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Livestock in farming systems research for smallholder agriculture: experiences of ILCA's highlands programme

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ABSTRACT

LIVESTOCK IN FARMING SYSTEMS RESEARCH FOR SMALLHOLDER AGRICULTURE: EXPERIENCES OF ILCA'S HIGHLANDS PROGRAMME

Traditional smallholder producers supply the bulk of the national agricultural output in sub-Saharan Africa, and in many areas their farming system is dominated by mixed crop and livestock production. Exploiting the complementarities and interactions which exist between both these components will substantially increase the overall farm productivity and efficiency of resource use. An efficient research mode is the farming systems research (FSR) approach, where due consideration is given to all the key components of the production and marketing system. On-farm testing, whereby an improved technology is evaluated on a whole-farm basis, is an essential and crucial part of the FSR approach. ILCA's Highlands Programme is gaining substantial experience with the conduct of FSR focussing on the livestock sub-system. The general research approach is illustrated as well as the specifics of livestock research.

Experiences of the Highlands Programme potentially relevant to Rwanda are reviewed. These include the introduction of dairy production, and the improvement of animal traction. Particular attention is addressed to the evaluation of improved technologies vis a vis the multiple objectives of smallholders for the different

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LIVESTOCK IN FARMING SYSTEMS RESEARCH FOR SMALLHOLDER AGRICULTURE: EXPERIENCES OF ILCA'S HIGHLANDS PROGRAMME

Guido Gryseels[1)]

1. Introduction

In Africa, as in most of the developing world, traditional smallholder producers supply the bulk of the national agricultural output. If self-sufficiency in food production is to be achieved, then productivity gains must be made by these smallholders. In many areas of sub-Saharan Africa, smallholder farming is dominated by mixed crop and livestock production.

Past experience has shown, both in Africa and elsewhere, that exploiting the complementarities which exist between crops and livestock in the smallholder setting will substantially increase the overall efficiency of resource use on the farm. In many situations, crops and livestock enterprises are already linked but many opportunities remain to increase substantially the returns to land, labour and capital.

Crop and livestock enterprise interactions in the smallholder mixed farm setting include the following:

- use of animal power for transport and crop production, where crops produce straws, stubbles and residues which in turn are fed to or utilized by livestock. These feedstuffs would otherwise be of little use to mankind;
- use of animal manure to improve soil fertility;
- reduction in overall production risk by combining crop and livestock enterprises;

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1) Economist, ILCA Highlands Research Programme. The author is grateful for the critical comments on an earlier draft by Frank Anderson, Michael Goe, Addis Anteneh, Mark Nicholson, Martin Butterworth, Stephen Sandford and Cees de Haan.

- improvement of crop productivity through the inclusion of improved legume-based pastures or forage crops in the crop rotation;
- consumption of milk and meat by smallholders adding significantly to human nutrition;
- the sale of livestock products such as milk to dramatically improve the cash flow and stabilize farm income;
- livestock as a "near cash" capital stock, important in areas where no institutional credit facilities exist; i.e. livestock can be sold at any time in the year, thereby supporting subsistence cropping where seeds, etc., often must be purchased at planting time long after the harvest;
- use of hides and skins for storage and transport of crop products.

Research must contribute to knowledge allowing for a more efficient exploitation of these complementarities. In the past, research and development efforts have often stressed technical innovations without fully understanding the impact of such interventions on the overall farm resource allocation.

A more efficient research mode may be the farming systems research (FSR) approach, where consideration is given to all the key components of the production and marketing system - implying a balanced emphasis on both crops and livestock in mixed farming systems. On-farm testing, whereby an improved technology is evaluated on a whole - farm basis, is an essential and crucial part of the FSR approach. To date, most FSR has been conducted in crop research institutes and FSR is accordingly most advanced for crop sub-systems. The livestock sub-system has received comparatively little attention in the context of FSR.

The International Livestock Centre for Africa (ILCA) is one of 13 international centres sponsored by the Consultative Group on International Agricultural Research (CGIAR). Through research, documentation and training, it is "to assist national efforts that

aim to change production and marketing systems in tropical Africa so as to increase the production of livestock and livestock products, and improve the quality of life of the people of this region." ILCA is engaged in applied livestock research and seeks to identify and resolve problems in sub-Saharan Africa. Research on specific topics or components is preceded by baseline studies ensuring the relevance and usefulness of the subsequent research. Field studies are carried out in each of the major ecological zones, arid/semi-arid, humid/ sub-humid and highlands. Substantial experience is being gained with the application of FSR focussing on the livestock sub-system. This paper reports on the approach to and the experiences with FSR in the Highlands Programme.

2. Some specifics of livestock research

Livestock are vital to subsistence and economic development in sub-Saharan Africa. They provide a flow of essential food products throughout the year, are a major source of government revenue and export earnings, sustain the employment and income of millions of people in rural areas, contribute draught power and manure for crop production and are the only food and cash security available to many Africans. The sale of livestock and their products often constitutes a major source of cash income on which subsistence farmers depend to buy consumer goods and the improved seeds, fertilizers and pesticides needed to increase crop yields. Where livestock development is successful, it can stimulate an increase in food grain production, and further economic growth.

Historically, livestock research in Africa has been conducted on experimental stations. Most of the work has been done with cattle, emphasizing crossbreeding, nutritional studies and animal health. Little effort has been directed to testing improved technologies at the farm level. As a result, methods for farmer-managed livestock experiments are not as well defined as for cropping systems. Various reasons may explain this lack of on-farm testing. According to the

Consortium for International Development (1980), national programs have emphasized crops because of their greater importance in supplying the basic food needs for the nation. Credit for the smallholder farmer tends to be crop-oriented and is more readily available for seed and fertilizer than for the purchase of livestock. In addition, on-farm testing is much more complicated for livestock than for crop innovations.

The production variability, confounded by the effects of management, is very high for livestock. In addition, livestock performance is to be evaluated not only in terms of productivity parameters such as milk yields and weight gains, but also on the impact on factors relating to reproductive performance and survival. The management factor is much more important in livestock than in crop experiments. Animals need to be fed and watered daily. For crop production, time is not such a limiting factor. Seeding and fertilizing normally only need to be done once, and not even on a particular day. The mobility of livestock is a serious constraint for the data collection.

Because of the variability of genetic resources and management practices, a large number of animals are required for each treatment in on-farm testing. Most smallholders have few large ruminants, and as a result a substantial number of farms are required to achieve acceptable levels of statistical significance of results. Also, trials involving livestock need to be conducted over an extended time period, at least 3 years, to capture the principal effects on lifetime productivity of the stock.

The economic evaluation of a livestock project is complicated by the fact that due to the time lags in reproduction it is a developing enterprise, and not of a steady state nature. Moreover, the state of animals when they enter the research programme can result in favourable outcomes in the short term, but less favourable long term results. This 'initial conditions' problem would arise, for instance, if dairy cows are in-calf at the start of a programme and subsequent conception rates are poor because of management failures.

Account must be taken of the multiple objectives the farmer has for livestock enterprises.

As a result of the management constraint, on-farm experiments with livestock must consist of relatively simple treatments which can easily be understood by the farmers involved. An important aspect in livestock development is the special role played by women. Very often it will be the woman in a household who takes care of the animals. In many cases they milk the cow, feed the animals, handle the manure, clean the barn etc. This tends to be overlooked by researchers and extension workers, who typically focus on the household heads (i.e. men) in training courses, extension classes and contacts on the farm.

3. An approach to FSR in mixed crop-livestock farming systems

The following approach is presented in the context of FSR conducted in an area representative of a relatively large homogenous agricultural production zone. It is assumed that this area has not been the target of specific research, but has been identified by the national government as a priority development area. Furthermore, agricultural production in the area is assumed to be dominated by subsistence-oriented mixed crop/livestock smallholdings.

3.1. Diagnostic stage

The diagnostic stage in the research determines and assesses the environmental, technical, economic and sociological context within which the farming system operates. The literature review and systematic collection and analysis of the existing data done at this time would eventually be complemented with a separate problem-oriented baseline survey. Its objective is to provide a basic understanding of the farming system and the allocation, use and constraints of available resources. If conducted in a 'normal' year, the results of the survey may serve as a reference point in time for future comparison of selected

parameters. In the collection of data, a combination of a single interview with individuals and panel or group discussions may be used as a method of investigation. Group interviews are particularly useful for obtaining information on the role of livestock in the farming system, the agricultural calendar, grazing management, prevalent plant and animal diseases, crop yields, seeding rates and dates, livestock productivity, consumption patterns, cultural practices, sociological and religious habits ; and general agricultural problems in the area.

Together these steps permit an assessment of the agricultural development potential of the area and the feasibility of different development paths in relation to the existing economic and political framework. Research priorities are to be established. The diagnostic phase should also consider the 'zero option', that is the likely future perspectives of the area if no intervention takes place. At this time, the area is also divided in different land types, each of which may require a different production recommendation. This stratification is based on important environmental traits, generally reflected in the cropping pattern and the animal production system. (Zandstra, 1982).

3.2. Design and testing stage

A research site may then be selected. It should be representative of the target area so the results from the station are directly applicable and location specificity is minimized. Once the location of a site (i.e. a station) is determined, research on specific components of the farming system can begin. This is the 'design' stage of Gilbert et al (1980) where new sets of improved farming practices are evaluated. Component research will be tailored to the needs of the area but would include topics such as screening forage crops, agronomic trials with various crop varieties and their response to seeding and fertilizer rates, simple measures to improve animal health, and the response of animals to improved nutrition. It would include topics where results would be available in both the short and longer term. If appropriate,

a part of the station research may complement parallel component research at another site or sites. This research is basically technical in character but conducted with an awareness of the system aspects in the farm operation, and of price relationships. This component research is, however, not to be confused with research of individual disciplines. An animal traction research team for example should at least consist of an agricultural engineer, an economist and an animal physiologist.

At the same time as capital inputs are began on the station, routine data collection is made in the traditional farming areas beyond the station boundary. This data collection complements and supplements the initial baseline data analysis, and allows for in-depth study of topics either where seasonality is important (such as labour data, cash flows or time allocation of the various family members), or which were not covered in the initial survey phase. They also permit improved understanding and specification of the dynamics of the agricultural system which is not possible from analysis of cross-section data.

The next possible step, is the testing of a limited number of enterprise combinations in a whole-farm context. Available technologies are combined with the results of component research in the formulation of the combinations to be tested. Sometimes they will involve an incremental amount of risk, making immediate on-farm testing with farmers, in the traditional system, inappropriate. For this reason the different enterprise combinations could first be tested on research farms on the station under the supervision of research staff. Such research farms however are 'risk neutral', and should not be a substitute for later 'real world', on-farm testing. These research farms should provide upper limits to potential and practicable improvements of agricultural productivity at the farm level.

Data collections on the research farms parallel the collections being made on outside farms in the traditional system. These outside farms serve as a control group to assess agricultural productivity gains, or losses, made on the research farms. Component research continues with topics being introduced or discarded according to the need and the progress in the research.

As soon as practicable, the enterprise combinations are tested in a farm environment beyond the station. How rapidly this is done depends on the type of innovation being introduced and on evaluation of any adoption or adaptation problems which might occur at the farm level. Possible technologies to test on the livestock component could include the introduction of crossbred cows and forage crops, animal health packages for either cattle or sheep, calf rearing trials, animal traction combined with improved implements, improved dry season feeding to strategically supplement the ration of working oxen or cows in milk, sheep fattening, and the more efficient use of crop by-products or wastes. The choice between the species or ruminant will much be influenced by the quantity and quality of the available fodder and the seasonality of its supply. Once this feed balance is established, it will mainly be economic considerations that determine the enterprise choice. Generally, dairy is more profitable than beef production at the smallholder level. Sheep husbandry is often attractive as an additional activity as it is low risk and requires few inputs, but provides some security to the farmer in times of need.

On the crop side, one could evaluate improved seeds, the utilization of organic or chemical fertilizers, alternative rotation practices, better cultivation techniques or different crop varieties.

An important design consideration in regard to FSR with livestock is to split the control group of outside farmers into two groups. One group voluntarily adopts either one or a combination of the improvements being offered. The other group continues unaltered

as a control. The test farmers, i.e. those farmers in the group adopting the improved technologies implement these at their own expense and risk, and are responsible for their own management decisions, accepting or rejecting any of the components of the improvement package.[1] In this way an evaluation of the improved technologies is possible; firstly, by comparison with the prior performance of these test farmers using the traditional method of production; secondly, within any year through comparison of the test farmers with the control group farmers who did not adopt the improved technologies; and thirdly through a comparison of both farmer groups with the results of the research farms, or the component research on the station.

A number of the research farms on station may continue to be used to evaluate the original improvement packages being adopted by the test farmers. Knowledge of the system dynamics and its constraints can be further quantified and elaborated. The other research farms may be used to evaluate more innovative systems or improved technologies with the objective of creating new 'packages' or enterprise combinations. In this way the link between test farms and research farms is retained.

The data collected from outside and the results from test farmers, research farms and the component research should be combined and synthesised into various farm planning models in order to test alternative enterprise combinations, as well as gains, problems and opportunities presented by technology changes. Models describing the system should be constructed in an early stage of the research, but their usefulness will improve progressively as the quantitative data base strengthens. In the longer term, the essential role of

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1) Financial credits for development would be available where necessary to farmers through the usual government sources on standard conditions. In those cases where appropriate institutions do not exist it will be necessary for credits to be provided via the research project.

such models is to assist national agencies in the determination of research priorities and to enable field results obtained in the context of one production system to be utilized to greatest advantage in other similar systems. Simulation modelling is only a tool in the research approach and should never become a substitute for field research.

In the evaluation of mixed farming systems, particular attention should be given to the competition for farm resources (land, labour and capital) between the crop and the livestock enterprise at various time of the year. It is important to also focus on the input/output transfers between these enterprises as described in the introduction to this paper. The evaluation of the improved mixed farming system must also take into account the multiple objectives of management in regard to the various enterprises. Certain activities will have an intermediate role in farm production (such as animal traction), while others will generate end-products that can either be home consumed or sold.

This combination of systems research, component research and modelling as outlined above is the best way to produce relevant results and provides a sound basis for the development and transfer of the resultant technology to the target population in the selected area.

3.3. Adoption of the research approach and results by a national agency

National agricultural research agencies in Africa have limited funds and professional staff available to carry out their mandate. Any research approach must take those constraints into account. The approach to FSR presented here may be implemented by national agencies and is seen as an efficient way of determining productivity gains possible at the smallholder level. This assumes that smallholders are the important target group of research; a stance reinforced by the primary importance of smallholder production in Africa.

An important implication of the FSR approach is decentralization of national research activities and responsibilities. In the short run there may be institutional impediments to implementation because manpower shortages have caused a centralized structure in most African research agencies. Centralization leads to a definite inflexibility in operation of FSR with important practical consequences for the efficiency of operations. The suggested approach to FSR has important implications for experimental design, data collection and data analysis. It is essential that during the research planning stage, inputs are made from specialized disciplines such as biometrics to ensure the statistical adequacy of the results obtained. Standard recommendations on, for example, sample size of the outside and test farmer groups and selection procedures cannot be given.

Research workers must closely involve the local extension agents for continuous interaction, and prepare them for the development stage that will eventually follow the research phase.

Throughout the research, it is important to have regular formal and informal meetings with farmers of the area to perceive their ideas on research priorities and to get a continuous feedback on the FSR programme.

Other important issues in the conduct of FSR relate to the role and set up of control groups, the phasing of activities, team composition and organisation, the role and relevance of principal research sites, the transferability of FSR results, and training in FSR. There are clear cut guidelines for none of these topics, but great benefit can be obtained from regular interactions and dialogues with other FSR researchers, and a continuous follow up and review of FSR experiences in other geographical areas.

4. Review of experiences of ILCA's Highlands Programme

4.1. Background

ILCA's highlands research focussed initially on Ethiopia. This country has the largest highland area of the continent, accounting for almost half the total African highland zone.

Ethiopia is an ecologically diverse country with an agricultural sector contributing the major share of gross national product and almost all export earnings. Over 80% of the population is directly dependent upon agriculture and per capita income is estimated to be less than US$ 130 per annum.

The country covers a total of 1.22 million km^2, half of which is highland above 1500 m altitude. Ninety percent of the total human population of about 32 million live in the highlands. Ethiopia has the largest livestock population in Africa with approximately 26 million head of cattle, 24 million sheep, 12 million goats, 7 million equines and 1 million camels (Kouevi, 1976). The majority of the cattle, sheep and equines are in highland areas. Agricultural conditions vary widely in the different ecological zones of the country, according to topography, climate, soils and natural vegetation. However, the highlands are generally temperate and comparatively favourable for both crop and livestock production. Ethiopia's rugged terrain is a major constraint to economic development because of transport and communication problems. Three-quarters of the population live more than one day's round trip walk from an all-weather road.

Much of the ILCA research in the country focusses on the central highlands where smallholder mixed farming prevails. Average rainfall is between 800 and 1200 mm per annum, of which 70% falls in the main rainy season between July and September. Agricultural holdings range

from .5 to 5 hectares, and around 80% of farm produce is for subsistence consumption[1]. About two-thirds of the cultivated land is under cereals. The majority of the remainder is sown to pulses. The main crops are Teff, Wheat, Barley, Maize, Sorghum, Horse Beans, Chick Peas and Field Peas. Yields average between 600 and 1000 kg per hectare. The use of chemical fertilizers is limited, and averaged overall for the country 0.2 kg/ha per annum during the period 1970-77 (Blodig , 1982). Almost all farmers have some livestock and an average farm holding is two oxen, a cow, a few sheep and a donkey. Most of the manure is used as fuel for households and only little is returned as fertilizer to the fields.

Catt e are kept mainly as a source of draught power and manure production. Milk, meat, and hides are relatively less important by-products. Livestock are also a form of investment and security. Usually only oxen are used for cultivation. For threshing, the other large animals will also be used. Livestock productivity for all species is low. Milk offtake from indigenous zebu cows kept under traditional management, rarely exceeds 300 kg for a lactation period of seven months. Calving intervals average two years. Various factors contribute to this low productivity, including low genetic potential and generally inadequate nutrition, particularly during the extended dry season of up to seven months.

Sheep also have a low productivity level, subject, as are cattle to heavy endoparasite burdens and to extended periods of nutritional stress.

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1) In Ethiopia, land is not individually owned, but is allocated annually by the Peasants Association of which the farmer necessary is a member. The size of individual farming units, comprising several plots, depends on family size, local population density and the policies of the local Peasants Associations. Distribution of land takes account of the different fertility levels of the soils within the land area of the Association. Each Association has on average 200 members and controls around 800 ha of land.

4.2. ILCA Highlands Programme

The objective of ILCA's Highlands Programme is to study ways and means of improving the overall productivity of the smallholder farm by increasing the technical and economic efficiency of livestock enterprises. Particular emphasis is given to enhancing the complementarit of the livestock and crop components. The Highlands Programme has adopted the farming systems approach to research. This stresses on-farm technology testing and appraisal, indicated by relevant station research on components where greater experimental control is advantageous. In addition to research undertaken at its headquarters in Addis Ababa, ILCA's field activities focus on two study areas: Debre Zeit located 50 km south of Addis Ababa at an altitude of 1800 m , and Debre Berhan 120 km north west of Addis Ababa, at an altitude of 2800 m. In both areas ILCA has established research stations.

The station research focusses on components such as animal traction; forage, legume and crop agronomy; dairy technology; and valley bottom development through cheap methods of surface water control. On-station, ILCA also operates its own research farms, where various innovative enterprise combinations are being tested. In addition to this station research, a major part of the activities of the Highlands Programme are conducted outside the station. Baseline surveys in each of the study areas have been followed by continuing studies in the traditional farming system of the local Peasants Associations surrounding each of the ILCA sites. Detailed information about these 'outside' farmers was collected concerning assets, farm management operations (i.e. input-output data including labour use), livestock productivity, home consumption and household economics. As soon as constraints and potentials of these smallholder farms were identified, these studies were complemented by on farm trials of various innovations. The programme concentrated initially on research associated with improved dairy husbandry at the smallholder level.

4.3. Whole farm studies at Debre Zeit

ILCA's field research activities began at Debre Zeit in 1978. Eighteen traditional farmers agreed to participate in a research programme concentrating on the introduction of dairy production at the smallholder level. Each had 2.5 ha of arable land, and access to a 30 ha communal pasture. The ILCA programme consisted of the introduction of a relatively high milk yielding crossbred cow (Friesian X Boran)[1], to be fed mainly on home grown forages (oats and vetch, Vicia dasycarpa), together with the use of improved seeds and chemical fertilizer for traditional subsistence food crops, and improved farming practices.

The eighteen test farmers adopted this programme at their own risk and expense and it was their own decision whether or not to accept ILCA recommendations on technology and management. Extension inputs were provided by ILCA until early 1981, and then gradually reduced to simulate the conditions which normally occur in a development project. The farmers were informed about changes in ILCA support at least four months before they were implemented. The performance of these test farmers was monitored closely, and compared with the other outside farmers who continued with the traditional system and who served as a control group.

The programme tested appeared to be a feasible way of making significant welfare gains at the smallholder level. Yields of subsistence food crops of test farmers were on average more than 40% higher than those of the control group, while annual milk yields from the crossbred cows averaged 2300 kg, or more than seven times those of local breeds. In consequence, cash income per farm more than tripled. Where most traditional farms have a cash income of no more than US$ 200, the Debre Zeit test farmers now have an average annual cash income of around US$ 800. A major portion of the extra income has been used

1) The Boran is an indigenous Ethiopian Zebu breed.

to improve their basic living conditions, for example through new and better housing and clothes, and also to further increase the productivity of the crop enterprise.

Although this rapid increase in farm productivity, mainly generated by the improvement of the livestock component, can be sustained under smallholder conditions, the research has revealed and quantified number of specific constraints. These are as follows:

- Farmers replace the crops with the lowest gross margin to grow forages. In many cases pulses (field peas and chick peas), which make a valuable contribution to soil fertility, were replaced by the forage mixture of oats and vetch.
- Labour is allocated first to cereal crops, and only then to forage crops. Competition for labour during soil preparation means that less care is given to forages. Future forage screening will therefore concentrate on 'easy-care' forages and the opportunities for introducting perennial species[1], or permanent pastures, which would require a lower labour input.
- Fertilizer prices have increased rapidly in recent years. With present fertilizer/grain price ratios they can be applied only by a few farmers on the high value cereal crops.
  Research should therefore concentrate on more economic ways of restoring soil fertility, by utilizing manure, better crop rotations and selection of species for productivity with low fertilizer inputs.

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1) On-farm, farmer managed trials with perennial species will start in 1983. Ten test farmers will participate and each will grow 2000 m^2 of a mixture of lucerne and rhodes grass, in a cut and carry system.

- Because of existing price ratios, rearing male calves for beef is unprofitable and there is only a very limited market for veal due to religious restrictions. The use of crossbred oxen for draught is therefore being evaluated.

- Milk marketing is a severe problem during certain periods of year[1]. This indicates the need to evaluate the option of processing milk into a range of storable, transportable and high value products. A research programme to improve small scale dairy technologies was initiated during 1982.

- The ILCA activities were constrained by the number of crossbred cows available from the breeding ranches. Fewer cows were supplied for the research than originally scheduled, reducing the sample size. Therefore as from early 1981, farmers in the area who bought a crossbred cow through other channels were also involved in the research activities. This brought the total number of test farmers in the Debre Zeit area to 40.

- Cereal/milk price ratios have changed substantially from 1976 to 1982. Since 1976 the producer price for milk has remained at the same level, while cereal prices more than doubled during this period. As a result, test farmers allocated a smaller area of land to forage crops than anticipated. Nevertheless, impressive results were obtained with the introduction of improved dairying at the smallholder level.

In addition, studies with farmers in the traditional farming system have yielded a valuable time series data base to further assist definition of constraints and potentials of the system. The results are being fed back into the component research programme.

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1) The majority of people in the central Ethiopian highlands belong to the Coptic Orthodox Christian Church which prohibits the consumption of food stuffs containing animal protein except fish for a total of around 150 days per year. In addition there are infrastructural problems such as the lack of an efficient road and transport system.

4.4. Whole farm studies at Debre Berhan

The research activities in the Debre Berhan area started in 1979 and followed a more phased approach than at Debre Zeit. Little information was available on traditional agriculture in the area and on the improved technologies which could be applicable. Frost which occurs around the time of the harvesting for example, is an important agricultural hazard at Debre Berhan. Accordingly, it was proposed in addition to the prior forage and crop research, to first evaluate a number of farming systems under ILCA's control at the research station. Four different farming systems, each with four replicates, are being tested: An intensive dairy enterprise where crossbred cows are used both for traction and milk production; a sheep rearing enterprise with one crossbred cow for milk production; a combination of the first two but where one crossbred cow is linked up with a crossbred ox to provide the traction power, and a milk and potato system.

A strong data base has been developed on the traditional farming system. In addition to the initial baseline survey that included 226 farms belonging to 24 different Peasant Associations, routine data collections have been set up in the four Peasant Associations surrounding the ILCA station. As from mid 1982, a dairy production programme is being tested with 20 volunteering outside farmers according to the approach outlines in Section 3. A crossbred 3/4 Friesian X ¼ Boran cow was sold to these test farmers, who also grow forage crops, a mixture of oats and vetch. Results to date are extremely encouraging. Milk yields to date average 7 litres daily, and adoption of the technology seems to be with a minimum of difficulties. It is too early as yet to assess the competition between the crop and livestock enterprises for the available resources in land, labour and capital. There are marketing problems however, and beginning in 1983 some test farmers will participate in a research programme for village-level dairy milk processing technologies.

4.5. Animal traction research

ILCA's Highlands Programme has allocated substantial resources to animal traction research. Various topics are being examined including the evaluation of different cultivation techniques with both local and crossbred oxen using improved implements, the technical and economic efficiency of local versus crossbred oxen, the short and long term productivity of using crossbred cows for both draught power and milk production, the use of single rather than paired oxen for cultivation, and the efficiency of oxen under nutritional stress. In addition improved harnesses and yokes are being developed and tested.

At their request, five test farmers at Debre Zeit are using their crossbred cows for traction. The effects on milk yields appeared to be minimal but the long term impact on productivity is still being evaluated.

The option of using only one ox for cultivation will suit the high percentage of highland smallholders owning only one ox. In the ILCA study areas less than fifty percent of farmers have the two oxen presently required using the traditional method of cultivation. The other half are dependent on renting, borrowing, or exchanging arrangements for oxen.

The availability of draught power strongly determines the size of area cultivated, and the cropping pattern (see table). Cereals are much more labour intensive than pulses. At Debre Zeit for example, the following differences were observed in 1980 among the 42 outside farmers.

	Area cultivated (ha)	Areaa under cereals (%)	Area under pulses (%)
Farmers with no ox	1.2	54	46
Farmers with one ox	1.9	44	56
Farms with two oxen	2.7	67	33
Farms with three or more oxen	3.6	92	8

ILCA has developed a suitable yoke and harness, as well as a modified cultivator for use by a single ox. This technology has to date only been tested at the experimental level. Beginning early 1983, on-farm trials in the traditional farming system are conducted to evaluate this improved technology in a farm setting, in both the Debre Zeit and Debre Berhan study areas. Sixty farmers are participating in the research programme. All are members of Peasants Associations surrounding the ILCA stations and have in previous years supplied ILCA with data on their farm management operations. Farmers volunteered after a field day organised at the ILCA stations to demonstrate the technology and during which farmers had the opportunity to try out the techniques themselves.. ILCA has provided the farmers at cost price with a modified plough, an inverted 'V' yoke for single animal use and nylon rope for pulling the plough and reins.

The objectives of the single ox trial are to assess the feasibility of using a single ox drawing a modified plough for crop cultivation, and to evaluate the adoption of this improved technology in a farm setting so as to study its impact on farm productivity and income.

4.6. Future outlook

The Highlands Programme is gradually reducing its station activities, and is increasingly emphasizing the need for on-farm testing with volunteering farmers in the traditional smallholder sector. Until now, on-farm testing has been limited to smallholder dairy production and animal traction. Improvements in the animal traction component will also allow for the drainage and cultivation of the bottomlands that are presently seasonally flooded, and only used for dry season livestock grazing and hay production. Cultivation of food crops is presently done on the slopes. In the longer run, a major revision of this current agricultural practice could be considered: cultivation of food crops could be on drained bottomlands and the lower fertility slopes could then be used by livestock, the reverse of the present situation. In the forage research programme therefore, strong emphasis is being given to the identification of productive and persistent perennial grass/legume mixtures suited to introduction in the subsistence farm setting. Such a development would allow for a regeneration of degraded slopes and ensure future survival of the local farming community.

5. Conclusions

Farming Systems Research (FSR) represents a new approach to the study of smallholder mixed crop/livestock agriculture. The evaluation of an improved technology on a whole-farm basis, through farmer-managed tests is a crucial and essential part of the approach. Researchers need to closely study the impact of new technology on the competition for the land, labour and capital resources between the crop and livestock enterprise.[1] Particular attention must be given to the evaluation of improved technologies vis a vis the multiple objectives of smallholders for the different enterprises. Livestock

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1) Special care must be taken of time lag effects. For example, is a new technology labour saving or labour shifting? Does it improve cash income or cash flows?

provide more than milk, meat, hides or skins. They are a source of draught power, provide fuel and fertilizer, and offer security for the smallholder in times of need. The objectives of a subsistence farmer are more than just maximising cash income, or aggregate food production. Smallholders want food security, by reducing the production risks and stabilizing incomes. Taking into account these multiple objectives is *conditio sine qua non* if, as we believe, it is relevant studies in systems and not components in isolation that will identify and facilitate the greatest productivity gains to be achieved in the smallholder agricultural sector of the African economy.

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