Research with a farming systems perspective at ILCA

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Summary

ILCA HAS USED *a systems approach to research since the Centre was established. This strategy was adopted because of the original belief that technical answers were available for many of the problems limiting Africa's livestock development, but that not enough was known about the functioning of the production systems and how to introduce change in them. A better understanding of the systems and adaptive research were necessary to identify relevant improvements.*

The objectives of ILCA's systems research are to diagnose constraints to increased animal production, to develop prototype technologies under farm conditions, to develop research methodologies, to monitor technology adoption and to help develop the systems research capacities of national institutions in Africa.

This paper summarises ILCA's strategy in and experiences with systems research. It discusses the findings and progress to date of the Centre's programmes on smallholder farming in the Ethiopian highlands and on smallholder farming and agropastoralism in the humid and subhumid zones of Nigeria. Experiences in the pastoral systems of eastern Africa (Ethiopia and Kenya) and western Africa (Mali and Niger) are also discussed.

Field experiences have shown that little modern technology was available that had substantial advantages over traditional methods, given the economic and ecological conditions facing producers. As a result, ILCA has recently placed more emphasis on component research on such topics as forage legume agronomy and animal nutrition in order to generate new technology.

ILCA will continue with systems research through field programmes undertaking applied and adaptive research, supported by component research by HQ units. The Centre will also continue to give high priority to training national programmes in techniques appropriate to livestock production research in sub-Saharan Africa.

Introduction

The International Livestock Centre for Africa (ILCA) was established in 1974 to:

- Serve as a multidisciplinary institution for research to improve livestock production systems in sub-Saharan Africa;
- Provide training to increase regional competence in the systems approach to livestock research and development; and
- Act as a multidisciplinary documentation centre.

Livestock improvement at ILCA is only a means to an end: the Centre's overall objective is to increase food production in sub-Saharan Africa by maximising the contribution of livestock and through better integration of crop and livestock production.

The Centre has used a systems approach to research since it was established. This strategy originated from ILCA's Foundation Report, which stated that 'technical answers are available to many of the specific problems facing livestock development in Africa. The major constraint lies rather in the difficulty of introducing change into existing socio-economic systems, combined with inexperience in adapting technologies to suit local conditions' (Tribe et al, 1973). The approach was reinforced by the experiences in development projects, which showed that Western technology and the results of classical on-station research, whether in Africa or elsewhere, could not be transferred directly to African traditional systems. A better understanding of these systems and adaptive research were necessary to identify relevant improvements.

ILCA's research programme is characterised by decentralised field research teams in the major ecological zones of the subcontinent, supported and complemented by central component research units (Table 1). Networks provide a bridging mechanism between ILCA and national research programmes. Networks have been established on trypanotolerance, animal nutrition, forage legume agronomy, small ruminants and camels, livestock policy, animal productivity and information.

Table 1. *ILCA's research programmes.*

Component research units	Field programmes (location)
Headquarters (HQ)	East Africa
Animal Nutrition	Highlands (HQ)
Reproductive Physiology	Ethiopian Rangelands (HQ)
Small Ruminants and Camel	Kenya Rangelands (Nairobi)
Forage Legume Agronomy	
Pastoral Ecology	West Africa
Livestock Economics	Humid Zone (Ibadan, Nigeria)
Nairobi	Subhumid Zone (Kaduna, Nigeria)
Livestock Productivity and Trypanotolerance	Arid and Semi-arid Zones (Bamako, Mali; and Niamey, Niger)

Objectives and strategy

The objectives of ILCA's systems research are to:

- Diagnose constraints to increased animal production;
- Develop prototype technologies under farm conditions;
- Develop research methodologies;
- Monitor technology adoption; and
- Help develop the systems research capacities of national institutions.

In pursuing these objectives, ILCA has:

- Operated field teams in sub-Saharan Africa which test the systems approach and develop and evaluate specific techniques;
- Provided direct support to national research institutes in systems research;
- Developed and tested methods for rapid appraisal of pastoral and smallholder systems and of the effects of interventions;
- Begun to prepare manuals on livestock systems research for national programmes; and
- Participated in training courses in farming systems research by providing a 'livestock slot' in training courses organised by other organisations, and by organising courses on livestock systems research.

Approach

The historical context of ILCA's research

The assumption that solutions were known to many problems in African livestock production led to ILCA placing emphasis on zonal field programmes, as opposed to research at headquarters. Because of large differences in production systems among the ecological zones, it was believed that it would be difficult to transfer results between zones, making the decentralised approach necessary.

The field teams shared common assumptions about the base of knowledge at the outset of research, and about research methods. Among those assumptions was the need for emphasis on multidisciplinary systems research rather than component research. Much of ILCA's original work was published under the rubric of 'Systems Studies'.

There was also emphasis on on-farm, as opposed to on-station, research. This was due partly to the assumption that technical answers were available, and partly to the assumption that, where there were no technical answers, on-farm research was necessary to identify priorities for on-station research.

There was also an emphasis on the development of research methodologies. It was argued that livestock research was different from crop research. On-farm research with livestock has been said to be more complicated than with crops, because of the smaller number of animals per farm, multiple products, the lower degree of control due to the mobility of the animals, the daily rather than seasonal inputs required for animals, the greater influence of individual management factors, the extended time periods needed for experiments and the difficulties in achieving statistical significance with small samples (Bernsten, 1982).

Principal types of animal production systems

The principal types of livestock production systems in sub-Saharan Africa are pastoral, agropastoral, smallholder and ranching.

Pastoral systems involve extensive grazing, little agriculture and usually some degree of nomadism. Smallholder systems involve restricted grazing, exploit crop–livestock interactions (such as feeding crop residues to the animals) and incorporate livestock as a subsidiary

enterprise to cropping. Agropastoral systems are a transition between the pastoral and smallholder systems. Ranching is of little importance in most of sub-Saharan Africa.

Pastoral systems are more difficult to study than are smallholder systems due to:

- The greater mobility of the animals, the larger area exploited, communal land tenure and, in some cases, the lack of a fixed land base;
- The difficulty of identification of and access to production units, which are often widely separated;
- The longer cycles of drought and post-drought recovery;
- The lack of well developed databases for pastoral systems, including relevant on-station research; and
- Higher research costs per sample unit in low population density areas typical of pastoral systems.

Smallholder farming systems have higher population densities, higher production potentials and more diverse technological alternatives for change than pastoral systems. One problem with attempts to introduce new technologies is that there are many complementarities between crop and livestock enterprises. Therefore, evaluation of a new livestock technology should be done on a whole-farm basis.

Stages in ILCA's systems research

The diagnostic stage: Typically, this has included a baseline survey taking 3 to 6 months and longer term surveys (3 to 4 years) to describe existing systems. Researchers use farm-management and livestock productivity surveys and household studies. Recently, aerial surveys and satellite imagery have been used effectively in support of these activities. This stage defines the ecological, technical, economic and social context in which improvements are to be made, and identifies constraints to those improvements. It is not analogous to the surveys that define recommendation domains (Byerlee et al, 1980) because those domains were (very broadly) defined in the choice of ecological zone.

The design stage: This stage involves design of potential improvements. Their likely impact on the environment and on welfare is sometimes assessed through simulation and cost-benefit models. Research on the different components of the systems is then carried out at sites representative of the target area for improvement, taking into account other features of the system.

The testing stage: The potential improvements are tested in producer-managed trials. The methods for organising on-farm trials with livestock are not yet well defined, and various alternatives have been explored. The approach has varied according to whether smallholders or pastoralists have been the target population.

The extension stage: Technologies that are successful in the testing stage are made available to national extension services, whose participation is sought in all stages of FSR. Adoption is closely monitored to enable redesign and retesting if needed.

Summary of ILCA's experiences

Smallholder farming in the Ethiopian highlands

The objective of the Highlands Programme is to improve smallholder systems by increasing the efficiency of their livestock components. Particular emphasis is placed on the interactions between livestock and crop enterprises. Research is carried out in two highland areas, representative of the medium (Debre Zeit, 1800 m a.s.l.) and high altitude (Debre Berhan, 2800 m a.s.l.) zones of Ethiopia. The two are sufficiently different to require separate efforts.

The Programme first conducted rapid baseline studies at each location, to identify the major constraints limiting smallholder productivity. These are:

- Low soil fertility and high rates of erosion on slopes;
- Shortages of wood, resulting in manure being used as fuel rather than as fertilizer;
- Dry-season feed shortages, causing production losses in livestock;
- Variation in work oxen ownership, causing differences in areas cultivated, cropping patterns and income;
- Poor drainage of fertile bottom lands, limiting production of grain and crop byproducts;
- High mortality of young stock due to liver fluke and other parasitic diseases; and
- Marketing constraints for livestock products.

Station research has focused on soil fertility, forage production, draught animal utilisation and vertisol management.

The urgent need to increase productivity compelled the Programme to reduce the station-testing period for some technologies and to use farmers as test agents as early as possible. For example, the single-ox plough was offered to test farmers after less than 6 months of on-station testing.

It was recognised that local agriculture should be continuously monitored. Therefore, ILCA started ongoing studies with control farmers in the area surrounding each station at the same time as the on-station research was being started. This provided time-series data on the dynamics of the agricultural systems and baseline information against which the impact of innovations could be evaluated.

At Debre Zeit, on-farm testing began soon after the establishment of the research station, with 18 farmers trying a dairy-husbandry package. The 18 farmers adopted the package at their own risk and expense and decided whether or not to accept ILCA's recommendations. Extension inputs were provided by ILCA for the first two-and-a-half years and then gradually reduced to correspond to conditions that would normally apply in a development setting (Gryseels and Anderson, 1983). The performance of the test farmers was monitored and compared with that of farmers who did not adopt the package. The package substantially increased the farmers' cash incomes, but other constraints to adoption became apparent, including poor marketing facilities, high calf mortality, seasonal labour shortages and problems with breeding management and forage crop cultivation. These are now being addressed in component research.

The Programme monitors the impact of innovations on test farms and the voluntary spread of these innovations through the target farming communities. The Programme's strategy has been

to have as many test farmers as practicable at an early stage in on-farm testing so as to be able to quantify the whole-farm impacts of innovations. The results of the monitoring indicate any constraints to the adoption of innovations. Different groups of test farmers are used for different innovations, partly because they represent different recommendation domains and partly because of the difficulties in interpreting results if more than one innovation is tested by one farmer at any time. On-farm testing is in progress for the use of single oxen for cultivation instead of the conventional pair, the use of crossbred cows as draught animals, vertisol management through the use of broadbeds and furrows made using oxen-drawn implements, and water harvesting in small ponds and dams constructed using oxen.

The Programme collaborates closely with the Ethiopian Ministry of Agriculture in on-farm testing to facilitate the introduction of new technologies in both the study areas and other similar ones. On-farm trials have identified additional constraints to production which, according to their importance and 'researchability', are now being examined in applied on-station research. In some cases this has necessitated more sophisticated research than was originally anticipated.

Smallholder farming in the humid zone

The Humid Zone Programme is based at Ibadan, Nigeria. Its client production system is the mixed farming of the forest, in which small ruminant production is important. Major characteristics of the zone are tree crops, a high incidence of trypanosomiasis, mixed cropping and crop rotations incorporating fallows to restore soil fertility.

The Programme's initial diagnostic work, which began in 1979/80, focused on studies of village flocks, and indicated that PPR *(peste des petits ruminants)* was the major constraint to increased sheep and goat productivity. Vaccination of susceptible animals reduced adult goat mortality by an average of 50%. Further studies showed that, if PPR was controlled, flock sizes could double in 27 months, indicating that feed supplies would have to be increased to feed the larger number of animals.

The Programme then turned its attention to providing more feed through alley farming with leguminous trees, a system developed by the International Institute of Tropical Agriculture (IITA). The basic alley farming system was tested in a limited series of on-farm trials to identify necessary modifications to the system, since the IITA trials had not included a livestock component. On-station research was started in 1982 to modify the system to meet the needs of the farmers.

Current and future work in the humid zone has the following stages:

- Health and productivity monitoring of flocks;
- PPR campaign design and evaluation;
- Alley-farming trials on station, especially to evaluate different legume-tree species;
- Monitoring of alley farms, especially and tenure problems;
- Economic analysis of alley farming; and
- Alley farming networks in similar parts of West Africa to investigate the system's potential over wider areas.

After 6 years of research, the Programme initiated and assisted in the implementation of a small-ruminant development project in cooperation with the National Livestock Projects Unit (NLPU) of the Federal Livestock Department of Nigeria. This project involved 60 farmers in

1985, and is based on a development programme that includes the results of ILCA's research on animal health and feeding.

Agropastoralism in the subhumid zone

ILCA's Subhumid Zone Programme is based in Kaduna, Nigeria. The zone receives 1000–1500 mm average annual rainfall and has relatively good potential for crop and livestock production. Tsetse pressure has been high, but is decreasing as human population density, and hence cultivation intensity, increases. This has allowed higher livestock populations in the zone (Bourn, 1983).

The Programme's research began in 1979 with the assumption that nutrition was the primary constraint to increased livestock production and, as a corollary, that purchased feedstuffs would be too expensive or unavailable, so that increased forage production would have to be the main solution to the nutrition problem. Various interventions have been evaluated, including fodder banks with *Stylosanthes* species and intercropping food crops with forage legumes.

An animal nutrition research programme was established in close collaboration with the National Animal Production Research Institute (NAPRI) of Nigeria. First, on-station trials were conducted to determine animal feed requirements. Subsequently, researcher-managed on-farm trials were conducted to determine the best crops for meeting the feed requirements. Farmer-managed trials were then done with the collaboration of the NLPU in a smallholder dairy scheme.

The case of animal health illustrates how the work of other disciplines was related to the central hypothesis—inadequate nutrition. One of the proposed technologies for relieving nutritional stress is the use of fodder banks, in which herders grow legume forage crops for 4 to 5 years on the same site. It was reasoned that this system might be improved by including more productive animals, such as crossbred dairy cattle. Because those animals are more susceptible to disease than are the local breeds, research was begun to investigate disease problems. This involved incorporating crossbreds into herds and comparing their performance with that of local breeds.

Much of the Programme's current work is in evaluating the economics of the proposed animal nutrition interventions. Computer simulations are used to test the sensitivity of the profitability of fodder banks or intercropping to changes in meat and milk prices, herd structures and investment costs. This provides feedback into further station research and into on-farm trials with the proposed technologies.

Systems research in pastoral areas of eastern Africa

By the 1970s it was widely realised that development projects aimed at pastoral systems in much of sub-Saharan Africa were not achieving their objectives. It was assumed that this was largely due to poor design, ensuing from inadequate understanding of pastoral systems. It was expected that increased knowledge of pastoral systems would identify constraints and allow effective interventions to be de-designed. ILCA therefore started a series of interdisciplinary baseline studies in Ethiopia and Kenya.

Kenya

The main objective of the Kenya Rangelands Programme was to make an in-depth study of one specific traditional livestock system, which would consider the components of the system and the internal links within the system. The focus of the work was to make a detailed examination of the causal relationships between the various components or parameters of the system leading to the establishment of a methodology for systems studies, rather than to describe the system and determine constraints.

A wealth-stratified random sample of households in a relatively small area (1600 km^2) was chosen for the descriptive phase. While the household was the sampling unit, considerable attention was paid to intra-household and inter-household parameters affecting production. The intra-household focus yielded information on the division of resources and responsibilities within the family. The inter-household focus yielded understanding of control and maintenance of water and grazing, joint arrangements in livestock care etc. Two years' data were collected on such economic aspects as changes in livestock holdings, income, expenditure and labour and such technical parameters as primary and secondary production, milk offtake and seasonal weight changes in livestock. Aerial surveys were also used to estimate domestic and wildlife biomass and their movements. The Kenyan Ministry of Livestock Development cooperated in the veterinary studies of the descriptive phase.

Ethiopia

The Ethiopian Rangelands Programme (ERP) was set up in conjunction with the government's Rangeland Development Project (RDP). The ERP's objective was to investigate technical options for increasing the productivity of range systems in Ethiopia and associated African areas. The RDP had previously identified poor distribution of water points as a major constraint and had established a number of rainfed ponds in the preceding 4 years. RDP had also initiated measures for disease control, vaccination and cooperative cattle fattening systems. ILCA's research thrust was to acquire more data on specific production constraints and on the impact of the RDP's interventions.

The Ethiopian Rangelands Programme's descriptive phase differed significantly from that of the Kenyan Programme in two ways. It covered a larger area (16 000 km^2) and the research was designed and executed in closer collaboration with a government agency. In addition, satellite imagery was used to define ecological subunits in the area, in which aerial surveys were carried out. Research focused on communities which used the same dry-season water points within each ecological subunit. Later, household budget and livestock productivity studies were carried out on each household and/or herd.

The Programme focused its diagnostic studies in 11 widely distributed parts of the study area. The aspects studied included milk supply and calf growth, rangeland utilisation, management strategies, household budgets and marketing. Particular attention has been paid to the effects of watering frequency on animal productivity, to the effect of low weaning weights on herd productivity, to the possibilities of improving incipient agriculture and to interplanting cereals with forage legumes. Bush control and use of animal traction for pond maintenance, and the possibilities of increasing milk offtake for human consumption without reducing calf growth are also being studied.

The arid and semi-arid zones of West Africa

The arid and semi-arid zones have several characteristics that differentiate them from other mandate areas. They differ from the adjacent humid and subhumid zones in having a shorter growing season, lower human population densities, more ruminant stock per caput, lower soil fertility and less diverse cropping patterns. As a result, dry-matter yields are low, dry-season nutritional stress is severe, crop and animal production are risky and pastoralism is the dominant mode of land use. The zones differ from the eastern African pastoral systems because of the greater importance of cropping, transhumance and trade.

Research in these zones began with diagnostic studies of herd and farm management to determine constraints. Like pastoral systems research in eastern Africa, much of the work was based on the assumption that insufficient information was available about pastoral systems and the cropping systems associated with them. Various types of studies were undertaken including on-station research on draught animal nutrition, household budget studies, pasture studies, herd and flock management research and aerial surveys. Systems in the zone were broadly described as cultivation systems based on annual crop production by settled farmers, and transhumant systems based on pastoral production by semi-sedentary herders, with varying degrees of annual crop production.

The diagnostic phase showed that the principal constraints to animal production were poor nutrition, especially in the dry season, and poor herd and pasture management. Poor nutrition reduced the work capacity of draught animals at the beginning of the cultivation season, and affected meat and milk animals by increasing calf mortality, extending calving intervals and reducing weaning weights. Herd and pasture management were shown to affect the quantity of forage available and, ultimately, animal production.

Separate solutions to the nutrition problem were developed for the cultivation and transhumant systems. For the former, crops were identified that fit into the cultivation system, such as cowpea and forage legumes. For the transhumant and semi-sedentary systems, in which large stock (cattle and camels) are an important component, pasture management techniques that can increase primary productivity were identified. Flock-management techniques that increase secondary productivity without changes in primary productivity were also identified.

Studies on draught animal feeding at Niono in central Mali showed that better fed animals could plough larger areas earlier in the season. The nutritional improvement could be achieved by feeding legume hays, especially cowpea, and cottonseed cake, both of which are produced locally. Studies of flock management showed that changes in veterinary and breeding practices could increase small-ruminant production.

The role of modelling

Quantitative models are used principally for economic evaluation of technologies. The models have been used in two ways: to assess the profitability of interventions and to assess constraints in a system, thus indicating technical solutions.

The best example of the first use is a simulation model of supplementary feeding to a dairy cattle herd. This model, first developed at Texas A&M University, and modified by ILCA using data from Botswana, is being adapted for use in Mali and Nigeria. Other examples are component evaluation of fodder banks in the Sub-humid Zone Programme at Kaduna and of

alley farming in the Humid Zone Programme at Ibadan. This work uses station and farm data but is less comprehensive than herd simulation in that it evaluates only components, not the whole system. It is also less demanding in programming capacity and is better suited as a training instrument.

Examples of the second type of model include linear programming work in the Highlands Programme, where the database from on-station trials and from farmers' fields at two sites is well established. This work fits into the category of whole-farm evaluation as a guide to component research. Another example is the use of primary production simulations to examine the aggregate pastoral production potential of large areas. This work is done for much larger physical areas than the models mentioned above and is primarily concerned with definition of production possibilities for given ecologies, rather than technology evaluation. This is being done in Botswana and in Mali. The Ethiopian Rangelands Programme has also used simple simulation models to study the impact of calf growth on herd productivity.

Models are being developed to simulate aspects of pastoral systems and to test farming components in areas with higher population densities where annual cropping dominates. Some mix of these types of model may soon be applied to data from the Kenya Rangelands Programme, where the descriptive phase of research has been completed, and where a substantial amount of field data exists.

Cost-benefit studies

Some cost-benefit analysis of ILCA's interventions has been done. Work in the Ethiopian highlands has shown smallholder dairy enterprises based on crossbred cows to be highly profitable (Gryseels and Anderson, 1983). Partial budgeting has shown a small ruminant health package and supplementary feeding with leucaena foliage to be profitable under some circumstances in the humid zone (Sumberg et al, 1985). Partial budgeting has also shown fodder banks to be profitable in the subhumid zone (von Kaufmann, 1984). Similar exercises in the Ethiopian rangelands have shown promising results for calf supplementation. Some cost-benefit work has been done by ILCA in Mali and in Malawi on cattle fattening programmes. While this latter example is not directly linked to an ILCA field programme, it is an example of this technique being used in collaboration with a national programme.

Evaluation

Fulfillment of objectives

To diagnose constraints to animal production: This objective has been fulfilled in each of the major production systems.

The initial baseline surveys identified the general factors listed below as the principal constraints on animal production in the various zones:

Pastoral systems: Low dry-season feed quality, inadequate water supplies, and competition between people and calves for limited milk supplies.

Humid and subhumid zones: Animal diseases, poor feed quality and low soil fertility.

Ethiopian highlands: Availability of animal draught power; high mortality of young stock; liver fluke in sheep; inefficient water conservation and utilisation; inadequate supplies of protein supplements.

Although these constraints are of a general nature, the baseline surveys enabled them to be quantified and ranked in order of importance in each system, and allowed relevant research strategies to be defined. A crucial product of this process is the specification of desired technology characteristics.

To develop prototype technologies under farm conditions: No notable successes in development of new technology have been achieved in pastoral systems, but this has been due primarily to the emphasis in these systems on description rather than on development of interventions. In the smallholder systems, promising beginnings have been made in single-ox traction, fodder banks and alley farming with small ruminants, but these technologies have yet to be widely adopted.

To develop research methodologies: ILCA has developed techniques, or adapted them from other areas, for surveys, field research, on-farm research and monitoring with a reasonable degree of success. Techniques specific to pastoral systems, such as wide-scale aerial surveys, have proved useful. The Centre has been less successful with analytic techniques in FSR and with on-farm experimentation.

To monitor technology adoption: Substantial progress has been made in monitoring the adoption of ILCA-developed technologies in the Ethiopian highlands, and in the Humid and Subhumid Zones Programmes. Only minor interventions have been developed for pastoral systems, precluding monitoring of adoption. However, the pastoral systems programmes have had some success in monitoring ecological changes.

To help build the capacities of national institutions: In systems research ILCA has been successful in this objective, as shown by its close collaboration with national programmes in Nigeria, Mali, Kenya and Ethiopia. Institution building has been successful with smallholder systems, but less so with pastoral systems, because of the practical difficulties noted earlier in working with the latter and because of the relative weakness of national programmes in pastoral systems research. ILCA has also had effective collaboration in FSR-related work with national programmes in some countries in which it does not have resident scientists (Malawi, Zimbabwe and Rwanda).

Summary and outlook

Research at ILCA has broadly followed a multidisciplinary systems approach. When ILCA was founded it was generally believed that sufficient 'modern' technology was available to improve traditional livestock systems, but that not enough was known about the socio-economic environment in which livestock producers operated. ILCA therefore established field teams in the various ecological zones of sub-Saharan Africa with a heavy socio-economic emphasis, in order to study the major animal production systems and the interactions among their socio-economic and environmental components. Emphasis was given initially to detailed baseline studies and the transfer of existing technologies.

ILCA's experiences have shown that little 'modern' technology was available that gave substantial advantages over traditional methods, given the economic and ecological conditions

facing producers. As a result, the Centre has recently given more emphasis to component research, such as forage legume agronomy and animal nutrition, to generate new technology. The prime concern in this work is how changes in plant and animal nutrition and physiology influence the productivity of the livestock component and of the farming system as a whole.

ILCA continues to give a high priority to its task of strengthening national institutes. In that role, it sees its comparative advantage as being in such areas as germplasm collection, data analysis, documentation and information, survey techniques, training and network development. The Centre sees its future role in systems research as continuing to have its own field teams in order to undertake original research, to test technology components developed by headquarters units and to organise training for national programmes in techniques appropriate to livestock production research in sub-Saharan Africa.

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