake an expansion of MPP-I, under MPP-II for the period of 1975-80. However, this did not materialize as the Ministry of Agriculture had to give priority to the implementation of the land reform of 1975 and organization of peasant associations and service cooperatives. This is the effort towards fitting the project within the context of the new socio-economic situation created in the country after the revolution. Then the proposal of MPP-II was redrafted for the period 1978-82 in light of the new development. But the proposal was approved only in 1980, and MPP-II was underway starting 1980/81. This project operated in 440 districts out of the 580 districts of the country. The components of the project were an agricultural extension package, a cooperative marketing package and supporting services (Ibid).

Farmers' associations and cooperatives are the focal points of implementation, i.e peasant associations, service and producers cooperatives. This project was terminated in December 1985.

In its place, Peasant Agricultural Development Project (PADEP) was initiated to promote agricultural development in the dominant small-holder sector.

The PADEP operates in the potential areas of the country. The non potential areas continue to run at the pace of the extension service as it was under MPP II.
The main features of PADEP are:

1) The extension approach used in this strategy is a modified Training and Visit system (T&V). The Extension service would base itself at service cooperative level which encompasses both Peasant Associations and Producers' Cooperatives. In the PADEP area, one development agent shall offer service to 1300 households, unlike those in non PADEP areas, where the ratio is 1:2500. Intensification and expansion of the extension service is the overriding objective. The emphasis is said to be given to the provision of biological, chemical and mechanical technologies in order to increase farmers' capacity and productivity.

2) Improved research and extension linkage for smooth transfer of technology,

3) Use of radio broadcasts in the national language and local languages as the case is possible,

4) Decentralized management system,

5) Strong seasonal credit and farm input supply and distribution system (MOA- Amharic, 1987).

The implementation of PADEP was designed to take place under 8 projects encompassing the potential areas of the country. These projects are prepared with the prospect of financial and technical support from bilateral and multilateral donors. At the time of data collection for this study (September to October, 1989), there were only two projects that were close to starting. These are PADEP 1, financed by World bank and PADEP 5 financed by
IFAD. After termination of MPP II, the extension activities of the country are run on the Government budget.

3.1.1.3 Human Resources in Research and Extension

Human Resource in Agricultural Research

Presented below are the total number of research staff of the IAR and AUA only (Table 3.1 and 3.2)- For increase of IAR's research staff over time see Appendix 1.

Table 3.1 The Existing Work Force in the IAR as of 1986.

<table>
<thead>
<tr>
<th>Research Division</th>
<th>Phd.</th>
<th>MSc.</th>
<th>DVM</th>
<th>BSc.</th>
<th>Dip.</th>
<th>Others</th>
<th>Expat.</th>
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<td>49</td>
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<td>191</td>
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<td>4</td>
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<td>Total</td>
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<td>128</td>
<td>249</td>
<td>1169</td>
<td>13</td>
<td>1642</td>
</tr>
</tbody>
</table>

Table 3.2 Department Staff by Qualification (end of year, 1988), AUA

<table>
<thead>
<tr>
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<td>1</td>
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<td>13</td>
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<tr>
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</tr>
<tr>
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<td>11</td>
<td>20</td>
<td>36</td>
<td>11</td>
<td>126</td>
</tr>
</tbody>
</table>

Key: 
- DNSS = Division of Natural and Social Sciences
- AG.Ec. = Agricultural Economics
- AG.En. = Agricultural Engineering
- Pl.Sc. = Plant Sciences
- An.Sc. = Animal Sciences
- FoF = Faculty of Forestry

Source: AUA, 1988

The time of AUA's staff is distributed over research, extension and teaching in a proportion of one-third for each activity over a year. The faculty staff of the AUA are assisted by technical assistants.
Human Resources in Agricultural Extension

The figure presented below refers only to the MoA's. The MoA's extension personnel on the payroll as of 1989 is given in Table 3.3.

Table 3.3 Extension Staff of the Ministry of Agriculture

<table>
<thead>
<tr>
<th>Adm./Supervisor</th>
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<tr>
<td>Subject Matter</td>
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<tr>
<td>Development</td>
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</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>%</th>
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<th>No.</th>
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</thead>
<tbody>
<tr>
<td>300</td>
<td>7.6</td>
<td>1609</td>
<td>40.8</td>
<td>2032</td>
<td>51.6</td>
<td>3941</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: Ministry of Agriculture; Office record, 1989

Given the county's diverse agro-ecological and large geographic coverage, both the research and extension staff are far fewer than what is required in terms of number and qualification.

3.1.1.4 Research and Extension Policies

In principle, the research and extension activities are governed by the national policy. Between 1974-1984 different government decrees have served this purpose. After 1984, all activities in the country have been based on the Ten Years Perspective Plan.
With regard to scientific activities the Ethiopian Science and Technology Commission (ESTC) is the principal body responsible for the formulation of national policy and plans in the Science and Technology sectors, as well as overall promotion, stimulation and coordination of Scientific research and development activities.

The organizational setup of the ESTC is not of a network of Scientific and Technological institutions under its authority. Almost all Ministries and other state organs, as well as R&D institutions including those of the universities and the scientific community, are represented in the National Council or the sectorial Sub-Councils of the Commission (ESTC, 1988). In 1988 the commission organized a National Science and Technology Conference to help develop the National Science and Technology policies for each sector. The final proposal produced was presented to Government for a final decision.

To date, the research and extension organizations, including institutes of higher education, follow their own policies that are developed in accordance with the national policies.

3.1.1.5 Linkage Mechanisms among Institutions: Domestic and International

Domestic Linkages

Agricultural industry is influenced by biotic and abiotic
factors. The latter comprise of different sub-systems such as research, extension and producers. Knowledge of agricultural practices is produced, transformed, and transferred to final users among these sub-systems.

The smooth functioning of these sub-systems is ensured only with the strong support of other partners of the Agricultural Knowledge Systems (AKS) such as input manufacturers and suppliers, financial institutions, etc. To maintain these supports from the environments of the sub-systems, a forum for exchange of resources and information is indispensable. Nowadays, this forum is referred to as linkage mechanisms. This is the concrete procedure, regular events, arrangement, device or channel which bridges the gap between components of a system and allows communication between them (Röling, 1988 b; 1989).

A common linkage mechanism in Ethiopia is the representation of an organization in related activities. This kind of linkage mechanism is true for the ESTC, the Institute of Agricultural Research (IAR), University Senate etc.

Research and Extension linkage are being pursued by different linkage mechanisms. The National Crop Improvement Conference (NCIC) that was established under the auspices of the IAR in 1967 is one of the oldest linkage mechanisms. This conference has currently broadened its scope by including higher education and
development in all areas of national agricultural research and development. The other linkage mechanism is the Research and Extension Liaison Committee (RELC) that was established in 1986. This committee is organized at national and research centre level. At national level, it is represented by the major user Ministries and Universities. The Ministry of Agriculture (MoA) and IAR are the main constituencies of RELC. Universities are also active in the research centre-based RELC, where they represent research partnership.

Other linkage mechanisms such as Standing Committee, Workshops, Seminars and Technical Committees are commonly employed by IAR, MoA, Universities and other organizations.

**International Linkage: Access to External Knowledge**

This part refers only to IAR and AUA relations with the international scientific community. The Institute of Agricultural Research and AUA have a working relationship among the IARCs (Table 3.4 and Table 3.5).
Table 3.4 Types of Assistance from IARCs to IAR

<table>
<thead>
<tr>
<th>IARC</th>
<th>Germ-</th>
<th>Fund</th>
<th>Train-</th>
<th>Infor-</th>
<th>Consul-</th>
<th>Machi-</th>
<th>Construction</th>
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<tr>
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<tr>
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<td>x</td>
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</tr>
</tbody>
</table>

* = not available


Table 3.5 Types of Assistance from IARCs to AUA

<table>
<thead>
<tr>
<th>IARC</th>
<th>Germ-</th>
<th>Fund</th>
<th>Train-</th>
<th>Infor-</th>
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<tr>
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<tr>
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</tr>
<tr>
<td>ICRISAT</td>
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<td>x</td>
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</tbody>
</table>

Source: Research Office; AUA, 1989. * = not available
Even though the degree of assistance is not illustrated, Table 3.4 and Table 3.5 indicate that both IAR and AUA among others, receive germplasm, training and information from most of the IARCs. Note that the distribution of assistance for IAR is more fairly scattered over the donors than that of AUA. Moreover, AUA did not receive any assistance from ISNAR and CIAT during the report period.

3.1.1.6 Agricultural Credit and Marketing

Agricultural Credit

The government banking institution that is largely involved in agricultural credit is the Agricultural and Industrial Development Bank (AIDB). This bank offers credit to Service Cooperatives that are accorded legal status. Service Cooperatives provide credit to Peasant Associations and Producers' Cooperatives. Among individuals farmers the bank offers credit only to those who are involved in profit-oriented enterprises such as poultry, fattening and bee keeping. The large proportion of the food crop producers are devoid of the bank's credit service (see p. 70).

Agricultural Marketing

Since 1976, the Government established a grain marketing system. The agency responsible for grain purchase and distribution to the
urban dwellers is the Agricultural Marketing Corporation (AMC). The target crops for AMC are wheat, maize, tef (*Eragrostis tef*), barley, and sorghum. Over 60% of the purchases come from the peasant sector. These grains are purchased on a fixed price basis which is far cheaper when compared to the market price. Farmers can sell grains on the free market only after they have fulfilled their quota (for the consequences of the AMC price in farmers' management strategy and other related issues, see Franzel et al., 1989).

The price of inputs on the other hand is increasing from time to time (e.g. see Appendix 2 for fertilizer prices and the amount of sale to farmers). In ten markets over a 3 year period (1985-87) local maize prices on average were 2.7 times higher than AMC prices. In six locations over 3 years, local wheat prices on average were 2.3 times higher than the AMC prices. The use of fertilizer on maize is profitable at only 3% of the 35 sites where tests were conducted and on wheat at 43% of 28 sites (Ibid).

According to a recent Government decree adopting new policy measures for the future economic, political and social development, AMC has lost its privilege with the restoration of the free market price.
4.0 CONCEPTUAL FRAMEWORK

4.1 Factors Affecting Adoption of Agricultural Technologies

The shift from traditional methods of production to new, science-based methods involves new technological components, such as new varieties, cultural practices, commercial fertilizers and/or pesticides, new crops and/or even new farming systems, such as double-cropping. However, farmers do not make an automatic shift towards these new technologies. Their decision is affected by several factors both internal and/or external to the household. Earlier diffusion studies identify several socio-economic and socio-psychological characteristics of the adopter farmers to determine the rate of adoption of a particular technology (Rogers, 1969; 1971).

In Ethiopia, several technological packages have faced partial adoption or non-adoption due to the many variables affecting adoption.

In the Chilalo area where CADU has been initiated, most farmers are familiar with the wheat varieties and knowledge of fertilizer. However, farmers' interests to the CADU's implements was not favorable due to their technical shortcomings (Waktola, 1980).
Ayana (1985) using the probit regression techniques in the study of two extension districts found that at Welenkomi extension centre literacy, farm size and adequacy of rainfall affect positively and significantly the use of improved seeds and fertilizers, while unavailability of cash for down payment and price of inputs affect it negatively and significantly. In the Dillala extension centre he found that the value of livestock owned, price of farm output and non-farm income positively and significantly affect the adoption of improved seeds and/or fertilizers, while unavailability of cash for down payment is found to be negatively and significantly related to it. He also found other factors which were affecting the adoption of improved seeds and/or fertilizers. These include age of the farmers, farm fragmentation, low extension contact and socio-cultural factors which indirectly affect the supply of farm labour. In the Dillala extension centre 78% of sampled farmers have adopted fertilizers, while in Welenkomi only 28% have adopted it as of the 1983 crop year. The use of improved seeds is negligible in both areas. However, 75% of the farmers in Welenkomi and only 34.4% in Dillala have adopted herbicides as a substitute for hand weeding. In both extension areas, no farmer has adopted farm implements, insecticides or an improved storage system. Row planting has also not been adopted, and hence, cultural practices are of the traditional type.
Kebede, et al (1989) employing Logit Maximum Likelihood procedure, have found the variables affecting the probability of adoption of single-ox, fertilizer and pesticide technologies in the case study of Tegulet-Bulga District. Their result indicates that farm size is the most significant variable affecting the probability of adoption of all three technologies. Its impact is negative for single-ox technology and positive for fertilizers and pesticides. Economic factors such as income, wealth and debt generally exhibit a statistically significant influence on the adoption of single-ox and pesticides technologies as do family size, access to outside information, education and experience. Moreover, they show that the effect of socio-economic factors on adoption of fertilizer and pesticide technologies is greater in the area which has more access to outside information and off-farm activities than in more "self confined" areas. The impact of the degree of risk aversion of farmers is found to be significant and negative for single-ox technology in both areas, and for fertilizer and pesticide technologies in only one area.

The factors that affected the adoption of technologies in Ethiopia are by and large similar to those reported studies undertaken elsewhere. Generally the factors can be classified into four categories.
These are:

1) The farm: Crops, farm animals and the agro-ecological environment, fragmentation, and location
2) The farmers: Members of the household
3) Farmers' Opportunities: Access to resources, access to institutional services, price opportunities and access to infrastructure
4) Characteristics of technologies: Communicability, Complexity, Trialability, Compatibility and Relative advantage.

These categories are closely related to one another. Before going into the discourse of the variables associated with them it is worthwhile to pinpoint the underlying relationships.

Most technological interventions put much emphasis on the farm to improve crop/animal productivity i.e., on soils, plants, water etc. (Van Den Ban, 1988). In practice, the farmers' household, i.e., wife/husband, children and others as the case may be, remains in charge of the decision that would be taken. This does not mean to put emphasis on the household alone, but also to look at their farm and opportunities corresponding to the introduction of the technologies. The characteristics of technologies are another issue that needs to be considered from the point of view of farmers, their farm and opportunities to predict whether the technology would be adopted or not. Each category must be
examined in relation to the other three, rather than in isolation.

These reciprocal relationships amongst the four categories allows for room to manoeuvre in technological changes. In the situation where the farmers, their farm and opportunities are relatively constant in the short run, the success of an intervention depends on the characteristics of technology that can be manipulated by the researchers and their associates in the technology development processes. In such cases, adoption can be enhanced by targeting research and extension in accordance with the farmers, their farm and opportunities that remain constant over the short run.

A technology bears specific characteristics after certain development processes. If this technology is kept constant, the change process would be more difficult than that of the first case, where technology is variable. In most cases, researchers and extensionists have very low influence on farmers' opportunities. Apparently, they have less power on the farmers (who are of certain age, sex and affiliated to one or more associations or otherwise) and their farm with its relatively fixed, specific bio-physical environment.
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Among these factors, the most difficult to change is the farmer, followed by his/her farm, his/her opportunities and the characteristics of technologies in descending order.

This indicates the importance of assessing the prevailing situation before developing a particular package of agricultural technology. A failure to do so will undoubtedly result in misfit among the variables associated to the four categories that affect adoption of agricultural technologies.

Moreover the above phenomena hints at an alternative choice of strategy for intervention. Choosing the weakest category among the four categories is the best wayout, when other categories are kept constant. For instance, an intervention that opts to change farmers to make them accept a given technology within their existing farm situation and given opportunities may end up with less success (in worst case none). Whereas an intervention that opts to modify technologies that are offered to farmers, such that it suits the existing farm situation and farmers' opportunities are likely to meet with more success. The first intervention is perhaps the polar opposite of the second one, as it tries to fit farmers into what the intervening party has to offer.

Further discussion about variables affecting adoption within and across each category is presented in the subsequent paragraphs of
this section (Rogers, 1969; Donald, 1970; Rogers, 1971; Schutjer and van den Veen, 1977; Feder, et al, 1982; Rogers, 1983; Fliegel, 1984; Swanson, et al, 1984; Binswanger and Pingali, 1988; Röling, 1988 a).

1) **The farm:** Physical production is highly dependent on the farm's physical and biological environments. These include, fixed factors such as topography, rainfall and soils on the one hand and variable factors such as weeds, pests and diseases on the other. The threats or opportunities for crop and animal production emerges from these bio-physical factors. The success of any technical intervention, among others, is judged by the extent to which the technical alternative(s) overcome the troubled farm situation from what is not, to what is desired.

2) **Farmers:** Farmers are all the more homogeneous within their households than within communities. With regard to the former, the distinction is due to the major areas of division of labour that is associated with respective roles. Within a community, the important distinction between farmers can be: a) age, b) gender, and c) associations. The relevance of technology to each of these sub-categories is one of the factors that determines its adoption. The influence of these sub-categories are elaborated below.
a) **Age group:** Farmers' age has a great effect on agricultural innovation. The resource endowment of a young farmer and an adult farmer are very often different. The interest, experience and expectation of a new couple and retiring couples can differ substantially. Hence, these differences should be considered during technology development, farmers' participation and transfer.

b) **Gender:** In some societies, females are purely tagged with domestic activities with marginal farm work. In others, women assume the responsibility of food crop production or the production of cash crops. In a situation where there are objective differences such as resources, rather than subjective differences between male and female that are rooted in the culture of a society, special attention needs to be paid to the former differences than the latter. As result of lack of knowledge as to who (male/female) does a particular job, many development activities have excluded women and faced the adverse consequences.

c) **Associations:** When farmers are organized in cooperative societies, they may easily adopt some technologies that require collective effort or that are relatively indivisible. Those farmers who are organized in a cooperative and those operating on their own have different farm structures that have different production opportunities and constraints. Consequently, what is
adopted by cooperative members may not be adopted by individual farmers. This is particularly true for labour/capital intensive and indivisible technologies.

3) Farmers' Opportunities: A farmer's reaction to technologies depends on the opportunities available to him/her. The opportunities that affect farmers' decision are: a) access to resources, b) access to institutional services, c) price opportunities d) access to infrastructure. These opportunities together constitute a development mix where each, if considered separately appear weak (Röling, 1988 a). For instance, extension which belongs to institutional service, with a corresponding price policy for farm inputs and output is much more efficient than if no such pricing policy exists. Each of the sub-categories are further elaborated as follows:-

a) Access to resources: The resources employed in farming can be classified into land, labour and capital (others are dealt with under the institutional services). Each of these resources affects the decision for adoption. Given a certain level of resource endowment, the adoption decision is made depending on whether the technology introduced is relevant or available to a household.

i) Land size: Other things being constant, land size can have different effects on the rate of adoption of a technology. More
specifically, the relationship of farm size to adoption depends on such factors as fixed adoption costs, risk preferences, education, credit constraints, tenure arrangements, etc., These factor determine whether a technology is relevant and available to a house hold. For instance, theoretical literature suggests that the larger fixed costs cause a reduced tendency to adopt and slower rate of adoption on smaller farms from the point of view of relative advantage. With regard to tenure arrangements, Feder's (1982) review of several studies on this variable does not show sound argument in regard to the relationship between the land tenure systems and innovations, except his review of the work by Newbery which implies that sharecropping could hinder adoption of innovations. Generally, technologies with prolonged prospects are particularly sensitive to tenure arrangements.

ii) Labour: Some new technologies are relatively labour saving, and others are labour using. This again has to be related to other factors (land size, capital, etc.). The demand for labour is particularly important if there is a seasonal demand variation i.e. in accordance with the farm operations. Farmers' decisions on a particular technology with respect to labour, undergo different alternatives in the light of claims and benefits derived from committing those labour resources. They may shift labour from one task to another as the case may be. After exhausting all feasible possiblities, they will not adopt a technology if it is labour using, as compared to the previous
iii) **Capital**: Even though differential access to capital is often cited as a factor affecting differential rates of adoption, there is no general agreement among practitioners on this variable. There is a debate between those who acknowledge the differential adoption of indivisible technologies due to capital endowment on the one hand and those who disregard the differential adoption of such technologies due to capital on the other (Feder, 1982). Generally, access to capital in the form of either accumulated saving or capital market is necessary in financing the adoption of many agricultural technologies.

b) **Access to Institutional Services**: Technological change, however low or high, requires external services that a farmer cannot provide him/herself. In this connection the cost of service from the farmers' point of view is a very important aspect that affects adoption of a relevant technology when it is made available. The impact of the cost of production in adoption decision is dealt with under the discussion of relative advantage (p. 42).

i) **Education**: Feder's (1982) review shows the role of education on the rate of adoption of new technologies in developing agriculture. Moreover, Igoan et. al. (1988), using the Pearson Product Moment Correlation found a relatively high and
significant correlation between levels of formal education, literacy and adoption of agricultural innovations. When the production processes are getting more and more complex, the level of education that is required to handle the processes needs to be comparable. For example, new crop varieties, pesticides, fertilizers, machines, etc require some formal education (e.g. simple arithmetic to be able to measure different items). Some studies suggest that more than five years of schooling is required to be able to utilize the recommendation associated with new technologies (Rogers, 1969).

ii) **Extension:** extension communication with educative and informative purpose is an important component in the promotion of technological changes. Under an efficient extension system, the higher the farmer's contact with extension agent, the better is his/her use of specifications on new practices.

iii) **Credit:** differential access to credit is one of the primary factors that affect adoption of technologies. It is one of the means to acquire capital. Therefore, lack of institutional credit is an important factor that limits the adoption of new technologies that use external inputs. Many studies suggest that access to credit may not encourage adoption if there is restriction on input use (e.g. level of pesticide/herbicides). This situation would hold even if the market price was favourable to farmers.
iv) **Input Supply:** an important factor in explaining the adoption pattern is the availability of complementary inputs. It is obvious that HYV seeds will not be adopted by most farmers unless (a) seeds are available and (b) some fertilizers are available; in most cases, the high-yield potential of the seed can be realized only if at least some fertilizers are applied. The geographic accessibility, timeliness and the quantity of supply are among essential considerations with respect to agricultural inputs. These factors explain the state of availability of technology and its complementary inputs.

c) **Price Opportunities:** Price of farm inputs and outputs are one of the essential aspects of farmers' incentive in technological change. In order to maintain farmers' adoption behaviour, a sound price policy, among others, is of paramount importance.

d) **Access to Infrastructure:**

i) Marketing channels for supply of the necessary inputs and outlet for the farm produce is one of the driving motives for the agricultural sector in general. Thus, adoption is adversely affected by absence or inefficient marketing service.

ii) Road network with conducive vehicles and a fair price undoubtedly facilitates the services mentioned under "b" above. Lack of roads is one of the frequently mentioned obstacles for rural development.
4) Characteristics of Technologies:

The characteristics of technology emerge from the content of a technology. A package of agricultural technology can be classified into 'hardware' or the material technology and 'software' or cognitive technology (Rogers, 1983; 1986). The hardware refers to fertilizers, seed, tools, etc., whereas the software refers to the information base for hardware, such as row planting method or fertilizer application, seeding rate, etc. The compatibility of the software and the hardware is very essential for utilization of a package of technologies. The relevance and availability of technology depends on the characteristics associated with hardware and software of a technology.

Characteristics of technology that affect its adoption can be classified into intrinsic and extrinsic characteristics (Donald, 1976). The intrinsic characteristics include: communicability or observability, complexity and divisibility. The extrinsic characteristics include: compatibility and relative advantage. These ones are related to the farmers' decision environments.

These characteristics depend on the nature of the technology development process, often called R & D. According to Beal and Meehan (1986) R & D has more or less distinct stages with respect to problem solving. These stages ranges from knowledge production
(basic or applied research) to product-adoption/utilization. In total six stages are identified. The degree of farmers’ participation in the R & D is one of the factors that determine whether the technology may be complex, observable, etc. To enhance farmers’ participation in the process of R & D, Participatory Technology Development (PTD) strategy introduces five stages: 1) how to get started, 2) finding things to try, 3) trying out, 4) sharing results, and 5) sustaining the process (see ILEIA, 1989).

Conceptual definitions of the characteristics of technologies are given below (Rogers, 1971; Donald, 1976; Adams, 1982; Rogers, 1983).

a) **Observability**: refers to the degree to which it is possible to visualise or communicate the projected results of an innovation. The more visible the function of innovation is, the easier its acceptance will be.

b) **Complexity**: refers to the degree of difficulty in explaining, understanding and utilizing an innovation.

c) **Trialability**: This refers to the possibility of testing an innovation on a reduced scale in order to evaluate results before using it on a larger scale.
d) **Compatibility**: This refers to the degree of congruence existing between the intrinsic characteristics of an innovation and characteristics of other elements relevant in the decision environment i.e., its consistency with values and belief systems management objectives, the level of technology and the stage of farm development of the intended utilizer communities. The greater the compatibility, the greater will be the adoption of an innovation.

e) **Relative advantage**: this refers to the degree to which an innovation is recognised as better than the idea or object it is intended to replace. From the utilizers' (members of household) point of view, relative advantage involves claims that a technology may make on farmers' time, labour, ease of application, and economic costs and the corresponding utility derived thereby. The economic costs include; cost of initial acceptance, as well as the relative costs of permanent use and socio-psychological costs (immediacy of reward, status-quo, power relations etc.). It must be noted that a change in factor prices, change in peoples' values and belief systems affect the relative advantage. Moreover the degree of relative advantage is affected by the risks and uncertainties involved in technology. Uncertainty is a situation where we have no full account of an event. Risk is uncertainty that can be quantified, and therefore, can be calculated by mathematical tools (Cancian, 1979). When a technology that is introduced to farmers is made complex beyond
the farmers' understanding and involves high risk, farmers would capitalize much on their risk aversion strategies.

With respect to the characteristics of technologies discussed above Rogers (1986) makes the following observation as a general feature.

" 1) The Observability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption.
2) The Complexity of an innovation, as perceived by members of a social system, is negatively related to its rate of adoption.
3) The Trialability of an innovation, as perceived by members of a social system, is positively related to its rate of adoption.
4) The Compatibility of an innovation, as perceived by members of a social system, is positively related to its rate of adoption.
5) the Relative advantage of an innovation, as perceived by members of a social system, is positively related to its rate of adoption."

From the preceding discussion it is apparent that adoption of agricultural technologies is affected by the situation on the farm, the farmers and their opportunities and the characteristics of technology. In other words, adoption is the outcome of the interaction among farmers, their farm, their environments and technology.
Therefore, a failure in adoption of a technology can be sought among those categories that affect adoption and their interaction. An attempt to improve adoption of technology is possible only if the shortcoming(s) among these categories is corrected.

In spite of this, the gap between potential and actual yield of farms (research centre, commercial farms, cooperative farms, smallholder farms) is interpreted from different points of view.

One school of thought indicates that yield gap differences between research centres and actual farmers' yield are manifested due to high-yield and high profit technology not being profitable for farmers and not being adopted by farmers. The other school acknowledges biological and socio-economic constraints that are caused by a research and extension gap. These two schools of thought are presented below to show the predominant interpretation of yield gap and to identify an area for manoeuver. Note that the interpretation of yield gap hints at the direction of intervention that may follow.

According to the first school (Fig.4.1), the gap observed between research station yields where possible bio-technical potentials are tapped, and that of potential farm yields is called the first yield gap. The gap occurs due to the experiment station technology that is not applicable to the farmers' field.
The second yield gap occurs between the potential farm yield and economic farm yield, when high-yielding technology is not profitable for farmers to adopt.

Figure 4.1 Conceptual Model of the Constraints on Farm yields

Source: Gomez (1985).
The third yield gap takes place between economic farm yield and actual farm yield. The last gap occurs when high-yielding and high-profit technology is not adopted by farmers (Gomez, 1985).

Gomez's second and third gaps seem to refer more explicitly to farmers. The second gap emphasises profitability to the farmers who are supposed to adopt a technology. The profitability could be determined from the claims and benefits arising in committing a resource to the processes of technological change. The benefits could be only small amounts of resource used, more results, good quality, less risk, etc., as it may be seen by farmers.

His third gap, however, needs an interpretation relative to the first and second gaps. One of the interpretations could be farmers do not adopt high-yielding and high-profit technologies due to some constraints that are not very well addressed by the technologies in question. These could be social or bio-physical constraints that prevail at the household and farm level respectively. The other interpretation could be farmers do not adopt high-yielding and high-profit technologies due to a lack of awareness about the technologies, motivation, etc.

The latter reasoning is one of the overwhelming beliefs preoccupying most agronomists. Under such conditions, the point of leverage can be easier, as the failure is already attributed
to farmers. In other words, examining the essence of the technology and the farmers' environments is not necessary for the improvement of adoption. Had the reasons for non-adoption been so explicit, several projects that claim to have produced such technologies could not have failed.

The other school is the one represented by Stoop (Fig. 4.2). He acknowledges two gaps in the conceptualization of rice yield between experiment station and farmers' field.

The first gap he considers occurs due to non-transferable technology and environmental differences between the experiment station's and the farmers' fields. The second yield gap occurs between the potential farmers' yield and actual farmers' yield, which he accounts for in the research-extension gap due to biological constraints (varieties, weeds, diseases, pests, etc.) and socio-economic constraints (costs and benefits, credits, input availability, know-how, etc.) (Stoop, 1988). The gaps among users basically emerge from the prevailing differences in farm structures, know-how, objectives, etc.

In order to narrow the gap between research centre yields and actual farmers' yields, a focus on the gap created by research-extension is the most feasible alternative rather than considering 'farmers' blame.
Therefore, the explanation of yield gap by Stoop is more related to the four categories that affect adoption than that of Gomez.

Figure 4.2 Conceptualization of yield Gap
4.2 Performance of Research-Extension Systems

Research and extension sub-systems are the main partners of producer sub-systems in the process of knowledge generation and utilization. A mentally constructed entity that is surrounded by environments, where researchers, extensionists and producers are included is called the Agricultural knowledge System (AKS). AKS itself is a part of a larger system which encompasses its environments from which opportunities and threats emerge. The elements in its environment include socio-economic, political and agro-economical phenomena that are in a continuous state of change. Among the elements in the environment of AKS, policymakers largely contribute to the external force for change. These notions are treated extensively in several works (Nagel, 1979; Havelock, 1986; Swanson et al; 1988; Sims and Leonard, 1988; Engel, 1988 a, 1989; Röling, 1988 a & b, 1989, etc.). However, the practitioners are not unanimous in agreeing what the elements of the core sub-systems and their environment are.

Each element of the AKS contributes to the major knowledge processes such as generation, transformation, transfer, etc. (Engel, 1988 a). For instance, technology developed by the research sub-system is ultimately transferred to users sub-system. Performance of research-extension systems are judged on the basis of the adoption of technologies produced by the systems (Kaimowitz, et al, 1988).
According to Engel (1988 a) the system's performance is "the degree to which the system succeeds in producing the necessary knowledge. The intermediary outputs of the system may contain scientific insights, lessons from experience, technical recommendations or otherwise solutions and answers to problems the primary producers face within the specific domain. The output may be presented in the form of experts, different classes of documentaries, audio-visual or other information, database, software, knowledge-based systems and the like. These (half) products, reflect the 'the state of the art' of the knowledge available within the system." Performance is affected by relevance and availability of a technology. Relevance and availability of technologies are in turn affected by several variables related to farms, farmers, farmers' opportunities and technologies. Neither relevance or availability can fulfill conditions for high performance (Fig. 4.3). As it is apparent from the figure, the factors affecting relevance and availability emerge from the four categories affecting adoption. The latter is an indicator of performance at the technology level of research-extension sub-systems. Adoption can take place if, and only if, both relevance and availability conditions are satisfied.
FACTORS AFFECTING RELEVANCE & AVAILABILITY

FARM

FARMERS

FARMER'S OPPORTUNITIES

CHARACTERISTICS OF TECHNOLOGY

FACTORS AFFECTING PERFORMANCE

RELEVANCE

AVAILABILITY

PERFORMANCE

ADOPTION

Figure 4.3 THE CONCEPTUAL MODEL
That is to say adoption will not take place unless a relevant technology is made accessible. The higher the adoption of technologies produced by research and extension sub-systems, the better is the performance.

Kaimowitz and his associates, (1988) identified five criteria for the analysis of performance evaluation of the relationship between agricultural research and technology transfer. These are: system integration, availability, relevance, institutional sustainability and responsiveness of new technologies to resource-poor producers. They regard adoption as the best way to assess the relevance of widely available technology.

The study by Kaimowitz (ibid), is geared towards the overall institutional and technological performance. In this study, unlike theirs, the focus is on the technological level performance of the research and extension sub-systems. Hence, 1) integration of research and extension sub-systems is not studied, 2) Responsiveness to resource poor farmers is addressed by a relevance and availability test that is employed in relation to the variables discussed under the four major categories that affect adoption (farm, farmers, farmers' opportunities and characteristics of technology), 3) Institutional sustainability is not studied.

The conceptual framework is utilized to develop the research model employed to assess the relevance and availability of technologies of the case study crops (Ch. 5).
5.0 RESEARCH METHODOLOGY

5.1 The Research Model

In assessing the relevance (R) and availability (A) of sorghum, maize and tef technologies and their complementary inputs, the following model is employed (Fig 5.1). In the model the relationship between Relevance(R) and Availability(A) to Performance(P) of the research-extension systems is indicated. The technology level performance of research and extension sub-systems with respect to the case study crops are assessed on the basis of this model.

5.2 The Case Study Areas and Crops

The study has been undertaken in three selected regions of Ethiopia (1) Kuro, in the Eastern Hararghe Administrative region, in the vicinity of the Alemaya University of Agriculture (AUA), (2) Boffa, in the Eastern Shoa Administrative region, in the vicinity of the Institute of Agricultural Research's centre at Nazret and (3) Kurkura in the Eastern Shoa Administrative region in the vicinity of the Debreziet research centre of the AUA (for approximate location of the research centres see Fig. 5.2). These sites were selected for the case study having taken into account their accessibility for data collection and the combination of research and extension organizations practiced.
In these areas, the source of technology may be from IAR and/or AUA, while extension is done largely by the Ministry of Agriculture (MoA) and to a limited extent by AUA in the vicinity of its research centers.

Figure 5.1: THE RESEARCH MODEL
Figure 5.2 The Study Areas (see the Numbers: I, II, and III)
The crops selected for the study are Sorghum, Maize and Tef. They are selected because of their importance to the country’s food crop production and the research efforts done on these crops. In order to answer the research questions, specific production packages were considered for each crop.

The selected packages for the present study are:

Sorghum: Seredo variety
Maize: AL composite and katumani varieties
Tef: DZ-01 354, DZ-01 196 and DZ-01 199.

5.3 The Field Work

5.3.1 Selection of Respondents and Method of Data Collection

The Institute of Agricultural Research (IAR), the Alemaya University of Agriculture (AUA) and the Ministry of Agriculture (MoA) were approached for the background information on the technologies transferred to the farmers. These include components of a package, supply of inputs, price of inputs and farmers produce, etc. On the users side, individual farmers and cooperative members were approached in order to understand their practices and problems that would help in the assessment of the relevance and availability of technologies claimed by research and extension.

The available research reports were examined and informal discussions with concerned researchers and extension personnel
were held to identify the packages available for the crops. Thereafter, an interview schedule was prepared for researchers, extensionists and farmers. Researchers were asked about the initiation of the project (objectives), the development process and the specific components. Extensionists were asked about the components of the package they disseminate to farmers, the feedback to researchers and the problem they face, etc. The farmers' schedule covers all activities from land preparation to storage including seed and within these processes, what they received from extension/research, how they reacted to it (adaptation/adoption/rejection), the logic behind their measure etc. were included.

The choice of the respondents was based on Purposive sampling method (see Bernard, 1988) i.e., potential respondents who have relationships with the varieties were selected with the researcher's knowledge. Regardless of the researcher's preference, all respondents among research and extension personnel turn out to be male. Selection of the farmers interviewed was made with the assistance of the extension agents. The agents were helpful in explaining who received a particular crop variety and its location. With regard to farmers, approaching women household heads was not possible in the short period available as the extension agents in the areas do not have direct contact with women farmers.

The farmers were selected on the basis of: farmers' status:
contact farmer, non-contact farmer; literacy: basic literacy and above, illiterate; farm experience (age): young, mid-aged, + 50; crops grown: used one of the recent varieties of sorghum, used improved maize variety, grew tef. The farmers were interviewed in their fields, as well as at the Service Cooperative.

In the end, 7 researchers, 2 extension SMSs, 4 extension agents, 7 research and 5 extension administrators were interviewed from IAR, AUA and MoA. On the farmers' side, 17 individual farmers operating their own plots and 3 executive committee members/team leaders of Producers' Cooperative were interviewed (see Table 5.1).

Table 5.1 Summary of Respondents (farmers) per Area and Crop Varieties

<table>
<thead>
<tr>
<th>Varieties</th>
<th>No. of Farmers</th>
<th>Study Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seredo</td>
<td>4*</td>
<td>Boffa</td>
</tr>
<tr>
<td>Katumani</td>
<td>11*</td>
<td>Boffa</td>
</tr>
<tr>
<td>AL-Composite</td>
<td>4**</td>
<td>Alemaya</td>
</tr>
<tr>
<td>Tef</td>
<td>4</td>
<td>Debreziet</td>
</tr>
</tbody>
</table>

* 1 Cereal Team Leader of the Producers' Cooperative (PC) in the area
** 1 Cereal Team Leader and a member of the PC in the area

The extension Officers and research personnel were interviewed at their offices. The extension agents were interviewed in their village offices and in the fields during the visits held with
farmers.

The entire field work was done by the researcher, without any use of enumerators. The researcher has benefited much from his acquaintance with people and the farming system of the Alemaya study area where he was brought up and worked closely for two years with farmers as part of his job at the Alemaya University of Agriculture. Data collection in other study areas, among others, was facilitated by schoolmates who held positions in regional offices and Headquarters. The researcher's ability with the local language spoken in the study areas was one of the few important opportunities that assisted the data collection.

5.3.2 Field Problems

As the research agenda is mainly dealing with human-elements, there were some problems beyond the control of the researcher that affected the depth and breadth of the assessment. The problems are transportation (travel in city/towns was made by taxi), the visits to the rural areas that took much more time than expected and deferred appointments. These problems were aggravated by lack of telephone, high mobility of resource persons on official duties, or their occupation in meetings.
6.0 RESULTS AND DISCUSSION

6.1 The Case of Sorghum Production in the Nazret Area

6.1.1 Description of the Farmers’ Management Practices.

Sorghum is one of the major products in the area. It is next to only maize and tef (Mulatu and Regassa, 1987). Farmers in the area grow four types of sorghum, which they characterize based on head type, colour etc. The common sorghum varieties/types grown in the area are late maturing types that are considered as local varieties. The major farm operations involved in sorghum production in the area are as follows (1) land preparation, (2) sowing, (3) cultivation (shilshalo), (4) weeding and (5) harvesting.

In the land preparation, the main source of power is oxen power. Few farmers and the Producers’ Cooperative in the study area use tractors for the first ploughing. The tractors are rented from the Service Cooperative in the area. One of the farmers who were interviewed used to rent a tractor for the same purpose, but he abandoned it in the 1989 cropping season as the rent per hectare had risen from $ Eth. 27 to $ Eth. 77. Land has to be ploughed 2-3 times by oxen before sowing. The land preparation starts shortly after the beginning of the rainy season. After land preparation is completed, sowing proper starts which presupposes the availability of rain. The sowing is done by broadcasting the seed
by hand over the field. Each field is sown with only one type of crop i.e. a sole crop (a practice, they said, that has been practiced by their great-grandfathers). Together with sowing, those farmers who can afford fertilizers apply fertilizer by broadcasting. Among the farmers interviewed, only six had ever used commercial fertilizer, three had never used it and two who had got it from relatives in the neighborhood, had used it during the 1989 cropping season. The reported reasons for not using commercial fertilizer are lack of money, lack of fertilizer and substitution by manure. The commonly used fertilizer in the area is DAP. The preference of DAP over Urea is because Urea burns crops they said. Some farmers indicated that urea is good only if there is a lot of rain. The farmers use colour connotation to differentiate DAP from Urea, black for DAP and white for Urea. With respect to their knowledge about the nutrient content of DAP and Urea, some farmers, those who are more educated and are among the contact farmers, indicated that "DAP is useful for seed development whereas Urea is useful for the crop stand." However, all of the farmers interviewed at least know the time of DAP and Urea application. The differential preference of the fields fertilized was reported by farmers. Fertilization of a particular plot depends on the yield of the field in the previous harvest and the type of crop planned to be sown on that land. Price of the crop is one of the indicators to fertilize a plot of land. The criteria mentioned above holds for the fertilization with commercial fertilizer and manure as well.
In regard to sowing and fertilizing, there are two important decisions that have to be made. These are the seed rate and the rate of fertilizer application.

Farmers determine seed rate on the basis of their experiences. Their experiences show negative correlation between the seed rate and the amount of moisture during planting. In addition to this, farmers take into account the quality of land preparation as that also affects seed emergence. One farmer reported that instead of sowing little seed and having poor crop density, it would be preferable to thin it after safe emergence. Besides the moisture level, farmers also consider the amount of crop stand that may be uprooted during the cultivation practice that is called 'shilshalo', also done by oxen.

In the case of rate of fertilizer, most farmers reported their previous experience. The rate of fertilizer depends on the amount of fertilizer that one can buy. According to those who have used commercial fertilizer, the rate varies between one quarter to half the recommended rate i.e., 100 kg/ha DAP, and 50 kg/ha Urea. The method of application is broadcasting.

The next operation after sowing and fertilization is cultivation i.e., 'shilshalo.' Shilshalo is done when the crop stand is a little above the 'maresha', the plough share. The main reason to undertake this practice is to enhance soil aeration, water
percolation and to facilitate the hand weeding that follows (Urea which is recommended to apply during cultivation, is not used by farmers). Most farmers do not frequently weed sorghum fields due to the overlapping work in other plots. Therefore only one weeding of major weeds is done.

After weeding, some farmers reported bird scaring that lasts until the crop is fully matured. The final operation is harvesting which involves top-heading, gathering and finally, threshing during the dry season. The farm work is mainly the men's job. Women and children may help in weeding and particularly in the harvesting processes. Besides the family labour, they form working groups particularly during harvesting. This working group is called 'Jige'. Two farmers reported that such working groups are not good to use particularly during sowing and cultivation (shilshalo). These two operations require more careful work than others, they said. Some farmers store their produce in sacks, and some in bins. The problem of storage pests such as weevil was reported by all farmers interviewed.

The yield for sorghum on average stands in the order of 6-9 qt/ha. The major production constraints reported by the farmers are: drought, pests, particularly storage and poor soil fertility.

Both individual farmers and the cooperative members in the area
share the major agro-ecological constraints such as problems of moisture, bird attack, low soil fertility (relative differences are obvious), etc.

The major source of difference emerges from their difference in farm structure. The cooperative has enough pairs of oxen so that it can finish critical operations such as sowing. Besides, it has access to credit from the service cooperative or Government banks to buy sufficient fertilizer and other inputs.

Their method of sowing is by and large broadcasting. The method of fertilizer application on crops sown in rows is line application. The reason for minimal row sowing according to the cooperative's team leader is the problem of time and its labour requirement during sowing which is at a critical time. He added, a delay of one day brings much difference in the field at germination. Such uneven crop stands, he said, makes it difficult during cultivation.

The cooperative's farm practices manure harvesting technique in their stable after harvesting.

Both Cooperatives and individual farmers sell their produce to Service Cooperatives, which in turn sell it to AMC.
6.1.2 Technology of Sorghum Introduced

In order to improve Sorghum production in the area, two short-season improved varieties, viz., Gambella 1107 and Melkamash 79 were distributed to the farmers in the area. These two varieties were not adopted due to their susceptibility to Quela bird attack. Consequently, the intervention intended to overcome the poor yield of the local varieties failed.

Following that, researchers at the Nazret research centre began screening of varieties that are early maturing and tolerant to Quela bird attack. In the screening trial, 22 red and brown, and two white seeded (check) sorghum varieties were used (Regassa and Mulatu, Sept. 1989). The on-farm screening trial lasted for three years (1984-86). It was conducted in collaboration with the extension workers in the trial area. Farmers were involved in the trial management and variety evaluation. Based on the results of the three years on-farm trial, the Seredo variety was and still is recommended for the Nazret area and others that have similar Sorghum production constraints and utilization patterns (Ibid, p.4).

Seredo originated in Uganda and was introduced to Ethiopia through the Eastern African Coordinated Regional Sorghum Trial. It is a brown-seeded, high tannin, bird tolerant sorghum, best suited for bird-prone areas. This variety can be useful for
lowland areas (below 1600 m) that have problems with birds (Belayneh, 1988).

The Recommended Packages (R) for Seredo variety are:

R1 = The Seredo variety
R2 = Seeding rate = 10 Kg/ha
R3 = Method of planting: Row planting
R4 = Fertilizer
R5 = Rate of fertilizer; 100 kg/ha DAP and 50 kg/ha Urea
R6 = Method of fertilizer application: Side dressing.

6.1.3 Relevance of the Introduced Technology

Sorghum Seed - Seredo Variety

So far the farmers' response to the Seredo variety with respect to Quela bird attack is positive. In this respect the technology has shown relative advantage over the traditional varieties. However, some farmers have indicated their suspicion which is implied by their comment on the periodic occurrence of Quela bird attack in the area. Comparing with their tall varieties, farmers particularly appreciated its short height that eases the top-heading during harvesting (see Table 6.1)
In the Producers' Cooperative farms in the Boffa area, the Seredo variety was over sown in the field with a traditional variety after it was affected by early drought. This resulted in the Seredo variety showing better plant vigour and yield prospects than the traditional variety which is perhaps an indication of its earliness.

Assessment of the consumer tastes associated with food quality and yield level of the variety was not possible as the crop was only nearing maturity during data collection.

The attributes of the variety that are mentioned above have made it compatible to the farmers' harvesting practice. Its tolerance to birds and better field performance increased its relative advantages. The suspicion of the farmers' and its actual yield under farmers' management remains to be seen.

**Seeding Rate**

Farmers determine seeding rate, among others, on the basis of the available moisture at the time of planting, rather than on the area to be sown. Besides the moisture level that affects germination, farmers take into account the plant damage during cultivation by oxen. In this regard they follow risk averting strategies. The seed rate recommended by research centres which is based on the technical optimum (reflected by area i.e., per ha), does not address the farmers' risk and uncertainty. For
researchers such rates are the outcome of many 'normal' years where they do not bear the immediate consequences of the 'bad' year. On the farmers' side they bear the responsibility of ensuring the livelihood of their family. Therefore this recommendation is not relevant due to its failure to address risk and uncertainty against the farmers.

Row planting

Row planting normally presupposes mono-cropping. In this area, even though farmers do practice mono-cropping (note that different plots are sown with different crops as opposed to specialization), the sowing method remains broadcasting. Row planting is known to them through demonstrations undertaken in their vicinities and these days on cooperative farms. I am confident that the farmers are fully aware of the advantage of row planting. As to why they do not practice it, the comment made by one of the farmers interviewed is sufficient to explain.

"Row planting with oxen needs three persons. One person operates the plough, the second person drops the seed following the farrow, the third person covers the seed." This situation he said, would make it difficult for them.

In the area, the cooperative farm itself does practice limited row planting due to the problem of labour to cover the fields on time. Apparently, the practice does not take into account the shortage of labour, the urgency of sowing, the lack of equipment
that may speed up sowing. As a result the recommendation fails the relevance test by any standard.

**Fertilizer**

Fertilizer is one of the technologies whose effect is discernable by farmers. It is not complex to the understanding of farmers. Its response is easily observable to farmers who are used to using manure for the same purpose. The farmers in the Boffa area are no exception. Hence fertilizer as a material is highly relevant. The relevance of fertilizer in this sense should be considered only from the bio-physical response point of view which is accepted by farmers. The fact that farmers accept fertilizer technology is not in itself sufficient reason to include the technology in a package. Its relevance should be seen in the light of its availability (see 6.4). The same holds true for other purchased technologies such as pesticides and herbicides.

**Rate of Fertilizer**

The rate of fertilizer application is a function of the amount of fertilizer one can afford to apply of the recommended level (see availability). Owing to limited supply farmers apply far lower than the recommended rate. Given the present level of fertilizer supply, the recommendation is not relevant.
**Method of Fertilizer Application**

The method of fertilizer application of farmers corresponds to their method of sowing. Individual farmers who sow their farms using a broadcasting method, do so for fertilizer as well. The recommendation is not compatible to farm development and farmers' previous practices. Therefore it is not relevant.

6.1.4 **Availability of the Introduced Technology**

The seredo seed and fertilizer are the two material technologies that are accompanied by their methods of utilization.

**Seed**

The supply of seed for Seredo in the Boffa area is limited. In the first year it was distributed only to ten Contact Farmers and the Cooperative. The total farmers under the coverage of the extension agents in the Service Cooperative is 2150 (151 female).

**Fertilizer**

Fertilizer is supplied to farmers by the Agricultural Input Supply Corporation (AISCO) of the Ministry of Agriculture, through Service Cooperatives. Service Cooperatives distribute fertilizers to its members on a credit basis with 15% down payment. If a farmer could not pay his debt of the previous year, he is no longer eligible for credit. If most of the members of a Service Cooperative could not pay their debt, then the Service Cooperative will not get fertilizer quota from AISCO. Due to the effect of this regulation, there has been no fertilizer...
distribution in the Boffa area since 1987 crop season. The amount distributed last was 353 quintals of DAP.

Table 6.1 Summary of Relevance and Availability of Technology for the Seredo Variety.

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Relevance</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seredo Variety</td>
<td>relevant</td>
<td>limited availability</td>
</tr>
<tr>
<td>Seeding Rate</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Planting</td>
<td>not relevant *</td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>relevant</td>
<td>not available</td>
</tr>
<tr>
<td>Rate of Fertilizer</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Fertilizer application</td>
<td>not relevant</td>
<td></td>
</tr>
</tbody>
</table>

* = not applicable to cooperative farms.

6.2 The Case of Maize Production in the Nazret and the Alemaya Area

6.2.1 Nazret

6.2.1.1 Description of the Farmers' Management Practices

Maize is the major crop grown in the study area in terms of the area coverage. More than two-thirds of the farmers in the area grow maize. 'Chore' is the local maize variety that was grown by farmers. It matures about 210 days after planting. Its sowing period starts from early May after the showers of the small rainy season.
The main management practices and the logic of maize production are by and large similar to that of sorghum. These are land preparation, sowing, cultivation (shilshalo), weeding and harvesting. Farmers in the area allot relatively fertile land for maize production. The priority of manure or commercial fertilizer application also goes to the maize field (Mulatu and Regassa, 1987). This is due to the span of food supply from farmers field and the yield level, as compared to sorghum.

6.2.1.2 Technology of Maize Introduced in the Area

From the survey of production constraints conducted in the area, the intervening drought period that occurs before the main rainy season and the late maturing variety were identified as the major reasons that reduce maize yield.

In order to overcome the problem, a short-cycled variety that matures within the main rainy season was recommended. The variety recommended to meet this specification is called Katumani.

The Recommended packages (R) for katumani are:

R1= Katumani seed
R2= Seeding rate= 20-25 kg/ha
R3= Planting date= 8-28 June
R4= Method of planting: Row planting- Spacing between plants 20-25 cm- Spacing between rows 75 cm - Tide-ridge (6 m)
6.2.1.3 Relevance of the Introduced Technology

Maize seed - Katumani Variety

Katumani variety has been in use in the area for over ten years. The variety is very well fitted to the area's rainfall pattern. Farmers use the variety as a security crop. When they see the occurrence of early rain, they sow the long maturing variety, otherwise Katumani. This attribute makes the variety responsive to one of the objectives of its introduction in the area (see Table 6.2)

Farmers' yield in the Boffa area shows a wide range. The reported yield for the 1988 cropping season was 5.2-33 qt/ha. The cooperative farm obtained 22 qt/ha in the same season. The figures used to calculate the yield were obtained from farmers. As the area and production is not based on the researcher's measurement, the figure is highly suspect (maize consumption starts at green stage that is not measured, also land measurement varies from place to place). The yield of maize (all varieties) in the area is about 8 qt/ha (Mulatu and Regassa, 1987).

According to the recommendation, the yield of the variety that can be achieved is 30.3 qt/ha. This shows a substantial gap between research results and that of farmers'. The cause of the gap among others can be the methods of production that are not relevant to farmers (see below) and the shortcomings of the variety that are reported by the farmers - the latter factor needs
further investigation.

As far as the consumer taste is considered its white colour is compatible with the farmers' taste. Therefore, the variety is relevant from the above points of view.

Some shortcomings that are reported by farmers in the study area are:
* short and compact stand - it does not provide enough fodder for animals.
* weak anchorage (poor root system)
* susceptible to weed - requires more weeding
* susceptible to storage pests
* light in weight - poor market value
* low in yield as compared to local variety

**Planting date**

The planting date depends on the rainfall pattern over which no one has a reliable forecast. The planting date recommendation for Katumani is fairly wide. Even then farmers reported later planting dates due to activities on other plots and waiting for rainfall. Even though it is agronomically sound to determine a planting date for certain types of crop, recommending a calendar date of planting in the face of unreliable weather has an adverse effect on the intervening party. Therefore, the recommendation has no relevance for the farmers whose livelihood is based on
engineering crop enterprise.

**Seeding Rate**

Like the case of Sorghum, farmers determine the rate of seed according to moisture level. The farmers' rate varies as much as 2 to 3 times that of the recommended rate i.e., 25-30 kg/ha. They increase the rate to reduce risk of poor emergence. The rate that is by and large determined on the basis of technical optimum is not relevant to farmers.

**Row Planting**

Farmers in the area use the same technique of planting for both sorghum and maize which is broadcasting. Both the tied-ridge and row planting are not followed by farmers due to shortage of labour and urgency of the sowing operation. Hence the recommendation is not relevant.

**6.2.1.4 Availability of the Introduced Technology**

The material technology in the package of katumani is its seed. Generally the seed is in the farmers' hand. Even then, there is a problem of fresh seed as farmers need to replace the seed they used after 2-3 years. Hence, seed for replacement is not available.
Table 6.2 Summary of Relevance and Availability of technology for the Katumani Variety.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Relevance</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Katumani Variety</td>
<td>relevant</td>
<td>partially unavailable</td>
</tr>
<tr>
<td>Seeding Rate</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Planting Date</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Planting</td>
<td>not relevant</td>
<td></td>
</tr>
</tbody>
</table>

6.2.2 Alemaya

6.2.2.1 Description of the Farmers' Management Practices

Maize production is second to sorghum in the coverage area for Hararghie Regions (CSA, 1987). In Alemaya, the area covered by maize has increased since the early 1980's.

The individual farmers in the area depend on human and oxen power for land preparation. Sowing takes place after enough rainfall as determined by farmers. It is done by broadcasting, which is followed by 'Maresha' or 'Akaffa' an operation to turn the soil by way of loosening and covering the seed. 'Maresha'a is an oxen pulled plough whereas 'Akaffa' is operated by a person. Unlike farmers in the Boffa area, farmers in the Alemaya area grow crops in inter-cropping. As many as five crops could be inter-cropped, but commonly three. This practice is rooted in the Hararghie farming systems. Sorghum and maize are sown together.
Haricot bean is harvested twice from a field sown with sorghum and maize.

In about a month after sowing, the first cultivation 'Hagay' starts. It is done with aim of weeding, loosening the soil and moderating the over populated spots. The farmers in the Alemaya area do this practice entirely by human power, using 'Akaffa'.

The second cultivation, 'Keaba' is carried out in about three months after sowing. When the second cultivation is done, a second sowing for haricot beans is undertaken. Farmers who can obtain and afford fertilizer apply during the second cultivation. At this stage, thinning is done with the purpose of standardizing the field. The thinned product is used for animal feed, which is a dependable source of feed during the period. The other source of animal feed from maize is its tassels, that are removed during August-September.

Dried maize harvesting takes place in October/November. Farmers use different storage systems depending on the amount of their produce. Pits, bins and sacks are the type of storage systems in the area.

The major farm problems in the area as reported by the farmers are drought and storage pests. Lack of fertilizer is reported by
most of the farmers approached at different times.
The farmers organized in Producers' Cooperatives use tractors for land preparation. Other operations are done by 'Akaffa'.

6.2.2.2 Technology of Maize Introduced in the Area

Owing to the low yield of the traditional maize variety grown in the area, researchers in the Alemaya University (the then College of Agriculture) launched a research project on the development of high yielding varieties. Alemaya was the basic testing site. Bako, Awassa and Jimma were satellite stations for testing. Development of the variety lasted for 4-5 years. Researchers from IAR have participated in the development of the variety. Farmers have participated in on-farm trials and providing feedback to researchers on their evaluation.

One of the varieties developed for Alemaya and other areas with similar agro-ecological factors is AL-Composite.
The Recommended Packages (R) for AL-Composite are:

R1 = AL-Composite seed
R2 = Planting date - slightly varies - for the Alemaya area, mid April to first week of May
R3 = Method of planting: Row Planting - row to row spacing 75 cm and 30 cm between plants
R4 = Fertilizer
R5 = Rate of fertilizer: for most of the locations 75-100 kg/ha of P<sub>2</sub>O<sub>5</sub> and 75-100 kg/ha of N fertilizer are recommended with a possibility to use specific recommendations, if available.
R6 = Method of fertilizer application: Application of fertilizers should be in rows to avoid wastage and ensure effectivity. DAP fertilizer should be applied at the time of planting. Care should be taken to avoid seeds coming into direct contact with the fertilizer. It is recommended to apply N fertilizer in split applications. The first application at the knee high stage.
R7 = Method of Weed Control: Cultivate the field or use Herbicides to destroy weeds particularly at the early stage of the maize.
R8 = Method of pest control: - If there is an outbreak of army worm, spray Malathion or other similar chemical.
   - If too much borer infestation is anticipated, use DDT in solution or others such as Diazunon in granules and apply at the early stage of the maize.
Remarks [ by researchers ]

* use of such kinds of chemicals also destroys the natural predators so a refrain has to be made from using the same chemical over and over again.

* Another practice such as cleaning the field and destroying the plant refuses on which the borer disposes could minimize the borer population and its eventual infestation.

* Store the seeds in cool and clean storage. If the storage is air tight it avoids any spoilage. Use of chemicals such as phostoxin keeps grain free from insect attacks, etc.

Source: Mekonnen, 1979

6.2.2.3. Relevance of the Introduced Technology

AL-Composite seed

The high yielding capacity of AL-Composite attracted the interest of farmers a great deal. Its vigour and tall plant stand made it possible for large amounts of by-products for animal feed and firewood. As a result of these relative advantages the variety became representative in the Alemaya area (see Table 6.3).

The yield of the variety under individual farmers' management is 12-16 qt/ha. Some cooperative farms obtain 35-40 qt/ha (still a few scoring above this level). The research centers reported 80-100 qt/ha on repeated observation. From the figures, the yield
gap in this variety is indeed very high. Its yield under individual farmers is 5 to 6 times less than that of the expected yield (80-100 kg/ha). The cooperative farms obtain 2-3 times less. Apparently there seems to be a substantial difference between individual farmers and cooperative farms. The interesting thing is how to reduce the gap between these farmers? What are the reasons behind the yield variation between farmers and that of research centres?

To begin with the first question, crop management practices merit special attention when a yield gap between cooperative and individual farmers is dealt with. Generally, it is erroneous to compare the yield of two different crop management practices. The realistic picture of yield in individual farmers’ fields can be reached with consideration of the total crop production in a plot of land over a specific crop season, rather than considering one or two crops seen as ‘important’ by outsiders (e.g. researchers). Individual farmers in the area produce maize, sorghum and at most two harvests of haricot bean. Hence, a measurement of yield that disregards other crops that are intercropped, would lead to a great underestimation of the individual farmers’ practices. Statistics that do not consider variation in cropping pattern are obviously misleading.

The aforementioned figure on individual farmers’ yields also do not indicate the overall crop production per unit area.
Therefore, the gap between individual farmers and cooperative farmers is less worrying than it appears to be. Individual farmers might be as efficient as those of cooperative members within their own farming systems.

The second question may be addressed by the researchers' verdict on the packages of technologies promoted. Upon setting targets, they have clearly indicated the conditions that have to be fulfilled to tap the potential of the variety. The reason for the occurrence of such huge gaps is the absence of these conditions as a result of which some components of the technology become irrelevant (see below).

The yield of the cooperative farms is an indication of the possibility to improve the yield towards that which the researchers achieve. The cooperatives in the area are established on relatively fertile and uniform lands. They use tractors for land preparation i.e good seed bed, less weed, high water percolation. Besides, they are eligible for credit, and better fertilizer supply whereas the individual farmers do not get such facilities. This suggest the prevalence of a gap in both research and extension that among others resulted in the yield gap.

**Planting date**
Alemaya is the home of AL-Composite. The recommended planting date is more location specific and shows high coincidence with
that of farmers. Therefore the recommendation is relevant in the area.

Row Planting
In the Alemaya area, as anywhere in the crop-culture of the Harargie regions, inter-cropping is rooted in the farming systems. As it was indicated earlier, as many as five crops can be inter-cropped. This practice, coupled with the existing level of farm tool development, makes it difficult to shift to row planting. The cooperatives in the area, however, follow the row planting system with a labour intensive strategy. Hence, this recommendation is not relevant to individual farmers who, unlike cooperative farmers, can not afford labour.

Fertilizer
Introduced by the Alemaya University of Agriculture and MPP, fertilizer is one of the commonly utilized new technologies in the area. Its relevance for the area is unquestionable.

Rate of Fertilizer
The farmers in the area apply one quarter to half of the recommended rate of fertilizer. The main reasons being the limited supply and high price. Therefore, in the light of these situations, the recommendation is not relevant.

Method of fertilizer Application
Farmers do use both DAP and Urea fertilizers. Like elsewhere,
their method of application corresponds with their method of sowing i.e broadcasting. Hence, the recommendation is not relevant as it does not fit farmers’ practice and the development of their farm tools.

**Method of Weed Control: Cultivation/Herbicide**

Farmers in the area use intensive land preparation to reduce weed infestation. Cultivation reduces the subsequent weed infestation. However, I did not come across any farmer who used herbicide. As far as the recommendation is concerned the cultivation aspect is highly relevant as it is compatible to the farmers’ practices.

**Method of Pest Control**

Both army worm and stalk borer do occur in the area. The occurrence of the army worm is one of the reasons that initiate farmers for government support, the others being hail, flood and extreme drought. From the farmers’ point of view the chemicals recommended are found efficient in solving the field problems. Therefore, it is relevant.

**6.2.2.4 Availability of the Introduced Technology**

The material technologies that are accompanied by method of utilization are AL-composite seed, fertilizer and pesticides. The state of availability of these technologies is discussed below.
Seed
After its wide-spread use in the area, the seed of the AL-composite is localized in the farming community. However few cooperative farms still collect seed from the university when the need arises. Generally the area is seed self-sufficient in maize production.

Fertilizer
The Alemaya area is also under the AISCO fertilizer credit policy (see p 70). For the same reason the Service Cooperative does not get fertilizer. Hence fertilizer is not available.

Pesticides
Farmers in the Alemaya area report that the Ministry of Agriculture provide them with pesticides when army worm outbreak takes place. However the timeliness and the availability of equipment is reported to be poor.

Table 6.3 Summary of Relevance and Availability of Technology for the AL-Composite Variety.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Relevance</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>AL-Composite Variety</td>
<td>relevant</td>
<td>available</td>
</tr>
<tr>
<td>Planting Date</td>
<td>relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Planting</td>
<td>not relevant *</td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>relevant</td>
<td>not available</td>
</tr>
<tr>
<td>Rate of Fertilizer Application</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Fertilizer</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of Weed Control</td>
<td>relevant</td>
<td></td>
</tr>
<tr>
<td>Method of Pest Control</td>
<td>relevant</td>
<td>not available</td>
</tr>
</tbody>
</table>

* Not applicable to cooperative farms
6.3 The Case of Tef Production in the Debreziet Area

6.3.1 Description of Farmers' Management Practices

Tef (Eragrostis tef) is a land race. Its major production practices are land preparation, sowing, weeding and harvesting. The colour types that are grown by farmers are white and red. The land preparation of tef requires more ploughing than other large or medium grain cereals. As many as 10-12 ploughings were reported by the farmers visited. The common frequency of ploughing is 7-9 times. Sowing is done by broadcasting. The sowing of tef requires rather more moisture than other cereals. White and red tef are sown separately.

6.3.2 Technology of Tef Introduced in the Area

The major problem that initiated the research on this package was low yield in tef. In the 1960s germplasm collection was made in major tef producing regions of the country. After 4-6 years of selection, three varieties of tef were identified. These are: DZ-01-354, DZ-01-196 and DZ-01-99.

The selected varieties were tested under farmers' management practices. The package of tef in those days was, therefore, only the improved varieties. After the major achievement in tef breeding techniques in mid 1970s, other tef varieties were also developed and released. Management practices became available
also to those varieties that were developed earlier.

**Recommended packages (R) for tef are:**

<table>
<thead>
<tr>
<th>Package (R)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>Varieties - DZ-01-354, DZ-01 196 and DZ-01-99,</td>
</tr>
<tr>
<td>R2</td>
<td>Planting date - in Debreziet and similar areas, June 24 to July 1st, on light soils; July 1st to July 8 on heavy soils.</td>
</tr>
<tr>
<td>R3</td>
<td>Seeding rate in the Debreziet area, 25 kg/ha on light soils, 35 kg/ha on heavy soils,</td>
</tr>
<tr>
<td>R4</td>
<td>Method of Planting= Broadcasting</td>
</tr>
<tr>
<td>R5</td>
<td>Fertilizers,</td>
</tr>
<tr>
<td>R6</td>
<td>Rate of fertilizer: On heavy soils 130 kg/ha DAP during sowing, 6-8 weeks after sowing 80 kg/ha Urea. On light soils 130 kg/ha DAP during sowing and 35 kg/ha Urea 3-4 weeks after sowing.</td>
</tr>
<tr>
<td>R7</td>
<td>Method of fertilizer application: Broadcasting.</td>
</tr>
<tr>
<td>R8</td>
<td>Methods of Weed Control: - Manual method; 1-2 times hand weeding, - Chemical method; 2-3 kg/ha Gosaton, 2 weeks before sowing - 2,4-Dichlorophenox acetic acid (2,4-D); 1.5 l/ha 15–30 days after sowing, - Brittox 52% 2.5 l/ha,</td>
</tr>
</tbody>
</table>

**Source:** AUA, 1987.
6.3.3 Relevance of the Introduced Technology

Tef seeds - all varieties
The Tef varieties introduced after selection are widely grown in the Debreziet area. Farmers highly appreciate both white and red types of tef for food as well as market purposes. The tef yield under farmers' management is 8-10 qt/ha, whereas the yield level suggested [by researcher] to be obtained from farmers' fields is on average 17 qt/ha which again shows yield gap. The tef technology is largely farmer-centered (see below). The gap between researchers' projection and that of farmers', among others, may be explained by differences in planting dates, seed rate and weed infestation.

Planting Date
The planting date recommendation for the area is location specific. However, farmers reported late planting dates. One obvious reason is variation in the intensity of land preparation. From the farmers' point view the relevance of the recommendation is still questionable as farmers have reason(s) to do what they do. Therefore the recommendation is not relevant.

Seeding Rate
The seeding rate for tef is one step ahead of the blueprint. It explicitly addresses the variation of soil (light, heavy). Even then farmers still use as high as 40 kg/ha for reasons of weed
suppression and risk avoidance. The recommendation is not relevant as it does not address the farmers’ risk and alternative strategy for weed control.

Method of Planting
The planting method for Tef is similar to that of fermers’. Therefore, its relevance is unquestionable.

Fertilizer
The relevance of fertilizer in the farming systems is unquestionable. However, there is a slight deviation to the rate of application from the recommended amount.

Method of Fertilizer Application
Unlike the sorghum and maize varieties discussed earlier, the recommended method of fertilizer application in the case of tef is similar to that of the farmers’ method of sowing the crop. Consequently it is highly relevant as it fits farmers’ practice.

Method of Weed Control
Weeding is the integral part of tef production. It is commonly done by hand. Nowadays the introduction of herbicides in the area has made the control of leafy weeds much easier. The complementarity between chemical control and hand weeding ease labour for extra employment. From farmers’ point of view, the recommendation is relevant. From the national economy point of
view, it might be irrelevant as the farmers in the area do not seem to make alternative use of labour saved from hand weeding.

### 6.3.4 Availability of the Introduced Technology

The material components included in the tef technology are the seed, fertilizer and herbicides (see Table 6.4).

**Seed**

The tef seeds are selected by farmers after every harvest. Given the high storability of tef, the farmers do not have any problems with seed supply.

**Fertilizer**

With respect to fertilizer, the time of supply is more important than its physical availability. The area might be better off in fertilizer supply due to a the Training and Visit sytem (T & V) pilot project run in the area.

**Herbicides**

In the past Service Cooperatives used to distribute some herbicides to farmers. Now a days farmers buy herbicides from merchants who increase its price from time to time and even sell adulterated substances. Even though the farmers in the area can afford chemical weed control, it seems that they do not make alternative employment of the labour, saved from hand weeding. In order to make the best possible use of the foreign currency that is spent on the purchase of chemicals, a dialogue with farmers is
of paramount importance.

Table 6.4 Summary of Relevance and Availability of Technology for Tef Varieties.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Relevance</th>
<th>Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tef Varieties</td>
<td>relevant</td>
<td>available</td>
</tr>
<tr>
<td>Seeding Rate</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Planting Date</td>
<td>not relevant</td>
<td></td>
</tr>
<tr>
<td>Method of planting</td>
<td>relevant</td>
<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>relevant</td>
<td>Untimeliness</td>
</tr>
<tr>
<td>Rate of Fertilizer</td>
<td>moderately relevant</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of Fertilizer</td>
<td>relevant</td>
<td></td>
</tr>
<tr>
<td>Application</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Method of weed Control</td>
<td>relevant $</td>
<td>not available</td>
</tr>
</tbody>
</table>

$ - It is not relevant from the national economy point of view.

6.4 Summary and Conclusion of the Cases

The cases presented in this study indicate the technology level performance of the research-extension systems. The technologies of sorghum, maize and tef developed and disseminated in the respective areas generally show relevance with respect to the material technology i.e., seed, fertilizers, pesticides and herbicides. The relevance of methods (software) of production varies from package to package. Among them seeding rates, planting dates, methods of planting, rates and methods of fertilizer application are not relevant in the context of the factors affecting adoption (see Table 6.5). Even then, evaluation of the the components of technology presented in Table 6.5 across Sorghum, Maize and Tef packages reveals that AL-composite and the tef varieties show high performance. The main factors that affect
The relevance and availability of the respective technologies are presented in Table 6.6. From the interaction among the categories of factors affecting adoption (i.e., farm, farmers, farmers' opportunities, and the introduced technologies), the relative advantages and compatibility of the respective technologies are the important variables affecting technology adoption under the existing farm and farmers' opportunities. Hence, the aforementioned production methods (softwares) deserve special attention in the improvement of these crops.

Table 6.5 An overview of Performance Criteria

<table>
<thead>
<tr>
<th>Crop</th>
<th>Performance Valuation of Technologies #</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Performance criteria</td>
</tr>
<tr>
<td>Sorghum</td>
<td>Relevance</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
</tr>
<tr>
<td>Maize</td>
<td>Relevance</td>
</tr>
<tr>
<td>Katumani</td>
<td>Availability</td>
</tr>
<tr>
<td>AL-comp.</td>
<td>Relevance</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
</tr>
<tr>
<td>Tef</td>
<td>Relevance</td>
</tr>
<tr>
<td></td>
<td>Availability</td>
</tr>
</tbody>
</table>

# 1=Low, 5=Medium and 10=High

Key:
1. Seed
2. Seeding Rate
3. Planting Date
4. Method of Planting
5. Fertilizer
6. Rate of fertilizer application
7. Method of fertilizer application
8. Method of Weed Control
9. Method of Pest Control
Note that these components do not hold for all varieties considered in the study. Therefore, the numbers indicated do not necessarily correspond with the component of packages as presented in the previous sections of the chapter. However, the score on the respective technologies is based on the discussion made under relevance and availability assessment of each package.

Table 6.6 Factors Affecting Relevance and Availability of Packages of Sorghum, Maize and Tef Technologies

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Affecting Relevance</th>
<th>Affecting Availability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Seed</td>
<td>not reported</td>
<td>limited supply</td>
</tr>
<tr>
<td>2. Seeding rate</td>
<td>risk &amp; uncertainty</td>
<td></td>
</tr>
<tr>
<td>3. Planting date</td>
<td>risk &amp; uncertainty</td>
<td></td>
</tr>
<tr>
<td>4. Method of Planting*</td>
<td>lack of tools</td>
<td></td>
</tr>
<tr>
<td></td>
<td>shortage of labour</td>
<td></td>
</tr>
<tr>
<td></td>
<td>risk (mono-cropping)</td>
<td></td>
</tr>
<tr>
<td>5. Fertilizer</td>
<td>not reported</td>
<td>none/limited supply</td>
</tr>
<tr>
<td></td>
<td></td>
<td>high price</td>
</tr>
<tr>
<td></td>
<td></td>
<td>untimeliness</td>
</tr>
<tr>
<td></td>
<td></td>
<td>poor supply</td>
</tr>
<tr>
<td>6. Rate of fertilizer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Method of fertilizer application</td>
<td>method of planting</td>
<td></td>
</tr>
<tr>
<td>8. Method of Weed Control</td>
<td>method of planting</td>
<td>short supply of herbicides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>high price</td>
</tr>
<tr>
<td>9. Method of Pest Control</td>
<td>not reported</td>
<td>untimeliness</td>
</tr>
</tbody>
</table>

* = not applicable to Tef

The performance of the packages of the case study crops reflects the relevance and availability of each component. The yield gaps that are observed between the improved practices and that of the farmers' practices are a clear indicator for the room for improvement (see Appendix 3). In order to achieve that,
identification of the most limiting variable that affects yield is an essential task that needs to be done.

From the case study it is clear that the irrelevance of the methods of production and the unavailability of material technology are the areas of attention to explain the yield gap. These, according to Stoop (1988), account for the research-extension gap. Due to the gap, partial adoption is the common feature of sorghum, maize and tef packages. The studies by Waktola, 1980; Ayana, 1985 and Kebede, 1989 among others, reveal similar variables that account for partial adoption.

Even though developing cause and effect relationships is beyond the scope of this study, pinpointing some areas of focus to reduce the research-extension gap is in order.

The component of the technologies treated in the case study are more or less standardized packages. These are: improved varieties with their planting date, seeding rate and method of planting. The improved varieties are normally accompanied with commercial fertilizers that have specific rates and methods of application. Depending on the susceptibility to pests and diseases and the occurrence of weeds respective recommendations are set.

As it has been mentioned time and again, the adoption of these components depends on several factors that emerge from the level
of the technical problem on the farm, the farmer and his/her opportunities.

Having the results of empirical studies and observing the symptom of partial adoption over years, there does not seem to be an effort to change 'pushing' the standardized technologies, without the preconditions set by the researchers.

These could, among others, be due to the following: (1) research and extension priority to promote technology with specific components, (2) weak research and extension linkage, and (3) poor farmers' participation.

Researchers are not unanimous in their strategy to promote technological change in the country. Some follow replacement of the farmers' practices without due consideration of their opportunities, their farm and the variations among farmers themselves. The other group of researchers follow the improvement strategy whereby gradual introduction of improved practices would be pursued. For example, in the case of the Tef technology, except seeding rate and the planting date, the other methods are in accordance to what is available to farmers. From this, the tef technology might be more in the direction of the improvement strategy. This is particularly true for the methods of production (software). Therefore, the difference among the researchers might be one of the areas to settle before setting a package.
The research and extension linkage is one of the reasons that is very often mentioned in connection to poor performance of technological changes in Ethiopia. Promotion of standardized packages over the years is one of the indications of the weak research and extension linkage, that could normally have altered the packages through continuous feedback. Cognizant of this shortcoming in the national agricultural research and extension system, a national forum for research and extension linkage was created. However, there seems to be a danger in considering research and extension linkage as panacea, rather than as only one aspect that enhances performance of research and extension. Moreover weak research and extension reveals poor farmers' participation in technology development. Other possible areas of investigation are:-- the limiting factors for supply of fertilizer, improved, credit, etc.

These factors call for choice in range of the technological package that are addressed by strategies of change (improvement/replacement) pursued in national agricultural research and extension. For instance, from farmers' point of view the inclusion of fertilizer in a package needs to pass through several criteria. First, know-how with respect to time, rate, and method of fertilizer application. Second, the crop price to output price ratio should be favourable. In other words, how many quintals of maize, for example, does a farmer have to sell to buy a quintal of fertilizer? Third, the quantity supplied and the
timeliness of fertilizer that depends on the efficiency of market channels.

The first criteria implies the capacity of the extension service to speed up interpersonal communication. The last two criteria are very much related. The second one refers to a price policy, whereas the third criteria refers to the efficiency of the market.

Other things being equal, in a situation where favorable terms are not in place with respect to these criteria, inclusion of fertilizer in a package and setting a yield target under farmers' conditions will result in an unfulfilled profession.

Moreover, the relevance of purchased technologies discussed in the previous sections should be examined in the light of variations among farmers (resource-poor, resource-rich). The fact that technologies such as fertilizer are found relevant from the farmers' point of view should be guaranteed with its availability in terms of price, timing of distribution and quantity. Otherwise, its technical relevance, which made it acceptable by farmers alone does not determine whether it should be included in a package or not. As mentioned above, when price of inputs and that of outputs rise disproportionately, adverse to the farmers' interest, the gap between the 'poor' and the 'rich' will be widening. In this case, the 'rich' farmers will catch
the early benefits from the technologies, at the expense of the 'poor' ones. Therefore, formulation of technological packages, among others, should take into account the above factors.
7.0 IMPLICATION OF THE CASE FOR THE NATIONAL AGRICULTURAL RESEARCH AND EXTENSION SYSTEMS

7.1 Methodology in Assessing Relevance and Availability of Agricultural Technology

Evaluation of relevance and availability of technology can be done before (ex-ante) and after (ex-post) the large-scale dissemination. The two forms of evaluation are complementary practices to ensure sustainability of a technology. The approach to each of the evaluation are outlined below.

Ex-ante evaluation

STEPS:-

1. Identify the problems with people,
2. Analyse the problems with the people to identify causes, its importance to the farm and the people affected,
3. Prioritize the problems with the people,
4. Search for alternatives (basic, applied, adaptive researchers),
5. Test the alternatives against technical feasibility to overcome the troubled farm situation and opportunities of the people. Note that this step involves the inventorization of all factors affecting adoption (farm, farmers, farmers' opportunities and characteristics of technologies). If the test is satisfactory, go to Step 6. Otherwise continue with adjustment and search for other alternatives,
6. Mass production and dissemination of results,
7. Ex-post evaluation after a fairly long period of time (5-10 years) to adjust for any environmental changes.

Ex-post Evaluation

STEPS:-

1. Identify the packages of technologies that are disseminated to users,
2. Identify the categories of population who received the packages,
3. Identify the production practices (technologies) used by each category,
4. Examine the relevance and availability of the introduced technology against the farm situation, the farmers involved and farmers' opportunities. Here the factors affecting its adoption would be identified. If there is partial adoption or non-adoption go to Step 5, otherwise routinize the practice with the effort to develop better techniques,
5. Develop the cause and effect relationship of the factors involved and identify the most limiting factors with the participation of all actors (researchers, extensionists, farmers, policy-makers, etc.) to come up with new alternatives,

N.B In this study Step 1-4 of the ex-post evaluation were attempted.
As it was mentioned earlier, the data presented in this study is not sufficient to make recommendations for action. Therefore, the following hypotheses are suggested to study the performance of research and extension sub-systems both at technological and institutional levels. The first set of hypotheses are derived from the case study, whereas the second set of hypotheses are encountered during field work of the study.

The First Set of Hypotheses

1. The method of production (software) included in the package of technology promoted by research and extension systems are not relevant to the farmers' socio-economic environment.

2. The current yield gap between research centers and farmers' fields is highly dependent upon availability of inputs and appropriate methods (software) of production.

3. Research and extension subsystems are not sustainable at the technology level.

4. Aspects like utilization of by-products should also be considered in developing a variety. In line with this the relevance of the variety Katumani needs to be reassessed.

5. Inter-cropping is a more efficient system of production for individual farmers than monocropping.

6. Sorghum technology has less adoptability than maize and tef technology.
The Second Set of Hypotheses

1. The evidence of research-extension linkage deteriorates as one moves from the Headquarters to the field level.

2. The linkage mechanisms that are initiated between research and extension are not effective in accordance with their declared objectives.

3. Farmers' participation is limited to telling their farm problems.

4. FSR that is introduced in the IAR and AUA is not strong enough to exert a 'bottom up' research strategy.

7.3 Suggestion on how Research and Extension Sub-systems can Improve their Performance

High performance in the National Agricultural Research and Extension Systems is achieved if, and only if, the elements of the systems are synergically mobilized towards the national goal. The elements include: research bodies, extension institutions, training institutions, farmers, policy-makers, banking institutions, marketing institutions, etc. The national goal at this very time is food self-sufficiency. This and related national goals may be fulfilled, among others, with the implementation of the following.

1. Improve the supply and price of fertilizer and other chemicals where necessary,

2. Increase investment in research and extension to strengthen their linkage and thereby performance,
3. Proportionate allotment of credit to the larger small farmers' sector,
4. Improve farmers' participation in technology development,
5. Enhance inter-disciplinary technology development,
6. Target farmers for research and extension activities to avoid blanket recommendations,
7. Establish a system of management that effectively coordinates the national research and extension activities
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### Appendix 1 Composition and Growth trend of IAR Staff since 1960's

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Source: FAO Fertilizer Programme

US $ 1= ETH. $ 2.07.
### Appendix 3 Improvement Potential of Selected Crops

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