The dimensions of seasonal production in northern Zambia

The use of wetlands during the dry season

I. Farming systems research

The why and how of a new-old approach to agricultural research

MARCELO DOUGNAC
The dimensions of seasonal production in northern Zambia

I Farming systems research

Crop Production Science · 13

ISSN 1100-1186
ISRN SLU-VOL-CPS--13--SE

Uppsala 1992
126 pp.

Printed by SLU/Repro, Uppsala 1992

Abstract: As a component of a Farming Systems Research Programme, a study in Northern Zambia was initiated in 1984 to identify the causes of malnutrition and the possibilities to utilize the dambos to extend the agricultural season, in that way filling the production gaps during the dry season.

This document (part I), deals with the methodological aspects of the study, presenting a review of Farming Systems Research based on the author's personal experience and on literature studies. The origin, theoretical development and the practical implications of the approach are critically discussed.

The green revolution is presented in relation to resource - poor farming and transfer of technology.

The bias and constraints of national agricultural research in the third world, its relation with agriculture extension and the structural influences on traditional farming are also examined.

On-station and on-farm research are discussed with respect to their complementary role and the complexity of trial analysis and interpretation of results.

One way of technology generation in farming systems research is presented through a case study.

Part two will deal with the farming system and the agronomic feasibility, production strategies and risks of dambo utilization.

Key words: AGROVOC: Farming Systems Research, Participatory Research, on-farm research, traditional farming, technology generation, multidisciplinary research, Green Revolution.
The dimensions of seasonal production in northern Zambia

The use of wetlands during the dry season

I. Farming systems research

The why and how of a new-old approach to agricultural research

MARCELO DOUGNAC

Crop Production Science · 13
Uppsala 1992
Acknowledgement

My grateful thanks are due to the Third World farmers and African colleagues who have helped me to understand the real dimension of the tropical environment.

To Lennart Kåhre for his invaluable assistance on the revision of the manuscript and professional advice.

To my 12 year-old son Jorge who helped me with the design of several figures on the computer.

## CONTENTS

**PREFACE**

1. INTRODUCTION

2. THE ADVANCE OF "SCIENCE"

3. THE GREEN REVOLUTION, THE SMALL FARMERS AND THE TRANSFERENCE OF TECHNOLOGY

4. THE THIRD WORLD AND NATIONAL AGRICULTURAL RESEARCH

4.1 Characterization
   a) Research planning
   b) Research planners
   c) Information source
   d) International credit/donor agencies
   e) Links between research and extension
   f) Absence of farmer participation
   g) Research priorities

4.2 Multidisciplinary research

5. TRADITIONAL FARMING AND STRUCTURAL INFLUENCES

6. SYSTEM VERSUS SYSTEM

6.1 Commodity researchers' conventional view

6.2 Traditional farmer's conventional view

7. FARMING SYSTEMS RESEARCH

7.1 Background

7.2 The farming system

7.3 The approach

7.4 The methodology

7.5 The sequence

  7.5.1 The anglo-saxon sequence
    a) Zoning
    b) Area targeting
    c) Surveys
    d) Research priorities
    e) On-station research
    f) Adaptive Research
    g) On-farm tests
    h) Release of recommendations

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>PREFACE</td>
<td>1</td>
</tr>
<tr>
<td>1. INTRODUCTION</td>
<td>2</td>
</tr>
<tr>
<td>2. THE ADVANCE OF &quot;SCIENCE&quot;</td>
<td>4</td>
</tr>
<tr>
<td>3. THE GREEN REVOLUTION, THE SMALL FARMERS AND THE TRANSFERENCE OF TECHNOLOGY</td>
<td>6</td>
</tr>
<tr>
<td>4. THE THIRD WORLD AND NATIONAL AGRICULTURAL RESEARCH</td>
<td>14</td>
</tr>
<tr>
<td>4.1 Characterization</td>
<td>14</td>
</tr>
<tr>
<td>a) Research planning</td>
<td>14</td>
</tr>
<tr>
<td>b) Research planners</td>
<td>15</td>
</tr>
<tr>
<td>c) Information source</td>
<td>15</td>
</tr>
<tr>
<td>d) International credit/donor agencies</td>
<td>15</td>
</tr>
<tr>
<td>e) Links between research and extension</td>
<td>17</td>
</tr>
<tr>
<td>f) Absence of farmer participation</td>
<td>17</td>
</tr>
<tr>
<td>g) Research priorities</td>
<td>18</td>
</tr>
<tr>
<td>4.2 Multidisciplinary research</td>
<td>20</td>
</tr>
<tr>
<td>5. TRADITIONAL FARMING AND STRUCTURAL INFLUENCES</td>
<td>23</td>
</tr>
<tr>
<td>6. SYSTEM VERSUS SYSTEM</td>
<td>25</td>
</tr>
<tr>
<td>6.1 Commodity researchers' conventional view</td>
<td>25</td>
</tr>
<tr>
<td>6.2 Traditional farmer's conventional view</td>
<td>27</td>
</tr>
<tr>
<td>7. FARMING SYSTEMS RESEARCH</td>
<td>31</td>
</tr>
<tr>
<td>7.1 Background</td>
<td>31</td>
</tr>
<tr>
<td>7.2 The farming system</td>
<td>35</td>
</tr>
<tr>
<td>7.3 The approach</td>
<td>37</td>
</tr>
<tr>
<td>7.4 The methodology</td>
<td>40</td>
</tr>
<tr>
<td>7.5 The sequence</td>
<td>45</td>
</tr>
<tr>
<td>7.5.1 The anglo-saxon sequence</td>
<td>45</td>
</tr>
<tr>
<td>a) Zoning</td>
<td>45</td>
</tr>
<tr>
<td>b) Area targeting</td>
<td>45</td>
</tr>
<tr>
<td>c) Surveys</td>
<td>45</td>
</tr>
<tr>
<td>d) Research priorities</td>
<td>46</td>
</tr>
<tr>
<td>e) On-station research</td>
<td>47</td>
</tr>
<tr>
<td>f) Adaptive Research</td>
<td>47</td>
</tr>
<tr>
<td>g) On-farm tests</td>
<td>53</td>
</tr>
<tr>
<td>h) Release of recommendations</td>
<td>53</td>
</tr>
</tbody>
</table>
PREFACE

During almost 8 years as a Farming Systems Research (FSR) practitioner in Africa within a multinational group of professional and technical staff, I had the opportunity to "go back to the land", to a land very much alive, full of all types of organisms (people included) trying to share a common physical space, in harmony with the available resources and adopting, adapting and/or rejecting the external factors interfering with their domain.

The time spent as Project coordinator of a FSR (field) team in Northern Zambia taught me how difficult it is to implement a theoretical method despite the method being developed specifically to be used under those circumstances.

On the other hand, I realised that the method is not so important as the way in which it is adapted to the local conditions.

The amount of articles and documents found is exceptionally high, especially in relation to the relatively short time since the approach was "regained" by the scientific world. The subject has been analyzed, discussed and interpreted from all possible angles. This makes it almost impossible to find out "a typical" FSR approach, or to standardize the concept.

What I have written is not new or necessarily contradictory to what already exists, but the origin of the information is slightly different. I have written about what I think are the origins of FSR, the simplest way to express the concept behind FSR and some practical issues about its implementation.

The ideas are mainly based on my own experience, both in the field and through exposure to the experiences of others in Southern, Eastern and Western Africa and Latin America. To strengthen the "theoretical" value of this document, I also refer to several other authors.

One can argue that there are still many other sources of information which could be included. However, the objective is to produce a review, addressed mainly to non-FSR specialists and at the same time serving as a methodological explanation and background to my own technical research work on the utilization of marginal land during the dry season to increase food security in Southern and Eastern Africa.
1. INTRODUCTION

How can we talk about the future without knowing what has been left behind?

From the beginning of agriculture, the different ethnic groups set up their social organization and developed their cultures independently in order to improve the utilization of the territory they were occupying by transforming it into a self-sufficient economic region, and by regulating production as a function of needs. Each group, during the years, were building their own resources and learning how to manage them in a integral, integrated, intensive and sustainable form (e.g. Grillo, 1990).

Independently of how and why they did that, those reasons certainly were related to the peoples own needs, crop improvement was just a reaction to the people's food requirement and not to the plant itself.

It has also been accepted, despite the characteristics of the different people (fishermen, traders, agriculturalists, herdsman, warriors, etc.) that, beside their main activity they also had minor or secondary activities that complemented the major one. The decisions and interventions in any of those "enterprises" were taken in relation to the other ones trying to create a security net which could guarantee their survival.

Agriculture, as one of mankind's major activities, was developing in parallel in different continents; farmers selected and domesticated all the major and minor food crops on which humankind survives today. Early cultivators knew about the characteristics, food value and medicinal use of over 1,500 plant species. Over 500 vegetables were cultivated in ancient times. Moreover, agriculture did not originate in just one or two centres.

The best evidence of early domestication shows that experimentation with all the important semi-wild crops was occurring simultaneously in different areas of Asia, Africa, Europe and the Americas (Reed, 1977).

In ancient Egypt, a sophisticated river-side agriculture was developed diametrically different to the high land agriculture of the Andes or to the Mediterranean agriculture of Europe, but independently of where and how agriculture developed, it depended on the creativity of men to find ways of improving their welfare in harmony with the natural environment and
using some common strategies such as collection, saving and mixing of vegetative material to keep food and genetic diversity together with a rational use of natural resources.

Shiva (1989) quotes Erna Bennet, a former FAO genetic resources expert who said:

"the inhabited earth was the stage for 10,000 years, for an unrepeatable plant breeding experiment of enormous dimensions", adding himself, "in this experiment, millions of peasants and farmers participated over thousands of years in the development and maintenance of genetic diversity. The experiment was concentrated in the so-called developing world where the greatest concentration of genetic diversity are found, and were humans are cultivated crops the longest".

In Europe, the situation was not different; there is evidence that people were already growing barley and other crops more than 6000 years ago, and together with their third world colleagues the old Europeans farmers also contributed to the custody and development of genetic diversity. At present, the big difference is the fact that farmers of the industrial world still have the chance to benefit from the concentration of technology and intensive exploitation of genetic resources.

Picture 1. Saving and mixing of vegetative material - small farmers' strategy to keep food and genetical diversity.
2. THE ADVANCE OF "SCIENCE"

The real advance of science is not only represented by the acquisition of new knowledge but also from the ability to regain the knowledge already existing.

Prior to the institutionalising of research in the past century, technology had evolved over centuries through natural and farmer-selection of crop varieties and the evolution of materials and methods (Farrington, & Martin, 1987).

Farmers, like agricultural research scientists, are experimenters, and modern agricultural science rests upon the foundation of at least ten millennia of informal experimentation by anonymous subsistence and commercial farmers. The nature of this farm-based spontaneous research has rarely been systematically studied (Rhoades & Bebbington, 1988).

The knowledge accumulated through collaboration between farmers and Nature gives rise to an empirical type of know-how. The scientific methods opened the doors to modern agricultural research. The original interaction between the people's own circumstances and their need of experimentation or dissemination of information became weaker when more sophisticated research advanced.

Agricultural research in the past century tended to deal more with a specific crop or groups of crops than with people's problems. The investigations have focused on biological and production parameters, especially the increasing of yield, without much attention on the amount of resources needed to achieve this goal.

The principal concern of national agricultural research systems, certainly up to the late 1970s, was to enhance the yield potential of individual crop varieties suited to adequately-controllable environments (Farrington & Martin, 1987).

It frequently happened that the "already proved" technology worked very nicely on the commercial farmer's field, but it was sometimes rejected, or didn't work at all on the fields of semi-commercial and subsistence
farmers. Contrary to expectations, no significantly new technological packages capable of yielding increased net returns could be offered to the majority of peasants. The new packages often failed to take into account the features of subsistence agriculture that determine the management criteria and level of resources used by local farmers. In the majority of cases, new varieties could not surpass local varieties when managed with traditional practices (Perelman, 1977).

Picture 2. Farmers like research scientists are experimenters. Zambian farmer explaining "his" trial to national researchers.
3. THE GREEN REVOLUTION, THE SMALL FARMERS AND THE TRANSFERENCE OF TECHNOLOGY

"...the term 'Green Revolution' signifies the beginning of a new era for agricultural research and development in the Third World, one in which modern principles of genetics and plant breeding, agronomy, plant pathology, entomology, and economics have been applied to develop indigenous technologies appropriate to the conditions of local farmers".

(Borlaug, 1987)

The most important stage within agricultural sciences during the post-war era has been the world-wide implementation of the "Green Revolution".

Because of the role that the green revolution has played, it cannot be left out of any analysis regarding agricultural research, especially due to its controversy with respect to agricultural development in the third world.

The international research organizations which extended very rapidly in the early 1970s with the mission to spread the "Green Revolution" through the development of high-yielding varieties of wheat, rice and other crops have somehow been criticized because their assumption that the accumulated technical information developed over the past decades in the west could be modified and applied to crop production in the developing countries (Perelman, 1977).

This conception has led to the attitude that the existing food production problems in underdeveloped countries are due to the fact that local farmers are incapable of coping with crop production processes and that modern technologies from the temperate zones must be imported to promote suitable solutions (Altieri 1983).

The Green Revolution, as any other "revolution", has indeed people in favour of it and people against it, and the conclusion about cost and benefit will depend on the perspective in which the "revolution" is analyzed.
When numerical parameters are used to present "increasing or decreasing in overall productions" like the figures found on FAO's statistics from 1960 to 1990, then the Green Revolution has been a beneficial one.

This is especially true in cereal production: data extracted from FAO show the following production growth:

Table 1. Annual growth in cereal production, yield and area, 1961-1989

<table>
<thead>
<tr>
<th>Average annual rate of increase</th>
<th>Wheat %/yr</th>
<th>Maize %/yr</th>
<th>Rice %/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>In production</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globally</td>
<td>3.0</td>
<td>3.1</td>
<td>2.9</td>
</tr>
<tr>
<td>Developing world</td>
<td>4.0</td>
<td>3.7</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>In yield</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globally</td>
<td>2.6</td>
<td>2.4</td>
<td>2.1</td>
</tr>
<tr>
<td>Developing world</td>
<td>3.7</td>
<td>2.7</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>In area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Globally</td>
<td>0.4</td>
<td>0.8</td>
<td>0.7</td>
</tr>
<tr>
<td>Developing world</td>
<td>1.2</td>
<td>1.0</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Source: Adapted from CIMMYT annual report 1990.

The amounts of grain produced have undoubtedly increased, especially in Asia but with smaller effects in Latin America (Pineiro et al., 1979), and they have had little impact in Sub-Saharan Africa.

Graph 1 (Swaminathan, 1991) gives a fair view of production trends during the first twenty years of the Green Revolution.
This development is confirmed by Koppel (1990), who expresses that the Green Revolution benefited small farmers more than before, but the impact would be greater with maize, rice, and wheat growers operating under favourable agroeconomic environments.

Overall, high-yielding varieties accounted for about half the area planted to wheat and rice in the Third World in the early 1980s (Dalrymple, 1985).

Several prominent researchers can be cited in defence of the Green Revolution; for instance Swaminathan (1987) assures us that the Green Revolution has generated self-confidence in many developing countries with regard to their capability for achieving food self-sufficiency, like countries in South and Southeast Asia which have been able to increase production through vertical growth in productivity. In contrast to the general feeling he also assumes that the Green Revolution enhanced the
prestige of extension workers strengthening the feed-back process between research and extension.

Borlaug (1987) declares that the really important attribute of the new technologies has been their cost efficiency, the yield increasing effect and the land-augmenting effect. The combination of the new varieties and higher-yielding production technology has allowed farmers (resource-poor as well as resource-privileged) to increase total farm output through higher yield level and greater cropping intensity.

On the other hand, it has gradually been recognized that the type of breakthrough represented by the discovery and rapid spread of high-yielding varieties of rice and wheat is the exception, and not the rule (Horton, 1990).

Several negative aspects can be cited from the literature indicating that the benefits of the Green Revolution gained by third world farmers have been minimal, not only regarding their economic situation. It also had a negative effect on genetic diversity and other natural resources, leading to dependence on external inputs and increasing impoverishment of small farmers.

The areas where the new "miracle seed" were widely adopted were haunted by disease epidemics. Plant breeders soon learned that planting a whole region with genetically similar varieties leads to the danger of disastrous attacks by either pests or diseases (Adams et al., 1971).

The introduction of high-yielding varieties brought about by the Green Revolution strategy only presented an example of short-term benefits in exchange for long-term socio-economic and ecological disasters in the countryside. The new varieties contain the "seed of devastating food problems arising from the risks that accompany genetic uniformity and monoculture" (Rosario, 1991).

The increase of irrigated areas, other crucial element of the green revolution, has also been questioned. According to Yudelman (1989), 75% of the irrigated land in Pakistan suffers from high degree of salinity or waterlogging; the same occurs in India where he estimates that productivity has been reduced in 20 million hectares of land irrigated by canals because of salts, and about 7 million hectares lie unutilized due to accumulation of excesses of salts.
Picture 3. The Green Revolution in Africa Sorghum breeding programme in Zambia, an example of collaboration between the CGIAR system and national research programmes to develop hybrids adapted to local farming conditions.
The social benefits of irrigation are also questionable, big producers have gained more than small holders, and despite general improvement being present, the inequality of income has worsened. Farmers with poor resources, like female households, have probably suffered more than others due to the absence to legal rights to water use as well as other small farmers groups that have to pay excessive water fees.

Thus, it seems that only a small percent of farmers benefited from the Green Revolution (Altieri, 1983).

It can also be said that there are some successful African examples where high-yielding varieties of maize are widely grown in Kenya, Zambia, and Zimbabwe; and high-yielding varieties of hybrid oil palm in Nigeria and Sierra Leone (Eicher & Baker, 1982).

The last example is partly misleading, because the adoption of those maize varieties in Africa is not a product of the objective of transferring technology of the Green Revolution but a result of the national effort of those countries which, in collaboration with International Institutes, have been able to produce varieties adapted to their agroecological as well as socio-economic realities. If those varieties are closely observed, it can be seen that they do not depend on high levels of inputs and can be grown more or less under ordinary farmer practices and still produce "acceptable" yields. The dependency of farmers on the availability of new seed is still remaining but this is an institutional component that is more or less solved in the three countries mentioned.

The above-mentioned case is useful in defending the "Hybrids". However, the common identification of hybrid seed with commercial farming or using the hybrid seed as the "symbol" of the Green Revolution is not correct.

If the problem of seed distribution can be solved, the modern hybrid varieties may very well be suitable for small farmers. The production of modern hybrid seed is simple and in many cases is cheaper than the production of composite seed.

The problem is not related to the hybrid but to the "transferring of technology approach" behind the Green Revolution which has been unable to identify the right components to produce "small farmers hybrid seed". Many of the new varieties have never been accepted by farmers because they don't meet local requirements.
Even the new plant materials produced by international centres is now best regarded as rural and development means, rather than finished production technologies, since they are usually destined for breeding or screening programmes rather than for immediate use by farmers (Horton, 1990).

The recent years of research have proved that the incorporation of phenotypes and genetic characteristics appropriated to small producers is not really a problem.

Despite the fact that several major criticisms are well founded, there is no reason to ignore that the Green Revolution has been a very important part of agricultural development and it should be analysed on its historical perspective; the benefits gained should be used as a basis for further development and its negative effects as lessons for the future.

It is very encouraging to note the present development of most International Research Institutions, who are doing everything possible to rectify the errors or wrong approaches of the past, and through their achievements to improve the future benefits of their activities.

CIMMYT, in its 1990 Annual Report, refers to Edward Wolf saying that after 20 years, the Green Revolution stands as a touchstone in international agricultural development. This agricultural strategy transformed the lives and prospects of hundreds of millions of people. Now, however, there are disturbing signs that the revolution may be flagging.

Swaminathan (1990) mentions the need of making the Green Revolution "greener", covering more crops, areas and farming systems, improving the technical efficiency of small-farm agriculture with regard to the ecological implications of productivity-enhancing technologies. Productivity-enhancing technologies and the policies intended for implementation should consider the judgement of farmers and should centre on household-food security.

Finally, the CGIAR Technical Advisory Committee in May 1990, defined four major challenges for the CGIAR, that to a major degree are a positive answer to the most common criticisms of the Green Revolution:

a) protect the genetic base of agriculture
b) preserve the natural resource base upon which agricultural productivity depends

c) conduct effective research for less favourable environments, and

d) identify opportunities for implementing integrated farming systems that require fewer "external inputs"

The same Committee recommends a long-term approach to research the identification of accurate sustainability indicators in order to anticipate and respond to threats to sustainable agriculture.
4. THE THIRD WORLD AND NATIONAL AGRICULTURAL RESEARCH

The low adoption rate of technology in many development countries is the fault of neither farmers nor researchers but the way in which research activities have been carried out as a part of inefficient and incorrect research policies established by governments or international agencies. Such establishments have had a macro-economic view of agricultural development, trying at the same time to introduce values, priorities and research criteria developed somewhere else and foreign to the country's own culture, to the degree of rural development, and in many cases with absolute lack of respect to the knowledge available in those countries.

For instance, in Sierra Leone the national research policy is still aiming at high yields with high levels of external inputs. This is inconsistent with the existing conditions and objectives at farm level which aim at yield stability to assure food security in an unstable environment without any external inputs.

Little is known by researchers of the rationale of small farmers (Binder, 1989).

In Peru, Grillo (1990) mentions that farmers oppose the ideas of modernization of the national agriculture through the introduction of recommendations that in combination with credit permit the increasing of fertilizer and pesticide sales, because they "do not increase national production but enlarge their dependency and poison the environment and the society".

4.1 Characterization

The national agriculture research in most third world countries has presented several common features which have contributed to the low positive impact of its activities; which could be summarized as follow:

a) Research planning

The research programme has been worked out at central level, if not at the Ministry headquarters then at least at the national research centre. There was a conceptual and organizational separation between policy formulation
and policy implementation. National and sectorial objectives would be defined by the highest political level, and would determine the criteria on which the allocation of functions were to be based (Nogueira, M., 1990).

b) Research planners

The people involved in research planning have been mostly breeders and central policy-makers; the first group being concerned with genetics factors, and the second with strategical national issues such as to meet the increasing demand of food by the urban areas, development of cash crops for forex earning, or how to decrease the burden of the payment balance given incentives to the production of luxury crops (i.e. wheat) under importation to satisfy the food habits of a very small, but influential group of the population.

Most important, perhaps, is the urban and economic orientation of most elites in the poor countries. High-protein or other cash crop exports are often the major source of export earnings that - so the argument goes - must be used to purchase the infrastructure for industrialization (Dalberg, 1979).

c) Information source

The source of information for the research planners is restricted to the well-organized and politically influential group of commercial farmers.

Top-down systems have functioned reasonably well to meet the demands of resource-rich farmers, as well as those of both large- and small-scale producers of high value commodities. These farmers have been able to communicate their needs to researchers, either directly or through producer organizations, and to assess and adapt the recommendations which come to them through the extension system (Ewell, 1990). But resource-poor farmers seldom have access to institutionalized channels, such as producer associations, for communicating with technology designers about their experiences with recommended technology (Ashby, 1986).

d) International credit/donor agencies

The intervention of international credit organizations and the malady of donor organizations working at local level is a common feature in most countries. With very few exceptions, they have an extraordinary influence
on the policies of local government, production prices, development projects, etc., contributing to the introduction of *western values, technologies and infrastructure* which are strange to the idiosyncrasy of local people.

Moreover, donor agencies often encompass a wide range of interest, including geopolitical, commercial, bureaucratic and humanitarian concerns.

Their decisions are often influenced by pressure to move large sums of money quickly. This encourages the widespread and rapid replication of programmes developed previously, without first determining the modification needed to suit local conditions (Sims & Leonard, 1990; Duncan, 1986; Sussman, 1982; Tendler, 1975).

In Latin America during the 1950s, the politically motivated Point IV programmes of the USA established extension agencies in many developing countries, and assigned the role of catalysts for development to officials analogous to American county agents. Since extension services were linked neither with indigenous research systems, nor with active client groups, they soon degenerated into ritualistic exercises in the delivery of extension methodology (Rice, 1974).

The most important development (in Latin America during the 1960s) was the withdrawal of US technical assistance, creation of decentralized semi-autonomous research institutions, and the effect of agrarian reform and rural development policies (Nogueira, 1990).

In Africa, the *national* agricultural research activities are continuously affected by the presence of those organizations, the research and extension policies, plans and structures can often be seen as a ball played between international financial and technical organizations. At the end of the national match, regardless of who is playing, local farmers never win.

As one example, Binder, K. (1989) presents the NIADP agricultural development programme in Sierra Leone, financed by ECC and the World Bank as a large-scale, highly intensive approach which was economically and socially beyond the means of resource-poor farmers. In 1986/1987 the programme was phased out. The negative experience of farmers with misuse of their money, unreliable technical assistance, numerous court cases and few results has caused an atmosphere of mistrust towards any government agricultural development effort which might follow.
e) Links between research and extension.

In most developing countries, agricultural research and extension are separate public institutions with different mandates and different ways of operating. Even where they are formally located in the same ministry, they usually have very different organisational structures and operational procedures (Ewell, 1990).

Kaimowitz (1990) quotes the World Bank, USAID and FAO, identifying this lack of interactions between research and extension as one major factor affecting the effectiveness of their activities:

In Latin-America, political foreign interference has been pointed out as the major cause of this isolation, advice from the foreign agencies often has behind the moves towards autonomy, as in the case of institutional reforms introduced in Mexico in 1945 on the suggestion of the Rockefeller foundation (Noguerra, 1990)

This process was among the factors which contributed to the relative domestic isolation and highly developed external connections which began to characterize public agricultural institutions. Institutional relationships between countries were encouraged, again with significant participation of the Rockefeller Foundation. The Interamerican Institute for Agricultural Sciences (IICA), a branch of the multilateral Organization of American States (OAS), made an important contribution towards establishing horizontal relationships.

f) Absence of farmer participation.

"The way most planners and researchers perceive the role of the peasant farmers would be that of a milk cow: something that is to be domesticated, kept contented, and fed a diet that it is expected to consume uncomplaining, all to provide the products that the planners desire".
(Dalberg, 1979).
In most cases the small-scale and subsistence farmers have been ignored. Their own priorities, assessment of experimental material, and interpretation of results, is excluded from the process of technology generation.

Much so-called participation has been the participation of government officials, or of others at the behest of government officials (Skoog et al., 1990).

FAO (1990) refers to farmer participation in the following way: "Decision-makers are far removed from farmers, especially from the poor, small or subsistence farmers. Small farmers are often poorly represented at national level. Farmers are often seen as backward people who don't know what is good for them".

Traditionally, the process has been more a top-down imposition from scientists based at research centres to farmers through inefficient and neglected extension services.

g) Research priorities

In the past, the research priorities and objectives have been mostly focused on a single discipline or in some cases, on a crop or interaction between crops.

Planning tends to be dominated by specialists, whereas understanding of small farmers' problems requires interdisciplinarity (FAO, 1990).

Since academic research is heavily institutionalized and routinized, no major attempts have materialised to re-examine the foundations of disciplinary science to see if its underlying structures and assumptions are still sufficient to deal with the real world (Dalberg, A., 1979).

The scientist undertaking research has been working with biological and physical factors affecting crop production, aiming to maximize the output per unit of area. This has resulted in the current agricultural practices being dependant on external sources of inputs which are beyond the economic affordability of resource-poor peasants working in less favourable farming environments (Rosario, 1991).
The yields are often intimately tied to purchased inputs and accurate irrigation, so that high yields are not intrinsic of the seeds, but are functions of the availability of required inputs, which in turn have ecologically destructive impacts (Vandana Shiva, 1989).

The following graphs (Herdt, 1986) show how the increasing area under modern varieties of rice in The Philippines and wheat in Pakistan is closely related to the increasing use of nitrogen fertilizer uses.

Graph 2. Relation between area and nitrogen fertilizer uses in rice and wheat, The Philippines and Pakistan.
Source: Herdt, 1986
Normally the sustainability of the system and the socio-economic factors affecting farmers' enterprises were not taken into full consideration. Farmers' circumstances like resources, marketing, prices, culture and off-farm enterprises influencing their decisions, were not included as determining factors in research planning.

4.2. Multidisciplinary research

The monocrop approach developed gradually into a more biologic multidisciplinary working procedure, with a wider focus which included several crops (cereals, legumes, tubers, etc.) including different biological disciplines (soils, entomology, agronomy, breeding, etc.). Nonetheless, the technological messages were still not adopted by the majority of farmers, due to the lack of effective ways of identifying problems and the circumstances pertaining to specific groups of farmers. Therefore, it was impossible to formulate research programmes to meet their specific needs.

Despite this multidisciplinary approach the recommendations produced were still addressing the whole country, or a large region, without recognizing differences in interests, constraints and circumstances demanding specific recommendations.

In many cases, the impact of those technologies was regarded in terms of production and economic benefits, overlooking the implication of the technologies on the sustainability of the system itself.

Researchers continued looking at physical and biological constraints as major factors hindering production, without understanding that agriculture is an activity of human-beings, involving people as operators, as consumers, as producer of inputs, and as components and managers of the systems (Fernandez, 1988).

Still, the relations between enterprises, farming, trade, livestock, fishing, etc., have not been completely recognized as competitive for farmers' resources.

Chile is a typical example in which many professionals reject the idea that small farmers have special priorities and specific technological needs. They believe that the technology being produced by INIA (Chile's National Agricultural Research Institute) to satisfy the needs of big commercial farmers can be adapted, without major effort, to the needs of small
producers. However, according to an ISNAR study, in contrast to their expectation, the majority of (small) producers who participated on INIA's demonstrations, apparently have gone back to their own practices, because they feel that their traditional practices are more adequate, or due to the fact that they could not afford the technology proposed by INIA (Goldsworthy & Kaimotwitz, 1988).

In India concern is expressed that so much of the output of research is not adopted by farmers, with the rate of rejection informally estimated at 80% or more, with probably a higher figure for rainfed agriculture (Chamber, 1989).

The same situation is often found with the international research institutes. CIAT, for instance, was concerned about the low rate of adoption by African farmers of its bean varieties, and therefore they started bringing farmers into the process at a very early stage of the breeding programme (Osvaldo Voysey CIAT, 1989, personal communication).

In 1977, CIP and Peru's Ministry of Agriculture initiated on-farm research to test recommended technologies under farmers' conditions. Improved seed was the central component of the recommended package. To CIP's surprise, the improved seed performed only slightly better than the common seed used by the farmers. Since it cost much more, use of improved seed actually reduced farmers' incomes (Horton, D., 1990).

As a summary of the previous discussion, Figure 1 presents some common factors influencing national agricultural research and some main circumstances affecting farmers' decisions in developing countries. The content of the two wheels clearly shows the incoherence between either of the components. Then it is not difficult to realise why the technology generated has been unable to respond to farmers' expectations.
Common factors influencing national agricultural research

Common circumstances faced by traditional farmers.

Figure 1. The unconnected "wheels" of agricultural research and traditional farming.
5. TRADITIONAL FARMING AND STRUCTURAL INFLUENCES

There is one further more aspect to be observed in order to understand farmers' decisions. This is related to the local structures that have a great influence on their strategies (see Figure 2).

- **extension services**: in most cases there is a regional and field extension service working under poor conditions, isolated from their main bodies, recommending old packages and carrying out irrelevant demonstrations. This induces mistrust among farmers, frustration among extensionists and even open conflicts due to the influence that extension has on the credit agencies. That, in turn, gives wrong credits to wrong crops to the wrong farmers. Agricultural agencies often have poor relations with the bodies responsible for delivering technology support to farmers.

This results in inadequate follow-through and breakdown in the flow of information. Such research efforts are less likely to be relevant and farmers are less likely to receive the information and inputs they need (Kaimowitz, D. 1990).

- **cooperative unions**: in multiple cases the cooperative movement is not well inserted into the farmers' communities and the cooperative organization is not more than a distribution, marketing and credit agency. The credits offered are tied to a predetermined package which include the type of seed and the inputs required; the choice left to farmers is minimal. The type of seed and the inputs available cannot only be the wrong ones but they are also often distributed at the wrong time.

- **agricultural finance companies**: the type of funds made available for credits to farmers are usually very restrictive to specific improvements to the farm, to cash crops, and commonly to male farmers, often excluding female farmers from credit possibilities.

- **local agricultural researchers**: because of the centralized planning of research programmes, the research carried out locally is not always addressing local problems, and in many cases the technology developed is inappropriate.

- **local administration and regional planners**: The local government, the political party in power and the regional planners respond mostly to...
pre-established national development plans for the area. Those plans very seldom include priorities for development emanating from local problems and their intervention in the area has serious consequences in changing farmers' circumstances.

- **rural development programmes**: it is not unusual to find local rural development programmes on issues and problems incorrectly identified and building a rural infrastructure unable to respond to the farmers' needs, but affecting the capacity, the form or the benefits of production.

- **traditional leaders**: in many developing countries there is still a strong traditional organization (chief, village headman, witch doctors, etc) acting in discordance with the central government and having a strong influence on farming communities regarding aspects like land tenure, labour, social life, etc. Although many of these community responsibilities have been diminished, even severely curtailed with the incorporation of local groups into modern nation-states, the traditional authorities continue to be important in most areas, regardless whether they are officially recognized or not (Cohen, 1986).

![Figure 2: Traditional farming and the local structural load.](image)

24
6. SYSTEM VERSUS SYSTEM

Traditional has nothing to do with underdeveloped. Traditional agriculture is in a continuous state of development.

(Carlier, 1987)

Lack of collaboration between researchers and farmers can create a great vacuum in the understanding of either view. The perspective to evaluate a technology will determine the interpretation of its results and the degree of conviction by the researcher and adoption by the farmer. The same results may receive a completely different interpretation about benefits or disadvantages, depending on who and how to look at it.

6.1 Commodity researchers' conventional view

Modern agricultural research seems often to have maximum yield or production increase as its major goal; consequently it will evaluate results accordingly. The benefit of an improved cash crop system against a traditional cropping system is schematically compared in Figure 3.

The traditional system based on multicropping (several crops sharing the same land) is compared with a monoculture system "improved" in terms of grain yield. In the traditional system the corresponding crop is isolated from the other crops and reduced to the same part of the crop (grain yield).

As expected, the differences in yield are enormously in favour of the "improved" system, 6 tons against 1.5 tons. The "improved" system is seemingly superior to the traditional one; however, if a recommendation on this basis is given, the farmer will look at it with a big question mark and probably continue with the traditional one.

If the small farmers are not using the (delivered) technology, this is often thought to be due to their lack of knowledge (insufficient extension or training), lack of interest, lack of credit or lack of other resources outside the field of the research institution (Goldworthy & Kaimotwitz, 1988).
Figure 3 Commodity researchers' conventional views of system benefits.
To understand the traditional farmer's reaction, the researcher needs to look at the systems from a different perspective and accept that the goals of farming are also different.

In Fig. 4, the same comparison is made but from the traditional farmer's perspective.

6.2 Traditional farmer's conventional view

The discrepancy starts at the parameters for comparison; in the monoculture system the parameter is still reduced to the production of grain yield for cash earning. That, in its turn, will allow purchasing of goods needed by the household and payment of the credit obtained to procure the external inputs on which the production of this grain yield is based (hybrid seed, fertilizer, pesticides, transport, hired labour, high level of management, etc.).

High yields in modern agricultural systems are sustained by investing costly external resources of uncertain future availability. Thus, gains in crop yield directly depend on intensive management and on the uninterrupted availability of energy and resources (Altieri, 1983).

The monoculture system is based on the attainment and use of external inputs that imply a risk regarding degradation of soil, nutritional unbalance, marketing fluctuation, handling of chemicals, soil acidity, availability of inputs, rainfall, etc.

In the best case, when the farmer manages to get the expected monetary benefit, this does not necessarily imply that the household will satisfy its needs. The supplies of essential commodities in rural areas are often very uncertain.

The aim of the traditional system is different, the goal is not only the production of grain, or to obtain maximum yield of one of its components. Instead, it is broadened in order to achieve risk avoidance and food security. The farmer will not measure the yield of one crop but the beneficial combination of all of them. Total yield per hectare are often higher than the yield of a single crop, even if the yields of individual components are reduced (Altieri, 1983).
Traditional farmers will not compare the 6 tons of maize obtained by the monoculture system with the 1.5 tons of grain maize obtained by the traditional systems; they will consider the benefit of 6 tons of grain maize versus the combined benefit of 1 ton green maize + 1 ton grain maize + 400 kg of legumes + 200 kg of millet (beer = labour), cassava roots + cassava leaves, + legume leaves, + pumpkins, etc.

The benefits of the traditional systems are not measured by the cash but by the security that they imply. It permits the production of the farmer's own seed, provides off-season food stability, recycling of resources, surplus, etc.

The traditional system, by definition, is a low risk system based on internal inputs that are available on the farm (the balance plant-animals-water-soil) or provided inside the household (labour). The practice of polycultures is a traditional strategy to promote diversity of diet and income source, stability of production, minimization of risk, reduced insect and disease incidence, efficient use of labour, intensification of production with limited resources and maximization of returns under low level of technology (Francis et al., 1976; Harwood, 1979).

The conclusion of the farmers may therefore, be: the "improved" system can be inferior to the traditional one.

By acquiring an understanding of traditional cropping schemes, important ecological clues for the development of alternative production and management systems may be revealed. In the design of such systems it should always be kept in mind that the goal is not short-term maximization of yield, but rather stabilization of yield with the most efficient utilization of energy and of non-renewable resources, and a minimum degree of ecosystem degradation (Altieri, 1983).

In reality, the choice is not between traditional and modern technologies, it is between different traditions of technology, some dominant and some recessive, some appropriate and some inappropriate, some endogenous and some exogenous (Nandy, 1981).
Picture 4. The benefit of a traditional system is measured by the security that it implies. Home garden production in Zambia.
Figure 4. Traditional farmers conventional views of system benefits.
7. FARMING SYSTEMS RESEARCH

Understanding farmers' existing technology and farming systems is fundamental in the design of appropriate development strategies.

(Altieri, 1983)

7.1. Background

Recognizing the weakness of single-disciplinary agriculture research, a new approach started appearing, namely farming systems research (FSR), which follows a different sequence, based on system analysis, and having the farmer household at the centre.

As an effort to understand the reasons and factors affecting farmers' preferences, and being aware of the limited impact research had on the development of small farmers, many national and international institutions have embarked on a Farming Systems Research approach (FAO, 1990).

There are numerous theories about when and who developed the new concept. However, a group of people consisting of de Schlippe (1956), Mellor, Collinson (1976), Dillon (1976), Winkelmann (1976), Billaz (1976), Ruthenberg (1980), Norman (1980), etc., are internationally known as the fathers of farming systems research, and a fast-growing group - Biggs, Low (1983), Merrill-Sands, Preston, Avila (1984), Sutherland (1984), Kean (1983) Friedrich (1986) etc - could probably be called the children of farming systems research.

A third, less well-known group, the product of farming systems research (within which I include myself) is or has been, mainly trying to implement the approach in the field.

These three groups of people have played an important role on the theoretical development of the concept, and to a high degree, they have also contributed to the growing confusion generated from the enormous battery of definitions, re-definitions and terminology available in the literature. The overestimated need of theoretical discussion has resulted
in the tendency to re-define the concept or to incorporate new 
terminological components, instead of improving the practical 
implementation of the concept already in existence.

Borlaug (1987) also calls for a more integrated research approach, saying 
that no matter how excellent or spectacular the research done in any 
particular scientific discipline, its application in isolation will have little or 
no effect on crop production.

The research approach required must recognize and appreciate the need to 
have teams of scientists with different and complementary professional 
skills, and who are sensitive to the broad range of factors affecting 
productivity.

FSR is an effort to improve the relevance of the scientific work turning 
back to the source itself: the farm household and the factors which sustain 
the system in which the farm household is inserted. The information about 
the needs of the farming family is then brought to the research centres to 
ensure that the on-station research is properly oriented.

It involves also activities together with farmers, to discuss, plan, 
implement and analyse on-farm research programmes. These are oriented 
to identify constraints, adapt, modify or develop technological components 
to improve and maintain the sustainability of the farming system, in 
harmony with the farmer's overall strategy.

The approach toward farming systems has always existed among farmers, 
not least in third world countries.
One good example that proves the ancestral origin of the "modern FSR" is 
found in the description that Grillo (1990) makes of the Culture and the 
Andean Agriculture (see Fig. 6). He says: "...The holistic cosmo-vision, 
characteristic of the Andean society conceives that everything that exists is 
tied, nothing can exist isolated from each other."

The relation that the men and the Andean women have with the flora, 
fauna, the soil and the water is understood as they are integrated parts of a 
great unit, in which they are also included. The land does not belong to 
men, but men belong to the land. We are part of the land.

The Andean conception of the society is schematically presented in Figure 
The figure could also be used as a modern description of the Farming System concept to understand farmers circumstances as well as to provide a background for technology generation.

Figure 5. The Andean conception. Nature - society relationship (Grillo & Rengifo, 1990).
The fact that most theoretical methodological development is a product of western scientists, especially when the FSR field work is based on expatriate personnel, presents a danger of introduction of foreign values into the national research programmes.

Practical experience has shown that there is a major risk of this occurring at the beginning of the programmes. However, the interaction with local scientists, extension staff and especially farmers reduces that risk. The expatriate personnel (assuming that they stay long enough working in a FSR programme) sooner or later adapt more or less to the local conditions. The FSR Bible the expatriate had upon arrival becomes just a travel guide used to extract the major information. It also happens that a local adapted FSR methodology is developed by the teams. Good examples of this process are mentioned in "Resource-poor farmer participation in research: A synthesis of experiences from nine national agricultural research systems" (ISNAR, 1989).

Picture 5. Farmer, professional and technical staff discussing an on-farm experiment in Zambia.
7.2 The farming system

The farming system can be defined as a system in which the farmer's household make decisions on how to satisfy its needs and to achieve the family objectives. Those decisions are taken based on a reasonably stable number of household enterprises with well-defined practices responding to the agroecological, socio-economic and cultural environment, and in relation to the household goals, resources and preferences (Worman et al., 1980; Fredrich, 1987).

The farming system is part of a larger system that usually influences the circumstances within the system, or can also be divided in subsystems, like cropping system, livestock system, handhoe system, etc. (Shaner et al., 1982; Dougnac, 1990). A change in one sub-system initiates changes in the linkages within other sub-systems and ultimately in the whole farming system (Fresco, 1986).

Peasants all over the world have developed their own forms of farming to survive. This has come about within the framework of local possibilities and limitations of ecology and within the social, economic and political structure of their countries. It is not surprising, then, that there are a thousand-and-one different agricultural systems (Carlier, 1987).

The farming system has been schematically represented by several authors, all the representations aim to show the interdependence between the different components and the logic behind the farmer's decision regarding resources, risks and sustainability. Figures 7 and 8 are cited here as relevant illustrations.
Figure 6. Representation of farming systems with emphasis on risks, resources and management (Kortenhorst, 1986).
7.3 The approach

FSR is an applied solving approach having the farmers household as the centre (Farrington & Martin, 1987). The research priorities are established, in collaboration with farmers, by an interdisciplinary effort in which all the factors affecting farmer's decisions are involved.

Shaner, Philips and Schmehl (1982) define "interdisciplinary" as involving frequent interactions among people from different disciplines who work on common tasks and come up with better results than if they had worked independently.

Different disciplines (agronomy, economy, social-anthropology, extension, nutrition, etc.) are represented in a joint team interacting and complementing each other to zone a province or a region into areas with fairly closely defined and homogeneous farming systems as a basis for defining priorities, areas and activities (Dougnac & Allen, 1986).
This kind of research recognizes and focuses on the interdependency between technical and human elements in the farming system, aiming to develop technologies that increase productivity in a way that is useful and acceptable to the farming family, given its goals, resources and constraints.

The technological changes are assessed within a holistic framework, and the process of technology generation is focused on the household of the local farming system instead of on specific crops or isolated technical constraints.

FSR examines the socio-economics, as well as the technological constraints which prevent farmers from increasing production, whether for subsistence or income generation. These constraints are examined in the context of the farmers' natural and social environment. Then, they form the focus for simple experiments to test or develop technologies on farmers' own fields and under farmers' conditions and management (Daugnac & Allen, 1986). FSR has an area focus which complements the commodity focus of the station-based commodity research.

Picture 6. An FSR team interacting in the fi.
All the disciplines are intimately involved in every aspect of the project orientation. The details of trial design are discussed with the social scientist, just as the details of survey management are discussed with the agronomist and other biological scientists.

The questions or issues to be included in the survey work, the interview approach, analysis and interpretation of findings are products of everybody's contribution. The same is applied to sampling, farmer selection, experimental area, treatments, amount of replications, type and frequency of records taken, objectives and interpretation of trial results, thereby ensuring that the problems addressed by the trial programme reflect the finding of the survey work.

The principle of interaction includes the target farmers themselves; by definition FRS is client-oriented and farmer-participatory research. The degree of involvement and the type of interaction between researchers-extensionists and farmers varies widely among the different field programmes depending on the composition and cultural background of the team members and the support given by the traditional leaders, but specially its depends on the ability, professional competence, and wisdom shown during the identification of constraints and on the building of effective and mutually respectful partnerships with farmers.

Picture 7. The principle of interaction includes the farmers themselves.
7.4. The methodology

In most cases, FSR methodology follows a common sequence. However, different FSR schools present their specific variations, especially in areas like sampling, farmer selection, collection of data, analysis and interpretation of results, degree of farmer participation, etc. Two main schools, the Anglo-Saxon which is common among several CGIAR organizations, implemented in south-east Africa, north-south America and in various Asian countries; and the French, which is implemented in west Africa and most of the south American countries, present some very important differences in key aspects.

The French school is usually implemented by large teams, covering great areas, with particular emphasis on the description of the system, and many quantitative data, having the community forces (farmers' organizations and rural institutions) and "farmers" in more generic term, as implementers and the target of their activities.

The Anglo-Saxon school works with small teams, the target area is never bigger than a province, the survey work is oriented to more qualitative data as basis for the experimental programme, that is very crop-oriented and with statistical bias on experimental design and analyses of results. In contrast to the French school, which is socio-economically biased, the Anglo-Saxon school in practice uses the socio-economic analysis to support the agronomic results. The target group and major actors of the activities are not the community or rural institutions but the farmers household, and specific groups of farmers.

There are very few studies comparing the two approaches. Fresco (1984) and Fresco & Poats (1986) have analyzed the approaches of both schools and the following information is extracted from their studies.

Francophone refers to the approaches utilized during the 1960s and 1970s in the former French-speaking colonies in Africa and to the Systems Approach to agricultural production that evolved in the 1950s in the former Belgian colonies.

Anglophone refers loosely to the FSR/E and cropping systems research that evolved at the IARCs, at some U.S. Universities, and in certain national programmes around the world.

In conducting research activities, the Francophone "recherche-developpement" operates at four levels of observation with four units of
analysis corresponding to: the field/plot, the farm, the village, and the subregion (Table 3).

Table 2. Levels and units of analysis in the R-D (recherche-développement) approach to farming systems research (adapted from de Miranda and Billaz, 1980)

<table>
<thead>
<tr>
<th>Level</th>
<th>Unit of analysis</th>
<th>Study of:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. field/plot</td>
<td>a) cropping system (système de culture)</td>
<td>a) soils, agro-ecological history, crop/weed/insect populations, micro-climate</td>
</tr>
<tr>
<td></td>
<td>b) livestock system (système d'élevage)</td>
<td>b) also: herds, grazing conditions</td>
</tr>
<tr>
<td>2. farm</td>
<td>farming system (système de production)</td>
<td>means and methods of production, incl. non-agricultural work; recent history, past change in capital and technology utilization; labour films; household budgets</td>
</tr>
<tr>
<td>3. village</td>
<td>village production systems (système agraire/terroir)</td>
<td>management of natural resources, land evaluation, climate, vegetation, morphology, etc., (social) control of natural resources and water</td>
</tr>
<tr>
<td>4. subregion</td>
<td>subregional production systems (système agraire/petite région)</td>
<td>idem but on a scale of 10 000 ha and over</td>
</tr>
</tbody>
</table>
Pierre de Schlippe, a Belgian agronomist, must be regarded as one of the founder fathers of (the Francophone) farming systems. During the 1950s, his study of the traditional agriculture of the Zande in Zaire led him to conclude that agricultural technologies developed in research stations must be preceded by a detailed analysis of local agriculture traditions and the rationale behind them (de Schlippe 1956). De Schlippe warned against promoting interventions that were not based on a through knowledge of farmer practices and constraints. He proposed that traditional agriculture be studied by agricultural anthropologists because all students of traditional agriculture need to be both agronomists and social scientists.

According to Fresco (1984), the basic differences appear to be one of scale and time frame. The French approach constitutes an integral part of a long-term, country-wide rural development effort. The emphasis lies on developing the potential of a (sub)region whereby technology provides a starting point. Institutional linkages with development and extension programmes are crucial from the beginning, and in theory, the development process itself becomes a subject of research. One of the goals is to formulate adequate messages for dissemination by the extension services. Existence of concepts like "système agraire" and "milieu réel" point to a concern with development on a scale large enough to have an impact on regional and even national production levels.

This also implies that Francophone FSR will not focus exclusively on small farmers but will aim at a measurable impact on yields which is usually more easily achieved through larger farmers.

On the other hand, the Anglophone FSR is primarily concerned with the adaptation of existing agricultural research to provide technology relevant to low resource, low input farmers. Cropping systems research (that Fresco qualifies as a special Anglophone FSR approach, but which I believe is only one element within the more general Anglophone FSR), examines why technology developed in research stations has not led to yield increases and how constraints to adoption may be overcome.

The Anglophone approaches do not aim at a profound transformation of the agriculture production structure. The development of an institutional framework is not its main concern. Francophone and Anglophone FSR are not mutually exclusive but may strengthen each other.
Of course, those differences are more or less notorious depending on the country programme and the background of its members. The links among the different practitioners of FSR facilitate field programmes to develop their own methodology incorporating elements of both schools.

Table 3. *A comparison between Francophone and Anglophone approaches to Farming Systems Research (adapted from Fresco 1984)*

<table>
<thead>
<tr>
<th></th>
<th>R-D Francophone</th>
<th>FSR Anglophone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. OBJECTIVES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- explicit mention</td>
<td>XXX</td>
<td>X(XX)</td>
</tr>
<tr>
<td>of national policy</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- generation of technology relevant to small farmers</td>
<td>X</td>
<td>XXX</td>
</tr>
<tr>
<td>- Ex-post analysis of technology adoption results</td>
<td>XX</td>
<td>X(XX)</td>
</tr>
<tr>
<td><strong>2. PROBLEM DIAGNOSIS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- interdisciplinarity</td>
<td>XXX**</td>
<td>XXX***</td>
</tr>
<tr>
<td>- emphasis on hypothesis formulation</td>
<td>XXX</td>
<td>X(XX)</td>
</tr>
<tr>
<td>- holistic approach</td>
<td>XXX</td>
<td>XXX</td>
</tr>
<tr>
<td>- time perspective</td>
<td>XXX</td>
<td>X(XX)</td>
</tr>
<tr>
<td><strong>3. TARGET GROUP CATEGORISATION</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- farm enterprise as unit analysis</td>
<td>XXX</td>
<td>XX</td>
</tr>
<tr>
<td>- socioeconomic criteria for categorisation</td>
<td>XX</td>
<td>XXX</td>
</tr>
<tr>
<td>- geographical and physical criteria for categorisation</td>
<td>XXX</td>
<td>X</td>
</tr>
<tr>
<td><strong>4. ON-FARM EXPERIMENTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- farmer participation</td>
<td>X</td>
<td>X(XXX)</td>
</tr>
<tr>
<td>- size of trial plots</td>
<td>XXX</td>
<td>XX(X)</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>TYPE OF INTERVENTIONS</th>
<th>R-D Francophone</th>
<th>FSR Anglophone</th>
</tr>
</thead>
<tbody>
<tr>
<td>dissemination of technology</td>
<td>XXX</td>
<td>XX(X)</td>
</tr>
<tr>
<td>spatial reorganization of agricultural production</td>
<td>XXX</td>
<td>X(-)</td>
</tr>
<tr>
<td>organization of delivery systems</td>
<td>XXX</td>
<td>XX(X)</td>
</tr>
<tr>
<td>scale</td>
<td>XXX</td>
<td>X</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>INSTITUTIONAL CONTEXT</th>
<th>FSR, in most cases the team includes only agronomists and social scientists.</th>
</tr>
</thead>
<tbody>
<tr>
<td>close ties with/integrated to IARC</td>
<td>XXX****</td>
</tr>
<tr>
<td>linkages with extension services</td>
<td>XXX X****</td>
</tr>
<tr>
<td>links with (rural) development programmes</td>
<td>XXX X</td>
</tr>
</tbody>
</table>

* The brackets contain my own view.

** FSR, in most cases the team includes only agronomists and social scientists.

*** R-D include several specialities giving special emphasis to geography and physical aspects.

**** FSR is increasingly concerned about the linkages with National Research Institutions.

***** FSR is in a process of finding channels of interaction with extension services due to the fact that in most of their case studies one of the major weaknesses identified has been the lack of interaction between both services.
7.5. The sequence

Despite variations, it is possible to find a similar methodological sequence in most FSR programmes. In general, a normal sequence in the FSR process of technology generation can be presented by the following steps:

7.5.1. The anglo-saxon sequence

a) Zoning

In zoning, the information already available in a region or province is compiled by the team, analyzed and used as a basis to group farmers by farming activities, agroecological conditions, ethnological similarities, geographical barriers, etc., into farming systems or recommendation domains. The compilation of information is done at regional, provincial, district and community level.

b) Area targeting

During the zoning, several recommendation domains (RD) are identified. The human, financial and logistic resources of the teams are seldom sufficient to cover all of them, and then it is necessary to identify one or more target areas where activities are to be initiated. A target area will be selected on the basis of logistical, political, administrative and/or technical consideration.

c) Surveys

Three major types of surveys are commonly used, two of them, the informal and formal surveys, are usually called diagnosis studies, and are carried out prior to the experimental programme; they aim to study constraints of each farming system in order to understand the farmer's problems and identify potential for development and research opportunities.

The third type, the sondeo type of surveys (i.e. Rapid Rural Appraisal) are indiscriminately used during all the process as tools for system re-assessment and other minor studies needed to verify or find out specific information.

The survey work is a common task of all disciplines involved in the team. If the composition of the team is not enough to cover some special areas to be
surveyed, then resource people from outside the FSR team are temporarily integrated to it.

Depending on the nature of the study, the duration of the survey can take from one to several weeks of joint and interdisciplinary field work. Other types of studies require a permanent team of enumerators staying at the villages collecting daily data.

![Picture 8. The survey work is a common task of all disciplines in the team.](image)

**d) Research priorities**

The data under collection, or already collected, are the base for the establishment of research priorities. An [adaptive and/or applied research](https://www.nature.com/articles/s41598-018-32424-w) programme is formulated addressing the most important technological problems identified in the farming system. The establishment of research priorities is not an exclusive task of the FSR group. The survey findings need to be extended to extension services, commodity researchers and other individuals and organizations involved in local rural development. Special channels for priority discussions need to be established, not only among the people already mentioned but also with farmers to ensure that the research programme is really addressing their constraints.
The research priorities which depend on more basic research needs to be forwarded to the commodity research teams, to be included on their programmes.

e) On-station research

Making use of the existing body of knowledge and the scientific and technical facilities at the research centres, the research commodity specialists will find out solutions to technical problems identified in the field, developing techniques suitable for the specific agroecological situations and new practices and planting material that could be relevant to the problems identified.

ICRISAT (1983) identify three different steps in on-station research:

* Single-component research:
  This type of research aims to improve relevant knowledge of individual components, like soil characteristics, selection of genotypes, movement of fertilizer in the soil, etc.

* Multicomponent research:
  At this stage, the initial integration of components into a system, or part of a system is examined, for instance the integration of a cropping system to soil fertility management.

* Operational research:
  This is the final stage of on-station research, where systems or a part of a system is evaluated in operational scale, where all disciplines should interact. This type of research is usually carried out on benchmark locations or at national research stations.

On-station research is the basic scientific stone up from which to build up a consistent and sustainable adaptive research programme (see Figure 10).

f) Adaptive Research

To overcome the limitations that traditional agricultural research presents, a new approach was developed on the context of farming systems research.
The concept of "adaptive research" was introduced and it is implemented in practice through on-farm research.

The objectives of on-farm research could be summarized as follows:

1) - The real agroecological environment in which the technology will act should be maintained throughout the experimental process.

2) - Farmers' own practices should be mainly used as checkplots and their field as cross-checks. Farmers' fields also contribute to retaining the real environment affecting the experiment and providing information about farmers' criteria of site selection.

3) - Farmers should play a key role, participating fully in the management of the trial; even in researcher-managed trials most of the work is to be done by farmers themselves to increase their understanding about the experiments.

4) - Socioeconomic representativeness of farmers needs to be kept to cover the right target group.

5) - Preliminary analyses, using estimated values, need to be done to predict the implications of the experiment.

6) - Before designing an experiment, different alternative solutions should be considered. Failure to consider the better alternative will produce inferior results no matter how well the experiment is designed (Shaner et al., 1984).

7) - The research hypothesis should be based on problems as well as on opportunities. In this way the results will not only reveal solutions but the capacity of farmers and institutions to implement them.

8) - To carry out simple experiments using "viable" in preference to optimal experimental designs. Optimality does not have much operational meaning within the complexity of farmers' circumstances (Shaner et al., 1984).

When the research programme has been elaborated, and the research topics screened out, then the process of farmer and site selection starts.
A flexible method of sampling is needed to allow selection of farmers and experimental sites to be representative of the target and to make the programme as operational as possible.

The use of clusters is recommended to facilitate the supervision by the trial assistants and a broader interaction with non-trial farmers.

On-farm experimentation is not only a research method for technology development under farmers' conditions but a opportunity for researchers to learn from farmers, to make use of the accumulated indigenous knowledge among villagers, to preserve the genetic diversity, and to feed the research centres with the necessary information needed to elaborate relevant national research plans.

On-farm research allows a close interaction between researchers and farmers, the farmers' reactions should be well recorded and feed them back to researchers and developers to contribute to the improvement of relevant research programmes.

On-farm trials provide a link between farmers and scientists, ensuring the relevance of on-going research in relation to the farmers' communities. They can help remove barriers to the adoption of station-developed technologies (Raman, 1990).

In Table 4, Norman and Modiagotla (1990) present some differences between on-station and on-farm research. In Figure 10, Collinson (1982) shows how they complement each other.
Table 4. Some differences between on-station and on-farm research

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>On-station research</th>
<th>On-farm research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major emphasis of research</td>
<td>Applied</td>
<td>Adaptive</td>
</tr>
<tr>
<td>Location of trial</td>
<td>Usually experiment station</td>
<td>Unusually on-farm</td>
</tr>
<tr>
<td>Disciplines involved</td>
<td>Often single</td>
<td>Usually several</td>
</tr>
<tr>
<td></td>
<td>Mostly technical</td>
<td>Technical and social</td>
</tr>
<tr>
<td>Priority setting for trial:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Researcher</td>
<td>More involved</td>
<td>Less involved</td>
</tr>
<tr>
<td>Farmer</td>
<td>Less involved</td>
<td>More involved</td>
</tr>
<tr>
<td>Experimental Design:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complexity</td>
<td>Usually more</td>
<td>Usually less</td>
</tr>
<tr>
<td>Management</td>
<td>Researcher</td>
<td>Researcher or farmer</td>
</tr>
<tr>
<td>Implementation</td>
<td>Researcher</td>
<td>Researcher or farmer</td>
</tr>
<tr>
<td>Degree of experimental control</td>
<td>More</td>
<td>Usually less</td>
</tr>
<tr>
<td>Ability to establish cause/effect relationships:</td>
<td>Easier</td>
<td>Harder</td>
</tr>
<tr>
<td>Evaluation of trial results -</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factors taken into account:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systems perspective</td>
<td>Less likely</td>
<td>More likely</td>
</tr>
<tr>
<td>Technical feasibility</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Economic viability/reliability</td>
<td>Less likely</td>
<td>More likely</td>
</tr>
<tr>
<td>Social acceptability</td>
<td>Less likely</td>
<td>More likely</td>
</tr>
<tr>
<td>Farmer opinion</td>
<td>Not likely</td>
<td>More likely</td>
</tr>
<tr>
<td>Expense of experimental programme:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed (overhead) costs</td>
<td>Likely to be higher</td>
<td>Likely to be lower</td>
</tr>
<tr>
<td>Variable (recurrent) costs</td>
<td>Likely to be lower</td>
<td>Likely to be higher</td>
</tr>
</tbody>
</table>

Source: Norman and Modiakgotla (1990)
Figure 8. Relationship between on-station and on-farm research.

Participatory research can bring together knowledge and solutions of small-scale farming problems over a shorter period of time than conventional research and with greater confidence that the results will be adopted (Fernandez & Salvatierra, 1989).

The links between the two groups are essential along the whole process of technology generation. The on-farm and on-station research are strongly dependant on each other. The approach demands continuous discussions and exchange visits to both types of research plots. Interaction on planning, implementation and analysis of research programmes is also vital.

Both types of research have often been put against each other and compared in terms of which one produces better results. If somebody wants to make such comparisons then it should be done from a different perspective; instead of comparing FSR with commodity research, they should be put together and the joint benefits compared against the existence of only one of them or against the effect of lack of collaboration between them.

Picture 9. Maize breeders visiting on-farm trials in...
FSR is *not an alternative to* commodity research but *the necessary complement* to it. If researchers could agree on this way of comparing, then the need of collaboration and the complementing role should *not be* questioned.

g) On-farm tests

When one technological component *or a technology* has *proved successful* in on-farm trials, this information is *extended and tested within the target area* in big plots, without any intervention from researchers, but monitoring the response of the technology to farmers' practices and the level of adoption.

![Picture 10. On-farm test - the last stage of technology generation.](image)

h) Release of recommendations

When the technological components have been successfully tested and accepted by the majority of farmers within the target area, then, they are released and extended to farmers throughout the farming system.
7.5.2. The francophone sequence


a) Observation and analysis of constraints to rural and agricultural development. This requires a multidisciplinary effort whereby action is mainly taken by researchers. Surveys are carried out, leading to a "zonage" (zoning) (homogeneous units, based largely on agro-biological and technical criteria) and to a typology of farmers' enterprises.

b) Formulation of farm models or new farming systems. That is made in a quantitative way and comprising the hypotheses to be tested.

c) Multilocalional trials performed on substations, on farms and in "test-villages".

d) Evaluation and interpretation of trial results.

e) Proposal for and discussion with development programmes.

f) Definition of new hypotheses for further research.
7.6. Extension

Go to the people
Live among the people
Learn from the people
Plan with the people
Work with the people
Start with what they know
Build on what the people have
Teach by showing
Learn by doing
Not a showcase but a pattern
Not odds and ends but a system
Not piecemeal but integrated approach
Not to conform but to transform
Not to relieve but to release

(Chinese community organizer in the 1920s. Quoted by Carlier, 1987).

The involvement of extension services in the process is of vital importance; i.e., from the survey work, throughout experimentation and up to the release of recommendations.

Picture 11. Extension worker visiting on-farm trials.
The flexibility of the technology generated through FSR demands a special attitude and command of a systems perspective by extension staff in terms to address the right group of farmers with the right recommendation at a specific location and period of time.

The circumstances faced by farmers in developing countries are such that they usually adopt technologies in small pieces, just one or two components at a time to add to their own practices. To handle such a situation it demands a special skill among extensionists. Therefore their involvement is not only necessary in the technology development process. The interaction should be extended to training programmes both for administrators and field personnel.

A farming system perspective is essential to manage the type of information generated. The extensionist needs to be capable of handling the different alternatives available and to elaborate a message according the specific circumstances that the farmer is facing.

The active involvement of farmers and extensionists in the research process generates some secondary benefits like:

- links of cooperation and understanding, not only between themselves but also with researchers and local institutions.

- on-farm research can create a critical attitude from extension side in relation to the purely technical components. The big variation in the trials will help them to understand the performance of their own demonstration plots.

- through on-farm research the farmer him/herself becomes an extensionist, whose knowledge and experience can always be utilized.

- the participation of extension staff in diagnosis studies and interpretation of results contributes to increased understanding of farmer reactions.

- better use of resources, both for research and extension, through joint field visits, training programmes, field days and other field activities.

Linkages and integration of research and extension is becoming increasingly important, the lack of collaboration between those services has several times been identified as a bottle-neck in the process of
generation and diffusion of technology. Some serious efforts (with varying results) to improve those linkages can be found in several country programmes.

Ewell (1990) presents the Zambian Adaptive Research Planning Team (ARPT) as a programme in which it has made significant progress in forging links with extension at various levels from the field up to the top of the bureaucracy. He summarizes the Zambian example in the following table:
Table 5. Zambia: Links between on-farm research and extension at various levels of the administrative hierarchy (Ewell 1990)

<table>
<thead>
<tr>
<th>Administrative level</th>
<th>Linkage mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>National administration</td>
<td>The Assistant Director of Agriculture for Research and Extension has been involved in the on-farm research programme since it was first established, and confers frequently.</td>
</tr>
<tr>
<td>Provincial administration</td>
<td>Provincial ARPT committees are chaired by the Provincial Agricultural Officers, who are the heads of extension in each province. Meetings are attended by subject matter specialists from extension. The committees reach decisions concerning on-farm research and review the on-farm client-oriented research programmes. The committees have not been as effective as their creators hoped.</td>
</tr>
<tr>
<td>ARPT provincial teams</td>
<td>A Research-Extension Liaison Officer is assigned to each provincial team. As a professional employed by extension, he/she is responsible for facilitating the flow of information in both directions.</td>
</tr>
<tr>
<td>On-farm research teams</td>
<td>The trial assistants, who implement survey and on-farm experiments, are seconded to ARPT by extension.</td>
</tr>
<tr>
<td>Local extension workers</td>
<td>Contacts between researchers and local extension workers outside the research areas have been limited.</td>
</tr>
</tbody>
</table>
7.7. The role of farming systems research teams

The complexity of the problems and linkages demand a multifaceted and interdisciplinary approach that is able to probe deeply into or work intensively with individual factors and relationships without losing sight of how these pieces fit together. The usual research and development approaches are specialized, compartmentalized, and non-integrated. National planning, research, and development units are often in separated ministries and work independently, without any coordination. Agricultural research and extension units are not only administratively separated but often opposed and competitive, rather than cooperative. Foreign aid is similarly fragmented (McMillan & Hansen, 1988).

The final objective of FSR is the identification of those components, put them together in terms of creating conditions and a mechanism capable of developing technologies appropriate for the small farmer communities (see Figure 13).

This is exactly the role of the FSR teams. They are the catalysts in this process, their action is supposed to create those conditions needed by the system to move.

The composition of a FSR team varies with the type of production system that the team is working in, but social and biological scientists are always represented. One possible team composition is presented below:

| agr. economist |
| agronomist |
| socioanthropologist |
| nutritionist |
| aquaculturalist |

Figure 9. FSR team.
7.8. Institutional support

Improving the management of agricultural research institutes now presents one of the greatest challenges to the development community. Significant institutional innovation is needed to make the evolving global research system more aware of, and responsive to, its clients' needs (Horton, 1990).

The difficulties that the FS approach encounter have been mentioned (the sometime "opposition" among high research administrators, conservative researchers and policy-makers, the misunderstanding between commodity and FS researchers, etc.). Other common obstacles found are the rigid organization of the existing research institutions, the over-specialized post-degree training given by western Universities to Third world scientists, the influence of donor and financial agencies in government research policies (very short time and narrow investment policies), the lack of incentives to keep local scientists in research positions, the difficulties to constitute proper interdisciplinary teams and to coordinate the field activities, etc.

Agricultural universities and faculties, and management institutes which train scientists and extensionists, need to focus for change and adopt to different circumstances. For these changes and reversal of roles to occur on any scale is not easy. It requires resolute changes in institutions, in incentives and in methods and interactions. At first sight, the farmers-first approach appears incompatible with normal bureaucracy. But, reversals in government research organizations, although difficult to start and to sustain, are not impossible (Chambers, 1989), but it requires strong leadership at national level as well as of individual FSR teams, and indeed institutional support to allow the necessary adjustments of the research organizations, the institutionalizing of FSR as a full component within agricultural research, and the establishment of institutional channels of cooperation and interaction among programmes.

One well-known case is the one in Zambia where the success of the FSR approach has been mainly due to the strong support given by the national research leadership and to the "high level" decision taken to
institutionalize it as a full component of agriculture research activities (Dougnac, 1991).

SCHEMATIC SUMMARY

Bringing back Figures 1, 2, and 9 in a composite way (Figure 10), all the components can be seen in parallel. They belong to the same reality but act in isolation from each other.

Figure 10. The isolated factors in a conventional agriculture research situation.
Figures 1 and 2 show two different wheels, unable to move because there is no relationship between them.

Figure 3 groups the various components of the load which could relate the two wheels to each other.

The two oxen represent the institutional set-up. Figure 9 represents a possible channel of interaction ("the drivers").

Just the presence of an FSR programme is not enough to guarantee the success. It is necessary that the FS approach is officially adopted within national agricultural research. This is only possible through policy and institutional support.
8. TRIAL ANALYSIS, INTERPRETATION OF RESULTS AND OTHER IMPLICATIONS OF ON-STATION AND ON-FARM EXPERIMENTATION RESPECTIVELY

Scientists and technologists tend to be contemptuous of anything that is not "advanced knowledge", and particularly of anyone who is not a specialist in their own area. They tend to be infatuated with their own technology, often believing that "quality" means what is technically sophisticated rather than what gives value to the users (Drucker P., 1985).

8.1 Research objectives

8.1.1 On-station research

There are some basic objectives in agricultural research, like:

- general environmental observations,
- identification of constraints through exploratory research,
- priority areas of intervention
  a) breeding
  b) soil/water management
  c) agronomic practices
  d) socioeconomical and/or institutional improvements.
- to carry out verification experimental work to ensure that the problems/issues are correctly addressed.
- to generate theoretical knowledge and applicable technology.

To achieve the research objectives, the experimental work needs to be carried out in a scientific way, minimising error risks and ensuring confidence in the result obtained.
A common way of earning scientific confidence is through a well-planned research programme using statistic experimental design that gives credibility to the final analysis of results. Therefore, several experimental designs have been developed to satisfy the requirements of different types of experiments.

Traditionally, statistical analysis has been considered as the major source for interpretation of results. The bounds of Research Stations have allowed optimum conditions for supervision, management and control over the non-experimental factors, both for field and for laboratory experiments.

The need to increase the theoretical scientific knowledge or to solve purely technological aspects has the result that technology development finds its best environment on the fields of the research stations, but when this basic information is used in more practical issues where hindrances to production are encountered, then the bounds of the research station become too narrow.

The optimum research environment is not always an advantage because the real agroecological condition in which the technology will act may not be well represented and the socioeconomic factors which affect farmers are removed from the context of the experiment; consequently the interpretation of results will not necessarily be related to the main problem that the experiment is supposed to address.

8.1.2. On-farm research

The introduction of on-farm research as an experimental approach for farming systems research created major concern among agricultural researchers about the validity of the results coming from this type of experiment. In many cases the criticism came from the natural reaction of being invaded by, a new concept extraneous to them, by the "lack of respect" showed by the farming system researchers to their long experience, and by questioning the relevance of their results by conclusions coming from short-term experiments carried out usually by younger people under "unconventional" research environments.

The animosity increased when the results of those experiments were presented, due to the fact that often the statistical correctness was questionable (Kean & Singogo, 1989).
On-farm research was even mentioned as an unscientific research method and qualified as an extension method for testing "already developed technology" (Patel, personal communication, 1986).

On-station research scientists are sometimes unsure how to interpret and evaluate results from socioeconomic research.

Other kinds of data generated through farm-level research may also be unfamiliar and therefore, confusing. These differ in methods, modes of analysis over what constitutes "good science", and concerning the legitimacy of the respective approaches to research (Merrill-Sands & McAllister, 1986).

The reaction from traditional agricultural researchers is turning more positive to the new approach and for the time being the need of this type of research has been proved, together with how well it complements the on-station research.

Many countries have already institutionalized farming systems research as a component of their Research Institutions. Links of cooperation have also been established, not only among researchers but with agricultural extension, opening new ways for releasing more appropriate recommendations to farmers.

In South-East Africa alone, in 1986, there were already three countries (Zambia, Malawi and Zimbabwe) in which the national research and extension systems had been reorganized to accommodate FSR and its linkages among farmers, researchers and extension personnel through regionally deployed teams. Ten countries (Botswana, Ethiopia, Kenya, Lesotho, Sudan, Swaziland, Tanzania, Zimbabwe, Rwanda and Burundi) have FSR programmes trying to integrate them with technical component research and extension. Since then, several other countries have initiated pilot programmes in FSR (Fresco & Poats, 1986).

The acceptability of on-farm research has been product of a long and slow process, the flow of information to the commodity researchers originated on farmers' fields and diagnosis studies have contributed to reorient national research programmes. The research priorities seem to move again towards the people’s needs. There is a new tendency to put the farmers into the centre of agricultural research.
The result obtained in farmer's field experiments have greatly contributed to improve the final recommendations released.

The change of attitude to the traditional agricultural researchers, exposed to FSR, is mainly a product of the general overall benefits coming from the FSR activities, but not because they have been absolutely convinced about the scientific validity of on-farm experimental results.

The reductionists' attitude is based on their own scientific background, they have been trained by and have worked in the school of "statistical significance", which simply means that biological reaction is to be proved under mathematical parameters and the scientific relevance is measured through acceptable statistical variations.

When analysing the reasons behind the discrepancies, it is clear that the centre of the discussion is not really on-farm research as a valid research method, but STATISTICS as a basis for all types of research analysis. Conventional statistical methods have been the most used arguments to defend or criticise scientific work, and this has not been an exception in the case of on-farm research.

It seems necessary to look at the problem from a different angle: the objectives of research and the relevance of its results should be placed at the centre of the discussion, then the different alternatives of trial analysis will equally contribute to interpret the results. In other words, the objectives of the experiments should not be directed to satisfy a specific method of analysis. In contrast, the method of analysis should be one of the many tools used by the scientists to achieve the objectives of the experiment, having in mind that not always all tools are needed and also that the circumstances will determine the relevance of specific tools.

The role of farmers in technological development becomes more critical and increasingly cost effective as the proposed technology becomes more multi-faceted and complex. Under these circumstances, classical methods for designing, refining and evaluating technical innovations become less useful. When considering more complex technologies, such as intercropping and agroforestry systems which can potentially produce crops, wood, fruits and fodder, it is obvious that a traditional experimental approach seeking to identify management treatments which maximize an output becomes unwieldy and unrealistic. It is the farmers themselves who hold the keys for developing, evaluating and validating these systems (Okali & Sumberg, 1986, 1989; Atta-Krah & Francis, 1987).


Research is nothing else but the response of human beings to their own ignorance. Agricultural research has not been an exception, ranging from the early domestication of plants up to genetic manipulation in plant breeding in an effort to overcome lack of knowledge and for improving welfare.

The basic source of information has been the farmer's own experience. The adoption of new ideas has been based mainly on common sense.

Farmers continue using the same approach: indigenous knowledge plus common sense. At the same time, many scientists have forgotten about indigenous knowledge and sometimes replaced common sense by "statistical significance". Both approaches are not exclusive from each other, the question is "how to put them together".

The farmers' traditional research method is based on observations and empirical results. In most small farm systems, informal trials and experimentation by farmers are a common feature of their traditional practices.

\[\text{Picture 12. Traditional methods of seed storage.}\]
The initiative and specialized empirical knowledge of small farmers utilized in informal research is a valuable resource seldom explicitly incorporated into research programmes (Ashby, 1986). The level of adoption follows their own understanding of the benefits.

Even a small contribution of technology to the farmer's overall strategy can determine the degree of adoption, as illustrated by the following examples.

In the Andes, a household adopts a new variety of potatoes from a couple of tubers collected from another area, or from the local market. The variety is adopted despite the low yielding capacity because of good cooking or "chuno" characteristics.

In the family's food security strategy, increasing production is not a goal, productivity is not an issue; probably just a little gap that the new variety covers, namely cooking or "off-season food security" because "chuno" is the most common conservation method.
If the researchers are not very familiarized with farmers circumstances they will never identify it as important. Probably such a variety should be removed from the experimental programme because this type of assessment is difficult to quantify.

Even when production is an issue, the adoption of technology is not necessarily determined by the statistical significance of the results.

Introducing high-yielding varieties of maize is the major objective of the African research programmes, because the crop is becoming increasingly important as a staple food.

Over a long period farmers have developed their own maize "varieties", following their consumption preferences and varietal natural selection. The crop is grown under traditional cropping systems as one among many other crops. The yields of these "varieties" have been constantly low.

On the way to introducing new varieties, the old ones are taken as controls, usually in monocropping variety trials. Improved varieties commonly show higher yields than the old ones, representing under good management one or two tons difference per hectare.

Under small-scale farmer conditions it will represent perhaps only two or three hundred kilograms. The farmers cannot accept it due to the risks that the change of technology imply. Despite the fact that statistically the new variety is shown to be better, the farmer will continue growing his own variety. When the level of yield of a new variety shows perhaps a 100 or 150% yield increase, then the farmer will adopt it because this is a level that pays the risk, and gives an acceptable rate of profitability.

A good example is found in the Zambian case in which the old hybrid SR52 was never adopted by small-scale farmers and they continued growing their old material until new varieties were developed that fulfilled local farmers preferences regarding yield, grain type, and level of management.

The new varieties were massively adopted, producing an enormous increase in productivity without seriously affecting the production of other food crops.
The simple change of varieties, resulted in a productivity increasing by about 2 tons/ha (from about 800 kg/ha to about 2800 to 3000 kg/ha as provincial average) and the provincial production increased from 45 000 bags of maize in 1980 to about 450 000 bags in 1989. The area under maize cultivation, and the use of fertilizer and other agricultural inputs (with the only exception of purchased seed) increased at a rate which often was lower than production. (Sinkamba, Personal communication, 1990).

8.2.1. The role of women

Female farming is recognized to be a major feature in third world agriculture. Several studies show than in Africa about 30% of the farms are entirely managed by women and more than 50% are mainly operated by them (Moris, 1991). In Latin-America and Asia the situation is not much different, the only exemption are countries where agriculture is relatively well-developed, or in countries of Islamic origin, but in most cases everywhere where non-mechanized agriculture is predominant, female farming is the major driving force.
The culture, labour migration and household set-up of most third world countries imply that women are definitively the most important single factor in food production and crop husbandry within those regions. The fact that women are generally less "protected" than male farmers in terms of land right, access to credit, work load (they take care of the fields as well as household activities), access to extension, etc., means that they operate under extremely difficult management conditions and their success depends mostly on their own personal skills.

Agronomic practices on introduced crops and the management of traditional crops rest to a high degree on the experience accumulated by women, and because female farming is so strongly associated with food production most of the subsistence strategies have been developed by them. Unfortunately, the valuable source of information accumulated has not been completely understood and appreciated, either by extension or by researchers.

Despite the fact that traditionally, food production and the food security strategy of the household is completely in the hands of women, the research and extension activities still concentrate mainly on male farmers, neglecting the indigenous knowledge of women as well as the enormous potential for appropriate technology development existing among females.

Picture 15. Food security strategy is completely in the hands of women.
8.3. Appropriate evaluation of on-farm trials

There are several methodological aspects regarding FSR that influence on-farm research. The idea in this chapter is to restrict the discussion to the difficulties that this type of research present when analysing and interpreting results, rather than going into the complexity of the experimental designs themselves.

Despite the conventional experimental designs at times being difficult to execute due to the heterogeneity of the cropping pattern found in some fields (Chiduza & Nyamudeza, 1990), several authors have shown how experimental design can be modified to fit local practices (Chambert et al., 1989).

By experience, I think that the design used is not so important so long as the objectives of the experiment are being fulfilled, that the experiments are kept as simple as possible, and that the analysis corresponds to the design. It is better with no statistical analysis at all than to analyse it in a different way than the trial allows.

The need is not to keep the trials 'simple enough for farmers to understand and evaluate', nor to develop more sophisticated statistical methods, but rather for research and research institutions to accept the proposition that adoption by farmers is validation of a technology, even if we sometimes are unable to identify or quantify the technology's effects (Sumberg & Okali, 1989).

Farming Systems Research offers different ways of experimental analysis, which have been tried with more or less success, covering a broad range of possibilities, from purely statistical up to only assumptions of farmers' attitudes or preferences, passing through partial budget analysis, return to investment, human energy, etc.

As already mentioned, on-farm research requires a preliminary analysis based on estimations of feasibility, taking into consideration the agro-socio-economic-cultural factors which could affect the technology, and subsequent analysis based on more concrete values obtained from experimental results, farmers' reactions, institutional response, etc.

The conclusions should emerge from a well-balanced combination of the statistic and economic analysis, but both statisticians as well as economists
demand certain conditions under which the experiment should be undertaken, to allow them to use their expertise.

In on-station research it is very easy to fulfill those conditions because the non-experimental factors are well under control, and even some conditions can easily be simulated, which has the result that only treatment effects are affecting results.

On-station research methods, however, cannot be applied directly under the more variable conditions encountered by on-farm research. Such conditions mean a higher coefficient of variation (CVs) and higher rates of trial loss, and they require different types of experimental design. (Merril-Sands & Mc Allister, 1988)

8.4. Farm level experiments

The most widely accepted division of farm-level experiments is "Researcher managed trials" and "Farmer managed trials" (Dillon & Andersson, 1983). "Superimposed trials" are also commonly accepted as a combination of the others.

8.4.1. Researcher-managed trials

Researcher-managed trials are experiments carried out on a farmer’s field and using methods and techniques similar to those at the experimental station, aiming to screen technology according to specific agroecological conditions. In many cases, researchers try to simulate or copy some of the farmer’s conditions in order to make the environment more real but, since the non-experimental factors are fully controlled, the farmer’s participation is minimal.

I feel that this type of experiment should be classified outside the frame of farming systems research because it is very difficult to relate treatments or the technology tested to the conditions of specific group of farmers.

Even if the benefit of such an experiment is related to the biological and physical environment close to the farmer’s field, which facilitates interactions and reactions to the technology being tested, all other factors affecting the technology have been removed or are under research control. Therefore it is difficult to fit this type of experiment in a more integrated systems perspective, but judicious decisions can be made to include
background social and consumption data if such considerations are useful in trial analysis (FSSP, 1987).

In terms of design, the research-managed trials will have a considerable amount of treatments and replications per field, and only a few experimental sites. It will also allow more complex designs, and will be managed by researchers in a way very similar to that in station-trials.

Non-experimental variables may often represent future technical recommendations to farmers rather than farmers' current practices of farmers. Trials require close monitoring with frequent visits to observe the crops' progress, but they are not intended to generate information about how farmers respond to the technology (Ashby, 1986).

Gomez & Gomez (1983) call this type of experiment "Technology generation experiments" saying that "the farmer's field provides a set of physical and biological conditions, under which the trial is to be conducted and the technology developed.

Procedures for on-farm technology-generation trials are similar to those at the research station". The same scientists also offer methodological advice to allow researchers to cope with features of the farm which are different from those at the research station. To standardize and find experimental areas that are as homogeneous as possible, it is recommended to select the most accessible, the ones with more availability of resources and managed by cooperative farmers in sites presenting the least soil heterogeneity.

They confirm that, in spite of having experiments on farmers fields, the researcher-managed trials are more or less on-station research transferred to a more real physical environment, being a kind of intermediary stage between commodity and farming systems research.

Despite the relatively well controlled experimental environment, this type of trial is not without some of the common problems affecting on-farm research. I agree with Gomez & Gomez that errors can be expected to increase because the fields are less accessible and more difficult for researchers to supervise. In addition, damage by rats, stray animals, vandalism and theft are more apt to occur and will increase experimental error.
An important aspect when having trials on farmers' fields is the residual effect found on their land depending on the type of "cropping system" which prevails in the area. The generally low insect and disease pressure and the more uniformly managed farmer's fields, being free of residual effects may result in less experimental error. This may be correct when related to a monocropping system, like rice farming in Asia. However, I have experienced the opposite with non-rice cultivations in traditional cropping systems of small farmer communities in Africa and Latin America which are based on the multicropping of a small field, where disease, pest, and weed pressures are many times greater than that at research stations.

The same is valid with regard to the residual effect of the different cropping components. They contribute to increase the degree of soil variation.

All these factors serve to increment the risks of higher error, which makes the possibilities of a fair statistical analysis more difficult.

If those problems already appear in research-managed trials, is easy to imagine how difficult it is to implement and analyse, the "farmer-managed trials", which are the basis for on-farm research and the foundation for the conclusions emanating from farming systems research.

8.4.2. Farmer-managed trials

In practice, it is difficult to fit the real degree of farmer management within a pre-established level. What is really important is the fact that in this type of experiments the management is mainly carried out and determined by the farmer's own practices. As long as we are dealing with experiments it is impossible to completely exclude the influence of researchers on the management of trials. Even in "fully farmer-managed trials" I have noticed that after a researcher visits the site to talk with farmers and discuss the on-going experiment the farmer will utilize some elements of the discussion to somehow "improve" the current practices.

What really matters is that major managerial practices do not change and that at the end it is the farmer who decides on any change to the on-going management.

Many farmers are experimenters by nature and with the trial they will act in the same way as they do with their own fields, i.e. according to the circumstances, they make decisions "in situ" regarding their practices.
However, the fact that an experiment is supposed to be "farmer-managed" is not a reason for the technical staff to leave "everything up to the farmers". It is not uncommon that during the growing period and following their logic, the farmers decide to change "experimental factors", e.g., to distribute "more evenly" the fertilizers among all plots in a fertilizer trial, or to transplant, in a plant population trial, plants from a high plant density to a low plant density plot in order to get a "more even plant stand", or to start "pre-harvesting" before maturity due to lack of food at home.

The "presence" of researchers in this type of trials is at least as important as it is in researcher-managed trials. Otherwise, the results will be misinterpreted and many lead to wrong conclusions. In the same way that some farmers' reactions need to be considered in researcher-managed trials, the researcher has the right and the obligation to intervene in farmer-managed trials if the circumstances so require.

a) Superimposed trials

One of the most common types of "farmer-managed trials" are the "superimposed trials" where most of the major managerial practices (plant population, land preparation, variety, type of seed bed, etc.) is already taken over by the farmers before the trial is marked out.

The treatments are distributed among the plots following the same management or with a few changes jointly agreed with the farmer.

Those trials are designed to be very simple, involving only one or two factors. It is recommended to include replications in each location; the results could be combined with results of other locations for broader analysis and interpretation.

When trials are not superimposed it is recommended, as much possible, to plant the experiments within the farmer's own field. This provides researchers with a good opportunity to observe if the "farmer's management" really corresponds with their usual practices. On the other hand, it will keep the experiment under physical and biological pressures similar to those affecting the farmer's own crop.
8.5 Experimental vs non experimental variables

The "heterogeneity" of experimental areas is one of the most important aspects in on-farm research; the higher the degree of farmer management, and the larger the number of trial locations, the more important it is that researchers understand "variability" because that will always be present on the farmer's field.

It is important to try to decrease the level of variation in non-experimental variables to allow some type of statistical analysis, but not to a degree that variation between sites disappears, otherwise the technology tested will become site-specific instead of domain-specific. On-farm trials are designed to help detect differences under typical farmer management practices and environmental conditions.

Therefore non-experimental variables such as crop management practices should not differ from those normally used by farmers in their own fields (Artis et al., 1987).

The level of uniformity or diversity needs to be discussed with the household members in order for them to understand that the research effort is not directed at an individual household but at a wider target group. This will increase the farmer's commitment with the non-trial farmers and with the joint research/extension activities during the research and/or dissemination process.

When the differences between locations are so great that they do not permit a common analysis, then each site can be analyzed separately and relate the results to each other on a non-parametric analysis.

If a big variation is foreseen in one non-experimental factor at the time of designing an experiment, then it is better to re-design the experiment and include this element as one of the experimental factors in, for example, a split block experiment, (e.g. low vs high level of management, row planting vs broadcast, flat land vs ridges, etc.).

8.5.1. Check plots

In on-farm research the flexibility of the researcher to handle the field conditions will determine the final interpretation of results. The farm environment in which the trials are implemented can vary widely between
locations and within farmers' practices. This usually requires that the research team adopts a pragmatic approach during the research process.

"Check plot" is an important experimental variable, and to be sure that the analysis is correct the control should have a representative and consistent value constant throughout all replications. This is not a problem in on-station research where the control usually represents the current recommendation.

When testing or developing a technology under farmer conditions, in most cases the "CONTROL" used is "farmers practices", which really is a concept and not a concrete parameter.

"Farmer practices" is a tricky concept that gives theoretical validation to the final interpretation of results, but which in practice presents a lot of "unexpected" complications.

The most common approach is to give an "average value" obtained from a survey on this specific practice, or using the "average" of all check-plots from the different replications. This is the easiest way if all locations can be a part of a common analysis. It can satisfy statistical requirement, and thus the control becomes formally comparable to the treatments.

With this method, however, the researchers are often cheating themselves. For example, if the objective of the trial is to compare the benefits of recommended seed rate against "farmer's practices", it will be found that despite the farmers generally using a high seed rate, the differences among farmers (within the high seed rate) is enormous; there may be up to 200% of difference between trial farmers. The comparison between replications should be with its own check-plot and not with an artificially standardized value.

One way to avoid this problem may be to discuss what farmers themselves consider as common farmer practice in the area, and then simulate this value as a control. In this case, it is the farmers who are cheating themselves because a standardized farmer practice definitely does not exist.

Another approach is to stop caring about what "farmers practice" means and just tell the farmer to plant in the normal manner, and thereafter compare the results without quantifying the control. That is also wrong, because is not correct to compare a concrete value against a conceptual one.
ignoring that the response of the latter will depend largely on its managerial components (seed rate, planting depth, seed bed, number of weeding, etc.) which varies so widely among the check plots within the trial but which are constant after the other treatments.

This problem has caused, at least among FSR practitioners, a lot of worries about the value of using farmers' practices as an experimental variable. Some people would like to consider it as a non-experimental variable because otherwise the scientific value of the analysis is questionable.

In cases like this, the flexibility and common sense of researchers must be utilized. This is a practical implication of FSR, and must be solved in this context. The solution should come from an integrated approach. Any method can be used (average, individual analyses, non-quantifying of control, etc.), or a combination of them as long as the result obtained follows the same tendency as found when comparing, in a cross check, the results obtained in the trial with observations of the farmers' own fields.

8.7. Replications

A good strategy to compensate the risks of unsatisfactory statistical analysis is to increase the numbers of sites as much as possible, with no more than two replications per site, but in many locations. This strategy will not only have statistical advantages but also practical advantages.

In on-farm research, relatively high trial losses are expected. Sometimes farmers need to abandon a trial due to socio-economic reasons (sickness, funerals, etc.); it may also happen that some sites can be more or less destroyed by wild animals, acts of vandalism or theft. In other cases, the differences are so great that any attempts at statistical analysis is worthless.

Statistical analysis of on-farm trial data normally presents problems because of numerous zero values. Trials are often simple and small, and missing data reduce the sensitivity of the statistical test. As long as the researcher is satisfied that the missing data are not a result of the treatment, and if no logical explanation is available to explain anomalous data, then data should be declared missing.
Unless there are valid reasons to query zero yields, researchers should not feel uncomfortable with such data since disregarding them may bias whatever technology is under test (Chiduza & Nyamudeza, 1990).

When there are sufficient replications, the "saved sites" can still be analyzed and indeed are still very useful. An experiment "should NEVER be completely abandoned" no matter how bad it looks. In FSR the concept of "BAD" results may not exist. If occasionally something unexpected happens in the trial site the same thing will certainly happen in the farmer's fields.

Despite the fact that the information will not have statistical value it can still be recorded and analyzed by other means.

I have experienced that, in the long run, the "bad results" or "otherwise abandoned trials" have greater value than the "good ones" because they give a good understanding of real circumstances permitting reorientation of the research programmes.

8.8. Plot locations

In on-farm research there is no reason why all plots of the same replication should be in the same field; the limited availability of land or the characteristics of the field results in plots being unevenly distributed in the field or even on different fields; it is important that this is accepted, otherwise there is a major risk that plots will fall on unrepresentative pieces of land. If space is very limited or if the designed trial is too long to fit into a given farmer's field, the plots can be separated according to a special procedure (FSSP, 1987). It is not unusual to find some physical or morphological hinders in the middle of the field like trees or ant-hills, paths, etc., that should be avoided.

In on-farm research, and given special circumstances, each block can be treated as a kind of a single experiment, or just utilized as observation plots. There is always some valuable information to be collected no matter how "unconventional" the trial appears.

8.9. Borders

In some cases it is found that on-farm experiments are planted or superimposed on farmers' fields in any way just to "keep the environment
as real as possible". This extreme approach needs to be removed as a research practice. An experiment, after all, is an experiment which needs to be analyzed as such, no matter how farmer-managed the trial is; its borders should be well-defined and the treatments under observation clearly identifiable from the surrounding elements.

Having clearly defined borders has a practical advantage as well, because that allows farmers, researchers and visitors to freely walk around to evaluate differences during the growing season. I have also observed a better commitment from farmers when the experiment looks somehow "in order" and not as a "mess" within the field. The trial borders should be as small as possible because farmers do not like to leave land unused.

Picture 16.
Having clearly defined trial borders allows moving freely around the experiment.
8.10. THE ANALYSIS

..agronomy is still an art as well as a science; its scientific arsenal and lucid analyses should not lack a certain empiricism in approaching producer problems, but should use intuition and experience in the global appreciation of different situations.

(Charreau & Rouanet, 1987)

Because test farms represent different environments, emphasis should be placed on explaining the nature of the interaction effect between treatments and farms in terms of the relevant environmental factors - to gain a better understanding of the influence of those factors on the effectiveness of the treatment tested (Gomez & Gomez, 1984).

The relevant environmental factors necessarily include the socio-economic and institutional ones and indeed the interpretation of results should be based on socio-economic as well as agronomic analysis.

Because FSR is an integrated process, the analysis is, by definition, a product of several methods. Each method represents a tool which more or less contributes to the final conclusion, the specific circumstances will determine the relative importance of each of them.

FSSP, 1987 explains the process in the following way:
As shown in the diagram, the data is submitted to a series of analytical tools or tests that are drawn from various appropriate disciplines. Depending upon the nature of the problem, the type of trial design, and the kind of data generated, other disciplinary tools or analytical measures may be applied.

It is necessary that representatives of each discipline make their own analysis and thereafter sit together and discuss an integrated analysis and interpretation.

The following table provides a good example where the tools used in Botswana in FSR analysis can be seen (Worman et al., 1990).
Table 6. Tools used in farming systems analysis in Botswana

<table>
<thead>
<tr>
<th>CATEGORY OF ANALYSIS</th>
<th>MEASURE OR INTERPRETATION OF</th>
<th>PRIMARY TOOLS QUANTITATIVE</th>
<th>QUALITATIVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological</td>
<td>Effects of treatments, locations, years, and interactions</td>
<td>Descriptive* and t-tests, Analysis of variance, Least significant differences, Correlations and regression, Modified stability analysis</td>
<td>Farmer evaluation and observation, Researcher evaluation and observation</td>
</tr>
<tr>
<td>Economic</td>
<td>Assessment of profitability (costs and benefits), and risk</td>
<td>Descriptive* and t-tests, Cross tabulation and chi-square, Returns to factors of production, Budgets - partial and enterprise, Sensitivity analysis, Risk analysis, Marginal analysis</td>
<td>Farmer evaluation and observation, Researcher evaluation and observations</td>
</tr>
<tr>
<td>Environmental</td>
<td>Long-term impacts</td>
<td></td>
<td>Researcher evaluation</td>
</tr>
<tr>
<td>Social</td>
<td>Inter-household and intra-household equity effects, and consumption/nutrition effects</td>
<td>Index of acceptability, Modified partial budget analysis, Net nutritional benefit analysis, Food system calendar</td>
<td>Farmer evaluation and observations, Researcher evaluation and observations</td>
</tr>
<tr>
<td>General Acceptability</td>
<td>Adoption study</td>
<td>Index of acceptability</td>
<td>Researcher evaluation and observations</td>
</tr>
</tbody>
</table>

* Descriptive statistics are common to several types of analysis for use in summarizing and describing data. The tools include frequency distributions, measures of central tendency (mean, median & mode), measures of dispersion (standard deviation, variance, range, coefficient of variation), and graphics (histograms, bar charts, pie charts).

The analysis is probably the most difficult part of the process before releasing the recommendation because the starting point of each discipline can vary so enormously.

Analysis is a part of the process with the objective of predicting and explaining the acceptability of a new technology by farmer households (FSSP, 1987).

Just a few of the many "interdisciplinary" problems are:

- each discipline may be inclined to impose and over-value its importance with relation to the others;

- statistical analysis, as a mathematical measurement presenting too rigid results, sometimes contradicting farmer strategies;

- very often some of the agronomic conclusions are based on yield adjustments, field observations and previous experience which are not always possible to prove in a "scientific" discussion;

- the economic analysis is time specific, it is not valid over a long period of time because some of the parameters change from one season to the next like prices, marketing, availability of inputs and labour, etc.;

- livestock trial analyses are difficult to make under small farmers' conditions due to the difficulties in deciding the right value to give to the multiple-purpose use of the animals; another problem is related to the "mobility" of the plots;

Because of the small number of animals on farms, the high cost, and close emotional ties between the farm family and its animals, on-farm experimentation with animals becomes more difficult than with crops. Failure of a treatment, or even animals' adjustment to new feed sources, may lead to a drop in milk production, loss in weight, or listlessness. Disease effect can have more serious repercussions for livestock researchers than reductions of grain yield in a farm field.

For these reasons, the emphasis on ex-ante analysis of the biological and economic feasibility of new production methods should be greater in animal production than in cropping systems research. Modifying the animal production system - involving multiple products in a complex of difficult-to-cost crop by-products, labour, and agricultural inputs - can
make the analysis difficult. Because of such complexities, animal scientists have been slow to adopt on-farm research strategies.

This has prevented crop scientists, such as production-oriented agronomists, and economists from incorporating a livestock component in their analysis (de Leeuw, 1990).

The economic analysis usually includes "opportunity cost" as a valid parameter that farmers have difficulties to accept because they themselves do not consider household labour as a cost;

Even if only "economically productive" activities are considered, assessing opportunity costs is a very arbitrary business. Many of women's economically productive activities are particularly difficult to put a price on. How does one price the investment in child-care, which may well be one activity which agriculture displaces? (Allen, 1989).

Picture 17. FSR team discussing with farmers.
The socio-anthropological analysis includes "subjective values" which are not always accepted by biological scientists. One particular practical problem in integrating cultural and environmental data is that the sociological statistics on which cultural indices are based refer to political units (counties, states) which frequently do not coincide with natural units (climatic zones, soil types, biomes, physiographic regions) (Odum, 1971);

The nutritional analysis in most cases contradicts the conclusion of other disciplines because it is not necessarily based on economic returns or high yield but on nutritional intake and food security. Technologies that may be acceptable on the basis of biological and economic criteria, may often be rejected because of "unacceptable consumption characteristics" (FSSP Volume III, 1987). A final complication is that nutritional matters have a low visibility, which is reduced even more by the nutritional illiteracy of most administrators and economists (Dahlberg, 1979);
Allen (1988) argues that the use of energy as a measure in farming systems research is particularly attractive, because it is the most basic unit of account in the natural system, allowing us to measure the effort in human work, which is not the same as the time expended on it. In other words, it allows us to compare a couple of hours of hard work clearing land, with several hours of sitting shelling groundnuts.

Farmers' yield measurements are often based on volume and not in kg, and accordingly an increase in productivity doesn't necessarily represent benefits when the crop is to be sold at the local market.

Researchers, on the other hand, invariably analyze technologies on the basis of weight of the output. When crops are sold by cupful or plateful, the size of the seed is more important to the seller that its density (Allen, 1988).

To arrive at a common acceptable conclusion, the research team members need to be very open-minded. They should listen more than talk, and especially accept that the final decision about the relevance of the technology rests on the farming households and not on researchers.

Blanco (1990) argues that the origin of the problem is the character of the training received. The FSR team members should do everything possible to integrate themselves into the community and work together with the community members.

They must also be ready to meet changing circumstances, developing and adapting themselves to the dynamism of the system.
Picture 19. *Traditional labour distribution or traditional way to distribute labour?*
9. THE PROCESS OF TECHNOLOGY GENERATION IN FARMING SYSTEMS RESEARCH - A CASE STUDY

The following case rests heavily on a previous paper published in 1987 by the Adaptive Research Planning Team (ARPT) Zambia, and reproduced by Kean & Singogo (1988). This is a practical example of one way of technological generation using the farming systems approach.

Five years of on-farm research are included in this case. The objective is not to present the agronomical results but to display how the experiment evolved during time from a purely exploratory trial to the releasing of specific and optional recommendations and how new elements were included in the trial from season to season. The case shows the importance of the attitude and the ability of the research team in terms of adapting themselves and the experiment to the reaction of farmers and to the information emanating from the treatments. The example also proves the complementary role of the commodity and FSR and the benefits of their interaction.

The introductory part confirms the general description given in the first part of this document; despite being specifically related to the Zambian agricultural research situation.

9.1 Introduction

The process of generation of technology is an old issue with different facets. In Zambia, traditionally, the process has been more an up-down imposition from scientists based on Research Centres to "farmers" through the extension services.

The research priorities and objectives mostly focused on a single discipline or, in most cases, on one crop or interaction between crops.

The experimental phase of the process has traditionally been carried out between the narrow and well-controlled bounds of the Research Station. Consequently, the real agroecological environment in which the technology should be applied has been neglected.

Later on, the need of on-farm experimentation was recognised and on-farm trials were included, usually among commercial farmers known to be good
farmers on good land and with a well-known management capability. In other words, the Research Station conditions were simulated on farmers' fields.

In most cases, the scientists were working with biological and physical factors affecting farmers, i.e., climate, soil, diseases, pests, fertilisers, etc., aiming to maximize the output per unit of area.

The socioeconomic factors affecting farming enterprises were not taken into full consideration. Farmers circumstances like resources, marketing, prices, culture and "off farm" enterprises influencing farmers' decisions were not determinant factors in research planning.

The solo crop approach developed into more "Biologic Interdisciplinary working groups" through a wider focus which included several crops belonging in the same category (Cereal, Legumes, Tubers, etc.) interacting different biological disciplines (Entomologists, Soil Scientists, Agronomists, Breeders, etc.) but still the technology messages were not adopted by the majority of farmers due to the lack of effective ways of identifying the problems of specific groups of farmers. Therefore, it was impossible to formulate research programmes to meet their specific needs (Kean & Dougnac, 1984).

The recommendations produced were for the whole country, a region or province, without recognising that in the same area there are different types of farmers with different problems and circumstances which also demand different specific recommendations.

Relationships between enterprises, farming, livestock, fishing, trade etc., were not recognised as competitive for farmers' resources.

In 1980, FSR was established as a full component of research branch of the Ministry of Agriculture and Water Development (MAWD) following, more or less, the CIMMYT methodology in which FSR recognises and focuses on the interdependencies and interrelationships between the technical and human elements in the farming systems (Dillon, 1976). The primary aim of the FSR approach is to increase the overall efficiency. This can be interpreted as developing technology that increases productivity in a way that is useful and acceptable to the farming family, given its goals, resources and constraints (Norman, 1980).
The process of technology generation is therefore focused on the household of the local farming system instead of on specific crops or isolated technical constraints.

Picture 20. FSR focus on the household of the farming system.

ARPT was established in Luapula province in 1982 as component of the national FSR programme, and since then ARPT has contributed to a high degree to the re-orientation and re-definition of regional and provincial research policies.

From the start the research priorities are established by a interdisciplinary effort in which all the factors affecting farmers' decisions are involved.

Different disciplines like agronomy, economy, social anthropology, nutrition and extension are represented in a joint team interacting and complementing each other to zone a Province or Region into areas with fairly closely defined and homogeneous farming systems as a basis for defining priority areas and activities (Dougnac & Allen, 1986).
The Agronomist, Economist, Extensionist and Sociologist are intimately involved in every aspect of the project orientation. The details of trial designs are discussed with the Social Scientists, just as the details of survey management are discussed with the Agronomist and Extensionist.

The principle of coordinating and cooperation is extended to the target farmers themselves, who are brought into the process as much as possible. For the broader aspects of the programme planning, the survey work probably affords the most representative method of seeking farmers' opinions. In the middle of each season, however, feedback is sought from farmers at the field days, and at the end of each season the results are presented to farmers and their comments are used to contribute to the next season's work programme (Dougnac and Allen, 1986).

Picture 21. Farmers attending a field day.

The links with the Research Commodity Teams are essential along the whole process of technology generation. A two-way feedback is necessary to find appropriate technical solutions according to the farmers' circumstances.
The involvement of the extension services in the process is of vital importance; from the survey work, through experimentation up to recommendation release. The flexibility of the technology originated through on-farm research requires a special attitude and command of a system perspective by extension staff in terms to elaborate the right recommendations to the right type of farmers at a specific time and location. The circumstances of most farmers are such that they adopt technologies in small pieces, usually one or two components at a time.

A research programme should therefore initially aim to develop two or three best-bet technological innovations which have relatively high pay-offs when added to the farmer’s technology (Byerlee and Collinson, 1980). 

9.2. Background and definition of the system

Luapula Province in the North-west of Zambia lies between latitudes 8 and 12.4 degrees and longitudes 28.5 and 30 degrees with a plateau altitude of 1200 - 1500 metres and 900 - 1000 metres in the valley.

The soil profile is dominated by generally sandy loam and loam sandy soils. There is ferrallitic soil which is leached sand or leached red-brown loam. Most of the soil is acidic due to the heavy rainfall which easily reaches over 1 100 mm per year (ARPT zoning report, 1983).

The majority of the population is farming only for subsistence needs, which is directly related to provincial pre-eminence of fishing as a source of cash, with a large population of female-headed households and the predominant role of women generally in farming (Dougnac & Allen, 1986).

The recommendation domain covered by this experiment is characterised as a non-predominant fishing area with relatively high response to agricultural production and marketing.

The main features are:

- Hand hoe cultivation with some tractor hire. Oxen are very scarce.
- Cassava, maize and millet are the major starch staples, with beans, groundnuts, cassava and pumpkin leaves for relish.
- Maize, groundnuts, beans, millet and cassava are major cash earners.
- Shifting cultivation (Chitemene practice) is still in existence.

- Maize is by far the most important cash crop (ARPT zoning report 1983).

Although intercropping is very common with local maize beans and sweet potatoes, maize grown as cash crop (especially if purchased seed is used) is almost always grown alone.

The purchase of agricultural inputs is limited to areas near the capital of the Province, and to the few farmers who get exclusive advice.

Fertiliser use is restricted mostly to farmers who get loans or who are part of an agriculture extension programme. Most of the farmers keep their own seed or buy it locally. When new seed is bought, it usually covers only a minor part of the field.

Late planting is the most common practice. Crop rotation is only practised by a small group of farmers. More than 70% grow maize on the same land for at least 3 consecutive years. Bean production is low due to pests (Bean stem maggot), poor agronomic practices and because it is usually grown in the poorest soils.

Groundnuts, rice and soya are also grown in the area with varying success.
9.3. Sequence of a maize experiment from survey stage up to release of recommendations

a) 1982 - 1983 Agricultural Season

Maize, being the most important cash crop and one of the major staples for the area, should evidently be given priority as research task.

It was found that two different varieties of maize were extensively grown by farmers, namely "Kanjilimine" which is a very old material product of natural crossing between traditional open-pollinated and hybrid varieties.

The second variety found was the old hybrid SR 52 which was widely recommended by extension services and attached to all maize loans for the Province.

"Kanjilimine" is characterised by a multicolor medium size cob, very uneven vegetative growing, little response to fertiliser and good tolerance to streak virus and different types of soil stresses.

"Kanjilimine" is usually grown as subsistence crop, mainly for green maize in small fields around the houses or intercropped with other crops in shifting cultivation.

SR52 is a hybrid which demands early planting, good soil and presents a great response to fertilizers under high levels of management. SR52 is extremely susceptible to streak virus and other biological stresses (pest, diseases, weed competition, etc.).

A preliminary survey showed that the fields of SR 52 were giving extraordinary low yields (500 kg to one ton/ha).

On the other hand, Kanjilimine, without any inputs, was doing just as good (or as poorly) as SR 52.

It was decided to start an experiment testing different packages including seed bed preparation, different levels of fertiliser and spacing in both varieties. The results showed that under those conditions and in all treatments, SR 52 did worse than or performed not much better than, Kanjilimine.
b) 1983 - 1984 Agricultural Season

From the previous results, it was clear that under small farmer conditions, Kanjilimine was a better alternative, but due to its color there was no official market to sell the surplus. The official marketing agency only buys white grain maize.

After consultation with maize commodity researchers, the "variety factor" was included, looking for better alternatives for both varieties. Two open pollinated varieties were tested against them, namely Zuca and MMV 600.

The result under different input levels showed a big supremacy of both new varieties over the old ones. Zuca presented some undesirable agronomic characteristics that made farmers reject it.

MMV 600 was accepted as an interesting alternative to what farmers were using.

c) 1984 - 1985 Agricultural Season

The general conception of "farmers" was discussed and developed into the concept of "target group". Then different alternatives were tested for farmers who could afford some level of inputs or being participants of a credit scheme, namely the so-called "Lima farmers".

New consultations with the maize commodity team originated in two different trials.

One was oriented to the subsistence farmers' group, testing MMV 600 as an alternative to Kanjilimine growers. Zuca was discarded because of undesirable agronomic characteristics.

The second trial focused on alternatives to hybrid growers (Lima farmers) testing three new hybrid varieties:

a) MM 603, a streak virus tolerant variety and less susceptible to late planting than SR52.

b) A short maturity variety, MM 504 was also included (late planting is a common feature of the system).

c) And the new elite of SR 52 called MM 752.
Three levels of fertilisation, zero, 200 and 400 kg/ha, were tested with Lima farmers and only two levels, zero and 200 kg/ha, with subsistence farmers.

The results of the experiments confirmed the superiority of MMV 600 against the local Kanjilimine among subsistence farmers both at zero and low level of fertiliser.

Among Lima farmers, MM 603 out-yielded all varieties at zero and low levels of fertiliser. The response of MM 603 to an additional 200 kg of fertilizer was not significant. MM 504 reached the best yield level at high fertilisation rates. MM 752 and SR 52 were strongly affected by streak virus, yielding poorly under all treatments.

The results showed:

a) the supremacy of the open-pollinated variety MMV 600 over the local and SR 52 seed with zero and low levels of fertilisation.

b) the superiority of MM 504 and especially MM 603 among hybrids.

d) 1985 - 1986 Agricultural Season

There was already enough evidence that MMV 600 was a better alternative to Kanjilimine and to SR 52 among subsistence farmers, and MM 504 and MM 603 among hybrid growers.

A new problem emerged, namely if MMV 600 could be an alternative to MM 504 and MM 603 and vice-versa under different management levels. The "management factor" was therefore included in addition to variety and target group.

The work in 1985/86 combined the two previous trials to test the preferred hybrids against the open-pollinated variety under a range of fertiliser levels.

Kanjilimine, SR 52 and MM 752 were dropped because of their poor performance.

The trial also covered two different groups of farmers: purely subsistence farmers and those who had been subjected to some "Lima" extension training.
The differences in response were, apparently, not related to soil fertility because there were no significant differences between varieties and farmer categories at zero fertiliser level.

The level of management, however, seems to play an important role in the response to fertiliser with subsistence farmers, whose land preparation and weed control are usually poorer.

All three varieties showed a continuing response to level of fertiliser up to 400 kg/ha.

On "Lima" farmer's fields, however, where management of land and crop is usually better, only MMV 600 shows a continuing response to extra fertiliser.

With both hybrids, the response to levels higher than 200 kg is negligible.

e) 1986 - 1987 Agricultural Season

Large plots of about a quarter of an hectare were planted across the recommendation domain, repeating the previous year's treatments in fields of several subsistence and Lima farmers under full farmer management, without researcher interference. The objective was to confirm the results before releasing any recommendation. The results led to two completely different possible recommendations depending on whether they are aimed at low management subsistence farmers or "Lima" farmers with prior exposure to improved practices.

Therefore two new concepts emerged: "Specific Recommendation" and "Optional Alternative Recommendation".

For either group, MMV 600 is the option if the hybrids are not available in the local depots or if fertilisers are not available, or there is no intention to use them. In addition, MMV 600 allows seed to be kept for the next season. If hybrid seed is not available, MMV 600 will respond positively to increasing applications of fertiliser.

If commercial seed is available, and as long as there is the will and availability of fertiliser, a hybrid should be used.

For Lima farmers, the choice is MM 603, mostly because of a combined high yield at 200 kg fertiliser level and its tolerance to streak virus which
makes it less risky than MM 504. Also for subsistence farmers at the same level of fertiliser, MM 603 seems to be the best economic alternative.

For the food crop, MMV 600 is preferred by farmers due to its palatability and better storage characteristics. MM 504 must still be considered for this system because of its value as a short-season variety suitable for an area where late planting is a common practice.

The sequence used in technological generation from Technical Package - Variety - Variety + Target Group - Variety + Target Group + Management up to Specific and Optional Recommendation is outlined in the following scheme.
Figure 12. Evolution of the maize variety and management trial in Luapula Province
10. DISCUSSION

As in the past, the future of humanity will rest in its ability to satisfy the food demands of the population.

History shows that several strategies have been used by farmers to achieve the goal of self-sufficiency but also shows that those strategies have been determined, not only by farmers' needs but by the demands of the non-farming community for food supplies. This relationship became more notorious with the urbanization of most societies; farmer responsibility becomes more directed to the urban population than to their own communities.

The industrial revolution in western countries marks the initial era of cash crop production, both to satisfy the demands of the flourishing food industry as well to satisfy the requirements of the over-populated urban areas.

The industrial revolution gave resources and necessary incentives for intensification of agricultural production in industrial countries. Agriculture managed to develop at the same pace as industry, and both sectors could evolve simultaneously. New husbandry methods, production technologies and agricultural inputs appeared to meet the demands of the industrial sector.

The main objective of western agriculture during the last century has been the increase of production through improved productivity, releasing labour to the growing industrial sector.
The sustainability of traditional systems rests on the harmony between its components.

The needs for raw material and a new market for manufactured products extended the arms of the industrial revolution to the third world countries, specially in Africa and to some extent in Latin America and Asia. The "investment" of capital moved to the South and through the colonial power or imperialistic or neo-colonialism adventures, high level exploitation of natural resources started with the logical consequences in cultural, economic and administrative disadjustments.

Two different types of agriculture developed, one that could cope with the new development, very little in size but extremely political and economically influential, represented in Africa by the "white farmers" and in Latin-America by the "latifundistas" and other types of agriculture that kept their traditional character, very large in size but economically and politically insignificant.

The former were involved in commercial farming and the latter were struggling to survive in a subsistence economy.

The new situation caused migration from the rural areas, uncontrollable urbanization, disproportioned food demands from the urban population.
that accompanied administrative and environmental mismanagement, creating serious unbalances between population and production growth.

The failure of large-scale development schemes from the 1940s and 1950s opened the doors to the introduction of the Green Revolution under the assumption that well-organized and properly funded plant breeding programmes could deliver technical packages (improved seed + agricultural inputs) able to increase agricultural production (Richards, 1986). At the same time that the International Research Institutes were established. Methods for transferring those technologies were developed, assuming that the low level of production is inherent to farmers' ignorance and to the belief that the most appropriate ways of increasing efficiency of traditional farming was through "transference" of improved technological packages.

The varying results of the Green Revolution have already been discussed and despite the fact that several major criticisms are well-founded, there is no reason to ignore that the Green Revolution has been a very important stage in agricultural development. It should be analysed with regard to its historical perspective, the benefits gained should be used as a basis for further development, and its negative effects used as lessons for the future.

The failure of the Green Revolution to fully meet the needs of third world agriculture, not only regarding production but on the environmental impact and sustainability of the systems, is usually presented as the reason for the development of the Farming Systems approach as a method of research and extension oriented to the production of appropriate technologies for the small-farming sector which is strongly predominant among third world countries.

This assumption is only partially correct, the approach has always been present within the farming community, not only in the third world but also in industrial countries. Farming, more than an enterprise, has always been "a way of living".

Before the industrial revolution in the west, and up to now in most developing countries, farming has been a complex series of household activities oriented to satisfy essential needs, influencing and severely influenced by non-farm activities and socio-economic and environmental factors.
The traditional farming systems are characterized by a full harmony among factors that assure the sustainability through the interactions of the components.

This congruence among people, the nature, their culture and traditions has permitted the development of local administrative and bureaucratic structures and indeed the survival of their communities.

The technologies developed under the umbrella of the Green Revolution were, in most cases, unable to fit in those traditional systems; they were designed as "technological solutions" instead of "technological components". The improved technology is relevant only if it fits into the overall strategy which permits the sustainability of the system. If not, it doesn't matter how good the technology is. Certainly, it can be said that FSR is only a reaction to a type of overspecialized, centralised and isolated agricultural research.

Within this perspective we could say that Farming Systems Research is a reaction from the scientific world, not to scientific incompetence but to the weakness in research methodology. The approach to research was not wrong but incomplete; modern research methodologies left out important factors affecting production and thereby jeopardising the relevance of research findings.

What farming systems approach has done is only to return those production factors from the farming systems into the research programmes.

11. CONCLUSIONS

Among the clearest benefits of the adoption of the FS approach into national research activities, the following aspects could be mentioned:

a) The need of interdisciplinary work came up very clearly, against the idea that multi-disciplinarity was enough to guarantee disciplinary interaction. Experience shows that having different disciplines in the same team but acting in isolation from each other can have greater detrimental effects than single disciplinary work.
b) The experience and indigenous knowledge accumulated by farmers, for the first time, is formally and methodologically utilized in research planning, implementation and on the assessment of technologies.

c) Conditions for the establishment of feedback channels between research, extension and farmers have been created.

d) For the first time, gender issues emerge as a natural component of research activities and not as an external women's programme. This is given the right perspective to female farming within the system and the right prospect to the role of different household members in the production process.

Picture 23. Feedback channels have been created.

e) The incorporation of social sciences in agricultural research is contributing to create a research environment capable of understanding the production process not as a "objective" but as a consequence of the socio-economic and agro-ecological circumstances faced by the household.
(d) On-farm research has enriched the analytical process of agricultural research incorporating not only socio-economic parameters but giving the right perspective to the different analytical tools, incorporating farmers assessments and bringing back common sense as a valid method of analysis.

g) Through FSR, the socio-economic and agro-ecological implications of research activities became very clear, giving additional arguments for developing technologies able to contribute to the long-term sustainability of the farming system.

h) Since FSR activities are mainly concentrated in developing countries, it has opened new channels of collaboration between third world countries. The establishment of networks has strengthened the interaction of the developing countries with international agricultural research centres and new training alternatives for third world students have come up.

Picture 24. Gender issues emerge as a natural component of the research process.
Unfortunately, Farming Systems Research is not free of criticism, the other face of the coin presents several negative aspects. Among the clearest shortcomings, the following could be mentioned:

a) FSR has, sometimes, been used as an academic subject, as a new "science", and plenty of time has been wasted trying to agree on exact definitions instead of realizing the dynamics of what is intended to be defined, i.e., to understand the inter-relations of the factors affecting farmers' circumstances, and farmers' strategies to handle those factors.

FSR scientists have done themselves and their efforts a disservice by continually coining unnecessary new terms for their work. This often appears not to be because of scientific need but because of a desire for institutional trademarking. Although not unexpected in a relatively new field, FSR jargon has caused serious misunderstanding of what FSR is and does (Plucknett, et al. 1987).

A never-ending list of terms and definitions can be found in the international literature. The development of this subject is so dynamic that in an effort to improve or to correct some weaknesses of the approach, different researchers and authors have added new terms or changes to the old ones instead of trying to improve the practical use of the ones already in existence. At the end, and despite the diversity of terminology, the central concept remains the same.

b) FSR has often been utilized as a "trap for funding". Specially during the 1980s, it was enough to mention "FSR" in a project document to attract the interest of donor agencies.

c) FSR has certainly gone through a serious fashion stage in which a lot of unrealistic expectations were created among local governments and financial agencies. Fortunately, reality has shown that the development of appropriate technologies cannot be achieved by single changes to research methodologies and that FSR is not a "panacea" which has come to solve all types of problems.

d) FSR has sometimes degenerated into sterile arguments between commodity and farming systems researchers.

Instead of appreciating the complementary effect of both types of research they have been often presented as exclusive alternatives.
Several FSR programmes have failed mainly due to "professional blindness" of researchers and passivity of research authorities.

e) The high expectations and great interest that FSR has originated among local governments and donor agencies have led to research programmes being over-staffed with technical assistance and becoming fully externally funded, creating unsustainable situations with programmes collapsing when the foreign assistance is withdrawn.

f) Despite "theory", FSR has been unable to completely fill up the gaps existing between research and extension, some improvements do exist in some countries, but in general the links are still weak.

g) Sometimes, farming systems research programmes have been used to generate knowledge instead of appropriate technologies. At the end of those programmes, the "knowledge" was sometimes brought back to the foreign universities and local farmers remain without new technologies.

My final comment is that, despite all the weaknesses, Farming Systems Research is a valid approach. Such efforts to reach farmers have never been done previously.

Experience shows that FSR did not come to replace but to complement station based research. As long as both types of research fulfil the roles that they are supposed to play, FSR recognizes and emphasizes their interdependency and complementing roles. By definition, both on-station and on-farm research are equally "scientifically" valid despite the differences in design, management and criteria of result evaluations.

There is still space for further development and/or methodological improvement.
DEFINITIONS

As a "terminology hand-out", a list of the most common terms appearing in the literature is given below. In some cases, they are a "hybrid product" of different people's definitions, or my own simplification of a more complicated definition.

ADAPTIVE RESEARCH

This is the process of mobilizing knowledge and technologies which have already been tested under controlled conditions, and applying them to solving farmers' problems or expanding their production opportunities (Merrill & Sand et al., 1989). Adaptive research is probably the most important tool of on-farm research in its efforts to "adjust technology to the specific needs of a particular set of environmental or socio-economic conditions" (Farrington & Martin, 1987). For example, the introduction of an open-pollinated variety of maize which is acceptable for home consumption, which produces a reasonable yield under low management, where the colour of the grain is acceptable by the local mill, and which permits farmers to keep their own seed.

AGRICULTURAL KNOWLEDGE AND INFORMATION SYSTEM (AKIS)

An AKIS is a set of agricultural organizations and/or persons, and the links and interactions between them, engaged in such processes as the generation, transformation, transmission, storage, retrieval, integration, diffusion and utilization of knowledge and information, with the purpose of working energetically to support decision-making, problem-solving and innovations in a given country's agriculture or a domain (Röling, 1990).

APPLIED RESEARCH

This is the process of creating or improving a technology as a response to a specific situation (e.g. to introduce into a variety of maize already accepted by farmers a specific form that maintains the other characteristics and allows traditional methods of storage).
BASIC RESEARCH

This is the process of generating new understanding of the biological processes (Farrington and Martin 1987). For example, how photoperiodism is affected by stomata closure under water stress.

COMMODITY RESEARCH

This is usually referred to as crop research or research into a group of crops. It includes basic research such as plant breeding, as well as more multidisciplinary research such as agronomy, crop protection, food conservation, etc; the common feature is that this type of research is prevalently done under controlled conditions (research stations) or as on-farm tests to check some technology under specific agroecological conditions but without farmer participation or farmer circumstances being taken into consideration.

CLUSTER AREA

A selected minor area in a recommendation domain in which a set of experiments is planted. It has a logistic justification because it permits control of a series of experiments by field technicians in one visit to the area, reducing transport dependence and wastes of travelling time. At the same time, having a full series of experiments in a cluster, facilitates the interaction between trials- and non-trials farmers as well as the organization of field days and other events.

COMPONENT RESEARCH

This refers to work on a specific input into the farming system, i.e. seed, fertilizer, irrigation, etc.

CROPPING PATTERN

The arrangement of crops on a given field during a given period of time (Worman et al., 1990).

CROPPING SYSTEM

The crop production activity of a farm. It comprises all the components required by a set of crops to produce, and the relation between them and
the environment, including physical, technological, biological, labour and management factors (Worman et al., 1990).

CROPPING SYSTEMS RESEARCH

This is the component of FSR dealing with studies on crops and cropping patterns, alternative practices, interactions between crops and other enterprises, and between the household and environmental factors (Worman et al., 1990).

EXPLORATORY SURVEYS

This refers to the process of data collection by a group of researchers moving throughout the target area and informally interviewing farmers and other relevant people in order to get a preliminary or tentative understanding of farmers' constraints, practices, current technologies and level of income (Worman et al., 1990).

FARMING SYSTEM

This is a system in which the farmer's household makes decisions about how to satisfy its needs and to achieve the family objectives. These decisions are taken within a reasonably stable number of enterprises that the household manages according to well-defined practices responding to the agro-ecological, socioeconomic and cultural environment, and in relation to the household goals, resources and preferences. The farming system is part of a larger system that usually influences the circumstances within the system or can also be divided into sub-systems like cropping systems, livestock systems, handhoe systems, etc. (Shaner et al., 1982; Worman et al., 1990; Friedrich, 1987, 1990).

FARMING SYSTEM APPROACH

The approach recognizes that the operational units of production are systems and that changes in components or parts represent improvement only if they improve the systems as a whole, and that the production systems have a coherence (Fernandez, 1988) and rationality on the use of resources and on the response to institutional, climatic or political circumstances.
FARMING SYSTEMS DEVELOPMENT FSD

This is an FAO term which has its origin in the World Conference on Agrarian Reform and Rural Development (WCARRD) in 1979 (Friedrich, K., 1987).

According to FAO definitions, FSD is an approach used to develop farm household systems, based on the principle of productivity, profitability, stability, sustainability and equitability.

It emphasizes understanding of farm-household-community interlinkages, reviews constraints to an assessed potential for development, and is a continuous, dynamic and interactive learning process based on analysis, planning, monitoring and evaluation (FAO, 1989).

FARMING SYSTEMS PERSPECTIVE

A farming systems perspective takes into consideration all the integral components of the household on rural development activities, agricultural research and extension, training and policy decisions (Ndiritu, 1990).

FARMING SYSTEMS RESEARCH

This is an applied problem-solving approach, having the farmer's household as the centre. The research priorities are established, in collaboration with farmers, by an interdisciplinary effort in which all the factors affecting farmers' decisions are involved.

FSR has a area focus which complements the commodity focus of the station-based commodity research.

FSR examines the socio-economics, as well as the technological constraints which prevent farmers from increasing production, whether for subsistence or income generation. These constraints are examined in the context of the farmers' natural and social environment. Then, they form the focus for simple experiments to test or develop technologies on farmers' own fields and under farmers' conditions and management (e.g. Dougnac & Allen, 1987; Merrill-Sands et al., 1989, etc.).
FARMERS BACK TO FARMERS

With this model, applied agricultural research and development begins and ends with the farmer and involves interdisciplinary work in all phases of a continuous research/diffusion process. The model consists of a series of activities aimed at achieving acceptable solutions to farmers' problems that are linked in a circular form.

Whereas the model emphasizes the importance of careful problem identification, it is recognized that stages may be skipped and that work can begin at any point of the sequence (Gordon & Prain, 1989).

FARM-HOUSEHOLD MODEL

The farm-household model stresses the need to understand how government policies could simultaneously affect both the production and the consumption decisions of small farmers (Staatz & Eicher, 1986).

FARMERS INVOLVEMENT

When using this term, it is understood that the farmer has a critical role to play, not only implementing the agricultural development process, but also in planning it. He/she must be involved, with others, in diagnosis problems, designing potential solutions, and in testing and evaluating the potential solutions (Norman & Modiakgotla, 1990).

FARMERS' PARTICIPATORY RESEARCH

This is a concept which tries to summarize all the effort to define the importance of farmers in the development process since the results of the Green Revolution did not provide the benefits expected to the resource-poor farmers. The concept appeared after growing concern to understand the diverse and complex environment in which farmers operate, as well as the need to incorporate the indigenous knowledge of farmers in the process of technology development (Farrington & Martin, 1987).

FARMERS-MANAGED TRIAL

This is an on-farm experiment that, after joint planning with researchers, is completely managed by the farmer. This type of experiment usually comes at the end of the experimental sequence, in most cases as a kind of
verification trial, still site-specific and keeping one or two experimental factors to be analysed.

The aim of this type of experiment is to observe how the farmer implements suggested innovations. During the implementation of the experiment, the role of researchers is a passive one, becoming active only at planning and analysis stages.

FORMAL SURVEY

Formal survey is a study of randomized chosen households interviewed by trained personnel using pre-established questionnaires to provide quantitative data about farmers' circumstances (Shaner et al., 1982). A systematic method for measuring the number or proportion of people or things which have certain qualities or characteristics (Artis et al., FSSP Volume I, FSR/E Training Units).

Formal surveys are used as a tool for testing the hypotheses emanating from the informal surveys and for quantifying the selected parameters.

HOUSEHOLD

A group of people who stay together, eat from the same store and divide common duties. They share some goals, benefits and resources (Allen, 1989).

The household usually comprises, but not necessarily, of members of the same extended family and can operate under the leadership of one of its members or under collective management.

INFORMAL SURVEYS

See exploratory surveys.

INTERDISCIPLINARY RESEARCH

This is a kind of research in which scientists from different disciplines are involved in a research programme which is mutually planned, implemented and evaluated.
LEARNING FROM FARMERS' PRACTICES APPROACH

The approach consists of a systematic monitoring and economic evaluation of what farmers do with respect to short-term profitability and long-term sustainability. It consists of a very close observation of farming practices at the household field level during a growing period, this information is analyzed and used as a basis for the experimental programme (de Haen & Runge-Metzger, 1989).

MULTIDISCIPLINARY RESEARCH

This is a research programme which includes elements belonging to different disciplines, usually carried out by scientists representing those disciplines but not necessarily interacting during the research process. The "team" members sometimes have their own separate research programme following their own disciplines and the results are presented in a joint report (Merril-Sands et al., 1989).

ON-FARM RESEARCH

On-farm research refers to an experimental programme carried out on farmers' fields with participation of farmers to greater or lesser extents depending on the objectives of the experiment.

In the FSR framework, on-farm research refers to joint farmer/researcher experimental programmes that can be adaptive, or to applied research aiming to find out, or to adapt, technologies to improve the productivity of a whole farming system under specific agro-socioeconomic environment. Due to the conditions, circumstances and objectives of the experiments, the design, management, analysis, and interpretation of results make use of both conventional methods (statistics) and unconventional methods (farmers' assessments, cultural reactions, risk analysis, etc.).

ON-STATION RESEARCH

This refers to traditional agricultural research carried out under the well-controlled boundaries of a research centre. The so-called basic and commodity research are typically on-station research. It demands a very "scientific" design, the non-experimental factors should be kept under control and the analysis and interpretation is mainly based on statistically proved differences between treatments.
The aim of this type of experiment is to produce component technologies with wide adaptability across a broad range of environments (Merril-Sand et al., 1989).

**ON-FARM CLIENT-ORIENTED RESEARCH (OFCOR)**

The definition originated at ISNAR as a reaction to the "prostitution" of the FSR concept which has been misused and wrongly referred to by several authors.

The OFCOR objective is to strengthen the involvement of farmers, particularly resource-poor farmers, in the research process (Merril-Sands et al., 1989). It focuses on farmers as the clients of research, it emphasizes the diagnosis of constraints, and the setting of research priorities in the context of the whole farming system. It urges that the design of technological solutions is in response to opportunities or constraints identified on farm, and the involvement of farmers at various stages in the research process (ISNAR 1989).

**OPPORTUNITY**

A favourable or promising combination of circumstances that provide a chance for improving the system or solving a problem.

**PARTICIPATORY ACTION RESEARCH (PAR)**

It is a methodology which evolved to support deliberate, committed action for changes in urban community projects.

It proposes that the definition and study of the causes of the problems by the affected people is a way of achieving group involvement in designing strategies to solve those problems. PAR is mostly used to provide information to improve the action of social programmes, more than to generate and test hypotheses (Fernandez, 1984).

**PARTICIPATORY TECHNOLOGY DEVELOPMENT**

This has been defined as the practical process for bringing together the knowledge and research capacities of local farming communities with that of the commercial and scientific institutions in an interactive way. This implies that the people can identity and modify their own solutions to
their needs. The role of researchers and development workers is restricted to increase the capacity of the people to manage changes in their farming systems (Haverkort et al., 1988).

PRODUCTION SYSTEM

The term "production system" is an abbreviation of the term "agricultural production system". The "agricultural production system" consists of the crops and animal production activities of the farming system. Whereas diagnosis or evaluation considers the entire farming system, including household, non-farm, and off-farm production and consumption activities, the design and testing of observations are generally based on the agricultural production system. Farms in a given research domain share the same production system, and have similar problems and researchable priorities in that production system (FSSP 1987, Vol. I).

RAPID RURAL APPRAISAL

This is nothing more than the new fashionable English expression renaming the relatively old SONDEO diagnosis approach and other similar techniques.

The simple and effective diagnosis procedure developed in Central America, known as the sondeo (Hidebrand 1981) and the rapid rural appraisal (Chambers 1981) similar to the sondeo, are effective diagnosis tools that may be used to distinguish groups of farmers and their production constraints (Fresco, L., 1986).

RISK AVERSION

This refers to the attitude of farmers to reject even clearly superior innovations if the probability of failure is higher than if they continue using current practice (de Haen & Runge-Metzger, 1989).

RECHERCHE-DEVELOPPEMENT

Recherche-développement is francophone school expression for FSR, which is defined as an integrated attempt to define the sequence of technical and socioeconomic changes and pathways required for a farming system to reach optimal production levels. To achieve this result, there must be an on-going, functional partnership among research, farmers and development.
This triangular relationship allows researchers to learn from farmers how they manage their existing farming systems and allows farmers to try innovations proposed by researchers. The role of development is one of a long-term interactive process between researchers and farmers that leads to the diffusion of innovations (Fresco, L., 1984).

RECOMMENDATION DOMAIN

Sometimes this is also wrongly referred to as the target area and even as research domain.

Recommendation domain is the farming (sub) system chosen on the basis of similarities among the farming community (cultural, linguistic, type of economy, enterprises, etc.) reinforced by some geographical boundaries that make the area reasonably homogeneous in its characteristics. At the same time it needs to be broad enough to be operationally sensible, but narrow enough that any recommendation emanated could be expected to be applicable throughout (Simmonds, 1986).

It has also been defined as a group of roughly homogeneous farmers with similar circumstances for whom more or less the same recommendation can be made (CIMMYT, Byerlee et al., 1980).

The geographical border of the recommendation domain is the so-called target area and is only valid in operational terms because it is quite common that a technology developed in one domain can be applicable to a farmer group or area of another domain, in this case the domain for this recommendation overlaps the pre-established physical limits among the different "domains".

Obviously, the "recommendation domain" is related to the recommendation itself and not to the area of operation.

RESEARCH MANAGED TRIALS

This refers to on-farm experiments aimed at screening proposed technologies coming from on-station research to address them to local conditions and to evaluate their potential for local and regional coverage (Dillon & Anderson, 1983).

The farmers do not play any active role, apart from sometimes providing labour or as observers of what is going on in their fields.
SONDEO

This is a diagnosis technique to attempt to optimize cost-effectiveness with an emphasis on timely reporting and low demand of staff. The technique uses different types of information and investigation methods trying quickly to produce relatively accurate data through observations, checklists, group interviews, etc., rather than long diagnosis surveys based on extended and detailed questionnaires and close farmer-followed-up activities (Worman et al., 1990).

SYSTEM SUSTAINABILITY

Sustainability is a concept which is becoming increasingly popular among FSR practitioners. Despite sustainability having been defined as the ability of a system to maintain productivity in spite of a major disturbance, such as is caused by intensive stress or a large perturbation (Conway, G.R. 1985), in FSR it intends to stress the farming system's concept regarding the holistic approach, in which the system is defined as sustainable only if the concept of sustainability goes beyond the production system into the natural environment of which the farming system is a part. In other words, it stresses the need to maintain and enhance the environmental quality by conserving natural resources (Weinschenck, 1989).
REFERENCES


BINDER, K. (1989) The vicious circle of hunger and indebtedness. Analysis of the farming system of South-East Bombali District, Sierra Leone. ICRA.


BYRLEE, D.M., COLLINSON et al. (1980) Planning technologies appropriate to farmers - concept and procedures. CIMMYT, Mexico.


NORMAN, D., MONDIAGOTLA, E. (1990) Ensuring farmers input into the research process within an institutional setting. ODI, agricultural administration (research and extension) network. Network paper 16.


Publications in Crop Production Science:

1. Halling, Magnus A. 1988. Influence of autumn cutting time and weather on growth potential and growth of timothy (Phleum pratense L.) and red clover (Trifolium pratense L.). 84 pp. 60 SEK.


8. Chhabra, Madan Lal & Ohlsson, Ingvar. 1990. Description of a movable freezing chamber apparatus and specific instructions for its use in India. 12 pp. 30 SEK.


10. Torsell, B.W.R & Fagerberg, B. 1990. Predicting economic optimisation and nitrogen balance in the lay - ruminant system. 45 pp. 50 SEK.


The Department of Crop Production Science at the Swedish University of Agricultural Sciences is responsible for the following three series of publications:

- Crop Production Science
- Växtodling
- Interna Publikationer - Sveriges Lantbruksuniversitet, Institutionen för Växtodlingslära / Internal Publications - Swedish University of Agricultural Sciences, Department of Crop Production Science

The series are directed to different groups of readers. "Crop Production Science" is intended for an international readership and is therefore published in English. "Växtodling" is a series mainly intended for Swedish and Scandinavian readers and written in Swedish, but generally with summaries and texts of tables and figures also in English. The internal publications are for special types of material, i.e. certain reports, bulky tables, etc., which, in spite of having a limited readership, ought to be available through libraries.

Editorial Board

Ulf Wünsche (chairman)
Håkan Fogelfors
Lennart Kåhre