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ILRI 1997

Livestock, people and the environment

International Livestock Research Institute

Cover photo *A herdsman milking a cow in the early morning near Niamey, Niger Cattle are tethered overnight on croplands to provide vital nutrients for subsequent crops via their manure and urine Livestock transfer nutrients from rangelands to croplands and process nutrients in crop residues into forms more readily available to crops* (Photo D Elsworth)

ILRI 1997

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Contents

Foreword

Demand for meat and milk is projected to double by the year 2020 These increases will primarily be in developing countries [1] Two thirds of the world's livestock are found in developing countries and most are owned by rural smallholders Increased demand for livestock products should enable smallholder livestock producers to increase their income And consumers in developing countries, who will be increasingly urban, will also benefit if increased supplies of livestock products are available and affordable Research to improve livestock productivity will, therefore, benefit both producers and consumers of livestock products But increasing productivity is not sufficient The challenges to maintaining environmental quality and managing natural resources must be addressed as well Again, research can help meet these environmental challenges

The thread that ties together the articles in this Annual Report is 'Livestock, people and the environment' The placing of 'people' in the middle is deliberate People, their needs, their hopes and their desires for a better life are central to efforts aimed at protecting or enhancing the environment If they are not given this central role, such efforts are doomed to fail

The first article (*Livestock and nutrient cycling maintaining a balance*) clearly shows how livestock support intensified agricultural production systems Replenishing plant nutrients and organic matter in the soil is the basis of sustainable agriculture This is a role for livestock that smallholder farmers in the developing world readily recognise and one that was known—but now often forgotten—by farmers in temperate, developed countries

Making sense—and use—of genetic diversity highlights the role for indigenous animal genetic resources in the low-external-input production systems used by the vast majority of the world's smallholder farmers Indigenous populations have 'evolved' in these low-input systems and carry valuable traits such as resistance to diseases and the abilities to survive on poor-quality diets and tolerate harsh climates Characterising this valuable biodiversity is a crucial first step towards protecting it for future use by the world's smallholder farmers

ILRI's biotechnology research accounts for about 25% of the total annual CGIAR investment in biotechnology Improving productivity and reducing wastage from disease and parasites have real environmental benefits, as the two articles *Aspects of biotechnology research at ILRI* and *Diagnostics and the environment* demonstrate In particular, ILRI's biotechnology research aims for better-targeted, more environmentally friendly approaches to alleviating the disease constraints facing smallholder livestock production

Smallholder dairying—intimate links between people and livestock again demonstrates the central role livestock can play in improving the lives of rural people without degrading the environment This article stresses the need for a systems approach to development-oriented research, an approach that takes into account both productivity and sustainability

1 Delgado C, Courbois C and Rosegrant M 1998 Global food demand and the contribution of livestock as we enter the new millenium In Gill E M, Smith T, Pollot G and Owen E (eds), *Food Lands and Livelihoods Setting Research Agendas for Animal Science Proceedings, BSAS/CTA International Conference, Nairobi Kenya*

Concerns have been expressed that widespread environmental degradation would follow the control of the tsetse fly and trypanosomosis in sub-Saharan Africa Another view is that trypanosomosis will gradually be eradicated as agriculture intensifies and land use changes The article *Impact of trypanosomosis control* presents research-based information on these concerns and issues

ILRI in Latin America focuses on the globalisation of ILRI's programmes and the central theme of 'Livestock, people and the environment' in the institute's programme The global electronic consultation reported on in *Balancing human needs, livestock and the environment* was part of the broader multi donor, multi-partner study on Livestock and the Environment Finding a Balance [2] This conference and the study findings have been an important influence shaping ILRI's research activities

The requirements for development-oriented livestock research are great and resources are limited Progress will only be realised through partnerships with others For ILRI, these partnerships include those with other CGIAR centres and their national partners in the ecoregional consortia that are supported by the Systemwide Livestock Programme, with scientists from ad vanced research institutes in CGIAR member countries, and, importantly with national research institutes, universities and NGOs in developing countries The values gained from these partnerships were recognised in 1997 by the CGIAR Chairman's Award for Outstanding Scientific Partnership to the Kenya Agricultural Research Institute (KARI) and ILRI—an appropriate award because of the emphasis of this partnership on 'Livestock, people and the environment'

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2 de Haan C , Steinfeld H and Blackburn H 1997 *Livestock and the Environment Finding a Balance* European Commission Directorate-General for Development WREN Media, Suffolk, England, UK 115 pp

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Livestock and nutrient cycling: maintaining a balance

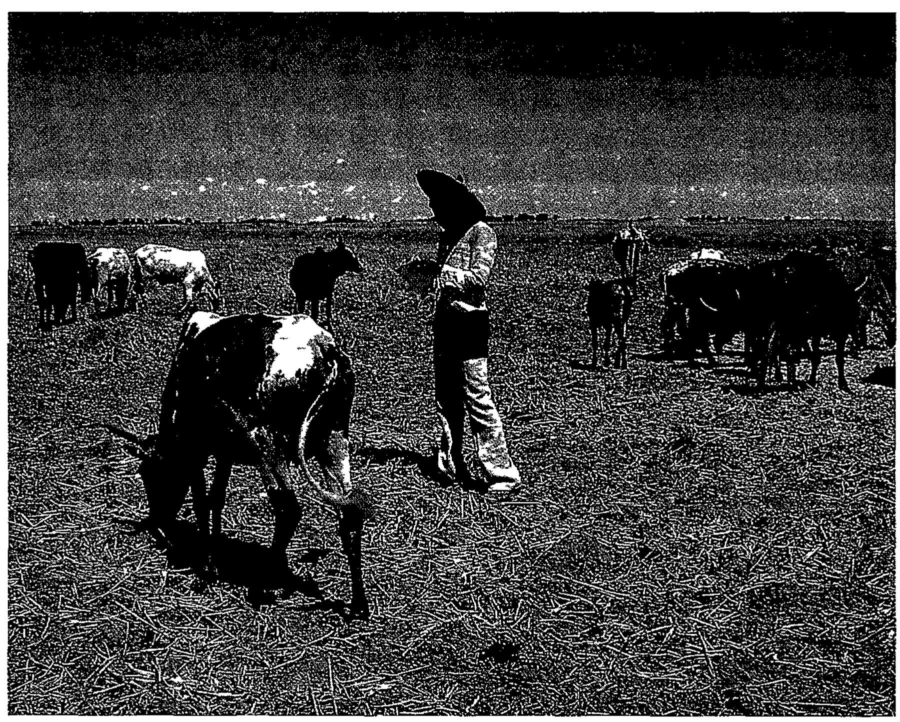
Crop farming takes it out of the soil—nutrients, that is

Farmers plant their crops, harvest the plants and typically cart them away to the homestead, where the grain is removed and either eaten by the family or sold The remains of the plant may or may not be returned to the fields

Obviously, there is a net loss of nutrients from the cropland, a loss that can be dramatic if crop residues are not returned to the soil Inevitably, land that is cropped year in, year out without any nutrients being added will not continue to support the same yields—crop yields fall

The role of livestock in helping put nutrients back into soil is well known by the world's small-scale farmers and by soil and livestock experts But in developed countries, where artificial fertilisers are abundant and affordable, this role of livestock is in danger of being forgotten In the developed world, livestock are now seen as consuming resources and producing pollutants But that was not always the case Before modern, intensive production systems, farmers kept livestock as much for their ability to provide fertiliser as for their products—milk, meat, tractive power In the 1840s, Philip Pusey stated that the practice of fattening cattle on arable farms in England was 'not from a view to profit in the sale of meat, but for the production of dung, and the consequent increase of the corn crop' (Pusey P 1842 On the progress of agricultural knowledge during the last four years *Journal of the Royal Agricultural Society of England* III 205)

Grazing cattle on crop residues in semi-arid West Africa Livestock manure and urine are vital sources of nutrients for crop production in many parts of the developing world



The contribution that livestock make to crop production is strongly influenced by human population density, cropping intensity and climate At one extreme, in arid lands unsuitable for cropping, pastoralism is the only option for sustaining livelihoods With rising population density and higher rainfall, there is increasing interaction between livestock and crops—livestock come to rely on crops for part of their feed, while crops benefit from nutrients delivered as faeces and urine from the livestock At the other extreme, in densely populated, intensively cropped regions, such as South-East Asia, livestock are highly valued by farmers as a means of producing fertiliser, converting plant material quickly and efficiently into a form that can be applied to the soil to maintain crop yields

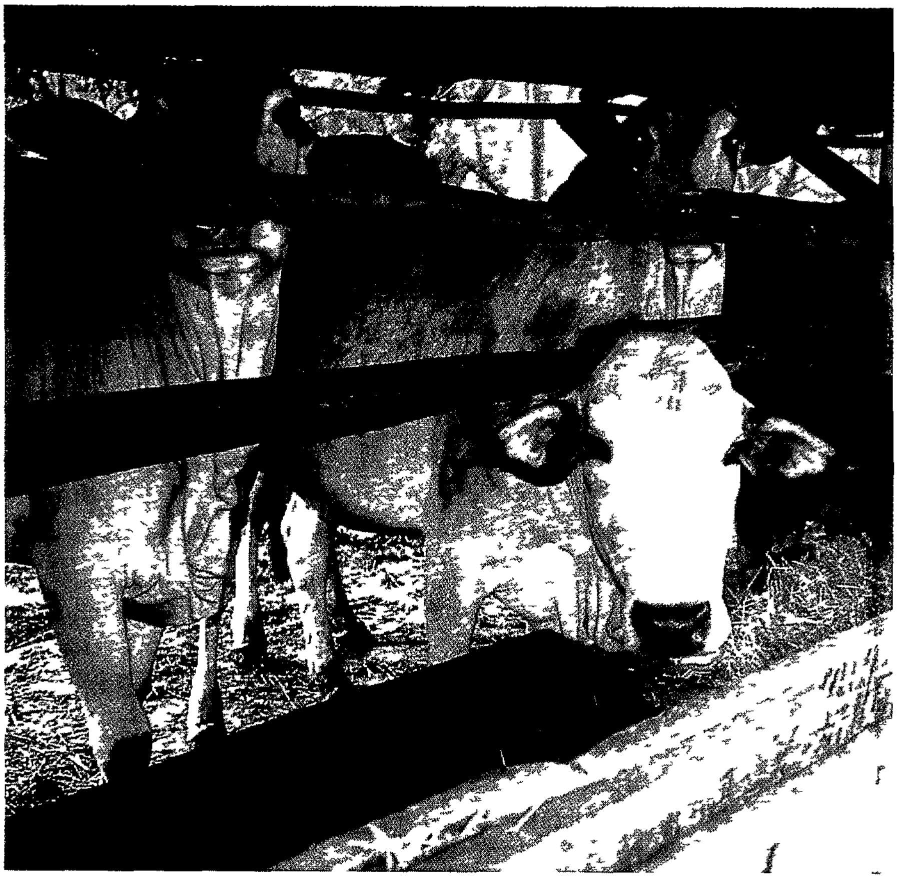
Two routes from soil to soil

Why involve livestock in cycling nutrients in crops back to soil? Why not just put the crop residues back on the land and let them decompose?

There are several reasons why livestock are important to this process on smallholder farms Firstly, cereal crop residues are often relatively slow to decompose in soil, so it can be a long time before the nutrients in the crop residues become available to the subsequent crop Also, while the soil microbes are breaking down the crop residues, they can actually tie up soil nitrogen for their own use, reducing the amount of nitrogen available to plants Thus, it may be months before the nutrients are available to plants

However, if one feeds crop residues to ruminant livestock, microbes in the animal's stomach break down the plant materials rapidly The excreta—faeces and urine—produced contain nutrients in forms that are more readily available to plants The nutrients not excreted are converted to valuable animal products—milk, meat, fibre, tractive power etc

Livestock do more than speed up nutrient turnover through the process of digestion As animals eat the palatable parts of the crop residues—the leaves for example—inedible fractions such as the stems are trampled underfoot (particularly if animals are stall-fed), where they mix with the faeces and soak up urine Trampling by the animal breaks up the stover,



Livestock in zero-grazing units, like these, commonly trample the unpalatable portion of their feed underfoot, where it mixes with faeces and urine The resultant 'compost' is excellent fertiliser for crops

speeding the decomposition process and increasing the capacity of the stover to absorb urine Nitrogen in animal urine is commonly 'lost' through volatilisation, but using crop residues to soak up the urine improves nutrient 'capture' 'Animal processed' inedible fractions of crop residues compost faster, making the nutrients in them available sooner

ILRI currently has two programmes that focus on livestock and nutrient cycling, one in Niger, in the semi arid tropics, and one in the East African highlands Circumstances are radically different between these two regions, but the key role of livestock in promoting sustainable production systems links them

Livestock protect fragile lands

The semi arid zone includes parts of 48 developing countries in Africa, Asia and Latin America, home to roughly one sixth of the world's population

This is one of the most fragile, vulnerable agro ecological zones Its soils are sandy, contain little organic matter, are poorly structured and hold little water Many of them crust over easily when they dry, making it difficult for seeds to germinate, and they are all easily eroded by water and by wind

Large parts of the world's semi arid lands can only be used sustainably by ruminant livestock, and then only if their numbers are con trolled and they are free to move over long distances, following the region's sparse and erratic rain But increasing human population is reducing the freedom of livestock herders to roam and driving farmers to crop land that once was under permanent grassland, exposing the soil to erosion and depriving livestock of grazing Even where cropping is feasible, the traditional fallowing system has broken down under the pressure to produce more food, hastening the decline in the already low soil fertility The high price of inorganic fertilisers, inappropriate policies and difficulties in getting agricultural inputs to rural areas mean that few farmers use improved crop varieties or fertilisers Manure is often the only fertiliser used by smallholder farmers in this zone

The easy answers are not to cultivate fragile land and to limit the number of livestock kept on the land But such easy remedies don't work in the real world What farmers and livestock owners need are options that help them produce the food and income they need to provide for their families and to contribute to the development of their societies One such option—indeed one of very few workable options—is to integrate cropping and livestock rearing in ways that allow each activity to support the other, minimising competition for resources This is the approach that ILRI is adopting with its partners and colleagues in these fragile areas

ILRI has a research team based in Niger at the Sahelian Center of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and another based at ICRISAT's Asia Center in India, addressing ways to improve crop–livestock integration and its contribution to food security in the semi-arid tropics

Livestock and nutrient cycling transfers in the semi-arid zone

In the past, and to some extent still, pastoralists bartered with farmers, exchanging their livestock's manure for crop residues and water owned by the farmers But pastoralism is declining in the face of drought and population pressure Slowly but surely, integrated crop–livestock systems are replacing this interplay of separate livestock and cropping systems

There are many competing demands placed on cropping systems in the semi-arid zone Crop residues are a vital source of livestock feed in parts of semi-arid Africa, crop residues provide nearly half the livestock's feed intake throughout the year and up to four-fifths of feed during critical periods Yet many farmers use the long, strong stems of crops such as sorghum and millet as building material or as fuel Alternatively, residues could be incorporated into the sandy soil to raise its organic matter content and its ability to retain water

Surprisingly, studies by ILRI and its partners in villages in Niger show that, despite the small amount of vegetation left on rangelands and crop fields by the end of the dry season, livestock eat less than a fifth of the vegetation from rangelands and only a tenth of the crop residues and weeds left on fields after harvest

There are too few livestock, and too little grazing land, for farmers to effectively manure all their fields every year As a result, farmers in semi-arid regions have developed systems for concentrating nutrients from the grazing land to selected fields, or even parts of fields that they feel are particularly short of nutrients

Studies suggest that, in semi-arid West Africa, 10 to 30 hectares

ILRI research has shown that corralling cattle and sheep overnight on croplands results in much higher yields from subsequent crops than collecting manure and spreading it over a similar area

of grazing land are needed to provide enough manure to support continuous cropping of millet on one hectare of cropland if there are no 'external' inputs such as fertiliser or supplementary feed for the livestock. Thus, the maximum proportion of the land that can be cropped sustainably based only on nutrient transfers from rangeland is between 4 and 9%.

But the vast majority of these studies use data on livestock populations and land-use types aggregated over vast areas. The ILRI-led research shows that local—village or even household-level—differences in management practices can have dramatic effects on the sustainability of integrated crop–livestock systems. Differences in farmers' production goals, resource endowments and socio-economic conditions create different opportunities for farmers to exploit crop residues, rangeland and other potential feed resources and for them to practise nutrient cycling.

The research in Niger has been studying nutrient management in several villages covering a range of climatic conditions, cropping intensities and livestock populations. The proportion of land that was manured in these villages ranged from only 3% in the village with the largest cropped area and the fewest livestock to 22% in the village with the smallest cropped area but an intermediate number of livestock. As might be expected, farmers who applied manure had more livestock and fallowed less land than did farmers who did not apply manure.

These studies have also shown marked changes in labour requirements and livestock management as the proportion of cropped land increases. The decline in grazing land associated with increased cropping forces farmers to move their livestock out of the village area during the cropping season, or to rely increasingly on stall-feeding their animals. Either option increases the need for labour during the wet season.

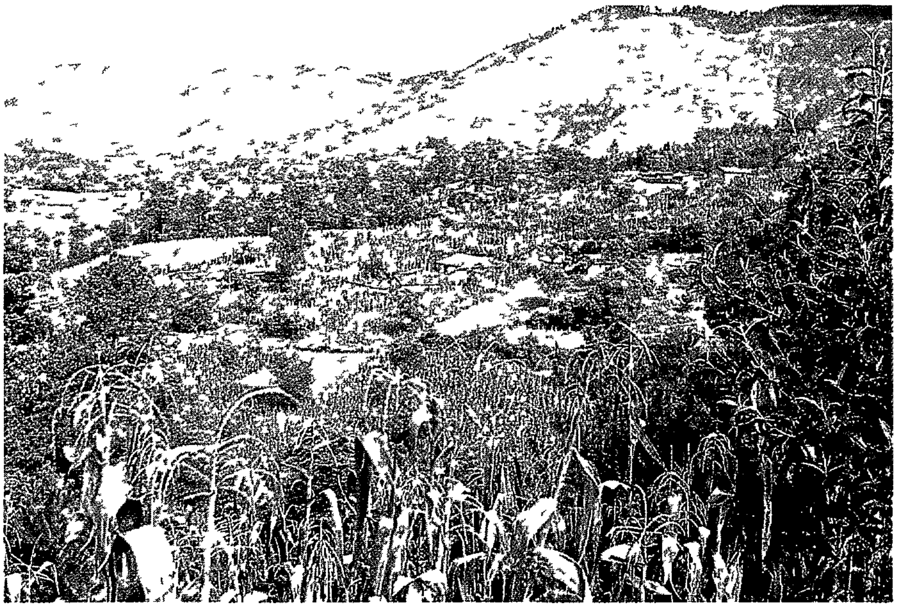
Increasing grazing pressure on the rangelands near some of the villages is leading to changes in the composition of the rangelands. Near the village of Kodey, where 62% of the land is cultivated, the grazing pressure on the remaining rangeland is so high during the wet season that the animals are eating over three-quarters of all the plant material that grows. Inevitably, palatable, nutritious plants are being replaced by plants that the livestock prefer not to eat.

Over a year, the amount of nutrients harvested from rangelands by grazing livestock and excreted in manure could compensate for between a fifth and a quarter of the nutrients harvested in crops from croplands. However, other ILRI studies have shown that applying both manure and urine dramatically increases the amount of both nitrogen and phosphorus made available to plants. Thus, changes in animal management, particularly to increase corralling on crop lands rather than hand-spreading manure, would improve the nutrient transfer process.

Obviously, cropping in this region cannot be sustained by livestock mediated nutrient transfers alone—nutrients will have to be brought into the system from outside, either as supplementary feed for the livestock or as inorganic fertiliser or both. ILRI and its partners are continuing to study the social, economic and environmental impact of this and to identify options such as economic incentives, policies and institutional changes that can facilitate the adoption of technical interventions in the semi arid zone.

The research in Niger is currently funded by the International

Croplands in semi-arid West Africa. Without livestock-mediated nutrient cycling, cropping would be untenable in this zone without greater inputs of chemical fertilisers.



Intensive smallholder agriculture in the East African highlands (left) and in Asia (below) Livestock play vital roles in supporting such intensive cropping systems

Fund for Agricultural Development (IFAD) and the International Development Research Centre (IDRC), Canada Previous funding came from the Rockefeller Foundation and BASF, Germany

Livestock and nutrient cycling in intensive smallholder dairy systems

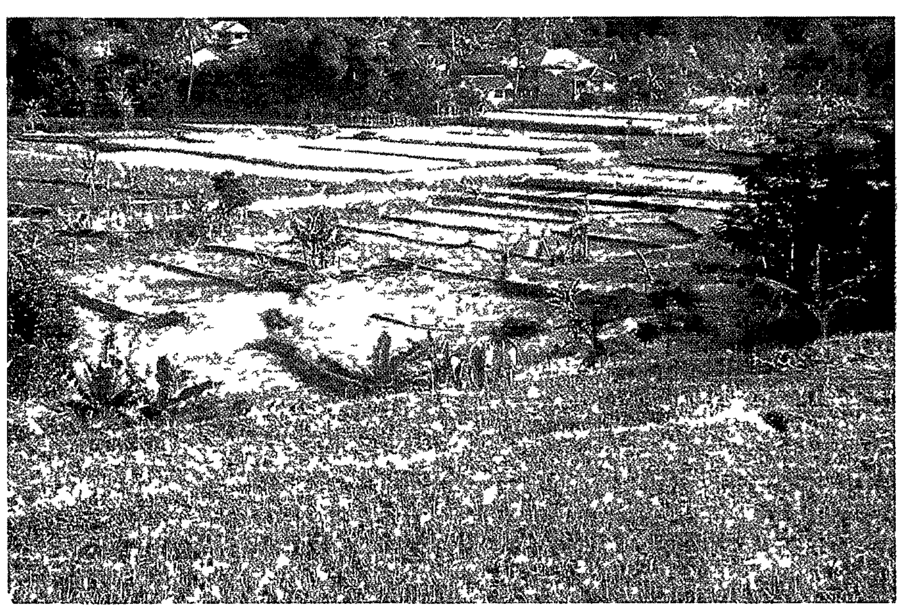
The farming systems in the East African highlands are radically different from those in the semi-arid tropics, except in their reliance on livestock for cycling nutrients and the contribution that animals make to maintaining agricultural sustainability

The East African highlands are densely populated and intensively farmed—farm sizes are now down to less than one hectare per family The time between harvest of the first maize crop and planting of the second is now only two weeks in the central Kenya highlands as demand for staple food soars Such cropping practices on small land areas can only be sustained if farmers put a lot of effort into maintaining and improving soil fertility

In this zone, research by ILRI and a consortium of national and international partners, funded by the Department for International Development (DFID), UK, the Canadian International Development Agency (CIDA) and the Rockefeller Foundation, focuses on smallholder crop–dairy farms With such a high population density, there is a ready market for milk and dairy products and smallholder farmers are rallying to meet the demand However, ask any farmer why she or he keeps a dairy cow and manure will be ranked alongside milk production

Smallholders value animal excreta highly not only because of the nutrients they contain but also because of the way they improve the soil, adding organic matter, imparting structure and boosting water-holding capacity Farmers currently pay US$ 80 for a tonne of manure containing 10 kg of nitrogen but only US$ 5 for the equivalent weight of nitrogen in the form of urea The price differential represents the value farmers put on the physical benefits they get from using manure

With land at such a premium for food and cash-crop production, grazing land is no longer available To the casual observer of such intensive cropping systems, livestock are not present However, in one



Harvesting feed for livestock from irrigation channels in rice fields Many farmers in South-East Asia keep livestock primarily for their manure

of the most densely populated areas of Kenya, Kiambu District, 77% of households actually keep cattle, unseen, in their backyards ILRI, in collaboration with the Kenya Agricultural Research Institute (KARI), the Ministry of Agriculture, NGOs and the private sector, recognises the need to support farmers' efforts to maintain livestock on farms and is conducting research into how livestock can more efficiently contribute to whole-farm productivity

Highland farmers grow Napier grass on small plots to feed their cattle Research has demonstrated that the contribution these plots make to cattle diets can be increased by 20% by interplanting Napier with leguminous forages such as *Desmodium* and *Macrotyloma* The legumes not only enhance the amount of protein in the diet but also improve soil fertility by 'fixing' nitrogen from the air Crops grown following the legumes benefit from this extra soil nitrogen, yielding more than if they follow just Napier or another food crop

Links with Asian agriculture

Can agricultural systems in the East African highlands maintain population densities rising now to over 500 people per square kilometre? Evidence from subhumid South-East Asia suggests that agriculture can support even higher populations In the late 19th century, a rapidly growing human population appeared to be driving the Indonesian island of Java towards ecological disaster One hundred years later, Javanese agriculture is supporting over 600 people per square kilometre through farming systems in which livestock are intimately linked with cropping through highly efficient nutrient cycling systems

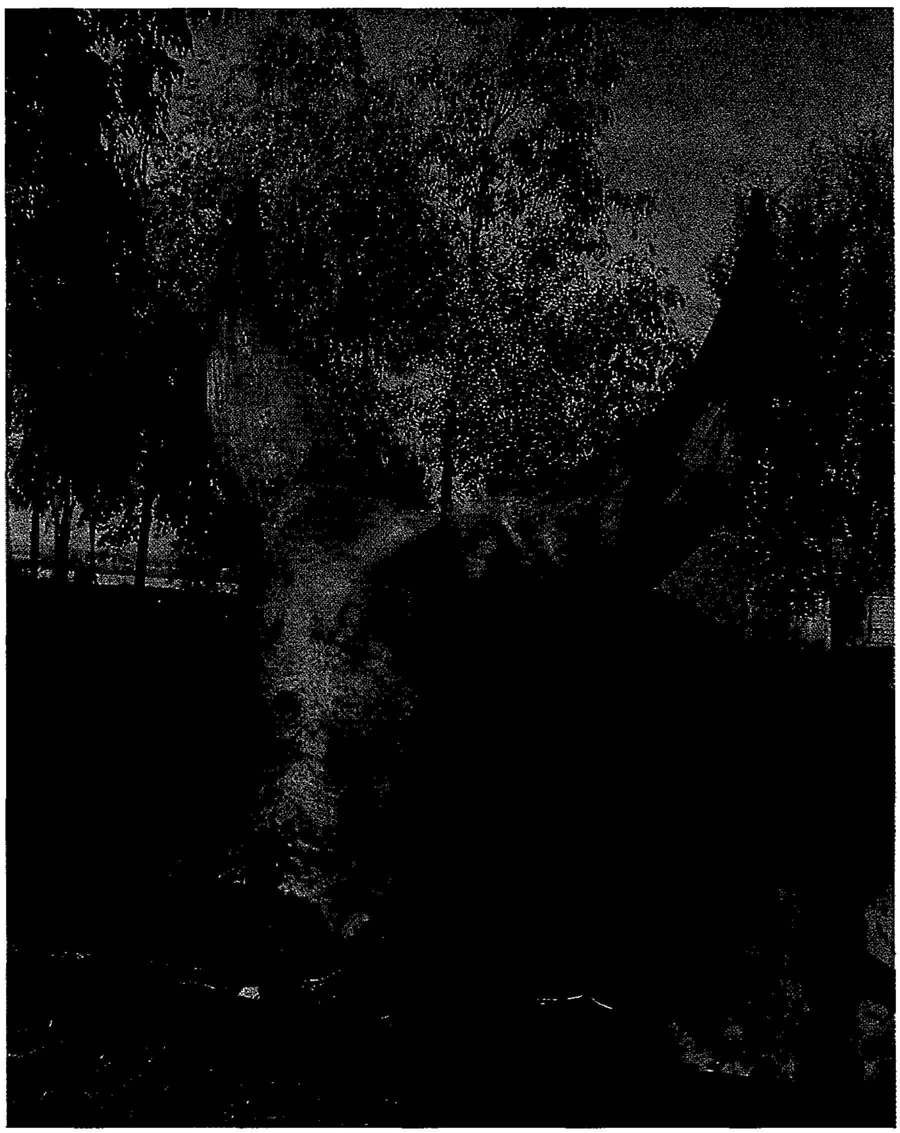
Nutrient cycling research in Niger and the East African highlands, together with ILRI's planned collaboration with partners in South East Asia, provides sites representing the evolution of farming systems over a continuum of intensification ILRI and its partners are elucidating the scientific basis for the contribution that livestock make to the sustainability of smallholder farming across this continuum In this way, ILRI and its partners are well placed to transfer livestock-based strategies for more intensive production of food to areas where population pressure is placing increasing strain upon agriculture

Making sense—and use—of genetic diversity

People began domesticating livestock about 12,000 years ago, selecting animals for their ability to provide food, fibre and traction and to meet other needs Over the millennia, this selection resulted in thousands of different breeds and strains of animals adapted to a wide range of environmental conditions and meeting diverse human needs Some are resistant to pests or diseases, others are able to flourish in harsh climates

But today, many of these diverse breeds are being lost, and at an alarming rate The Food and Agriculture Organization of the United Nations (FAO) estimates that 30% of livestock breeds are at risk of extinction and that about six breeds are lost every month, most of them in developing countries Half of the breeds that existed in Europe at the turn of the century have disappeared

The Kuri, one of many weird and wonderful—and potentially valuable—livestock breeds facing extinction



Yet these breeds may have carried genes that would have been of benefit to today's farmers, genes that have been lost forever We know so little of the breeds that still exist, the genes they carry, the production systems they could fit into, the benefits they could bring to farming communities in another place, another time Urgent efforts are needed to characterise breeds and to preserve this valuable resource for future generations

What is the greatest threat to many of the world's lesser-known livestock breeds and types? Habitat loss? Environmental change? Disease?

None of the above It is loss of interest in them by farmers, coupled with 'imports' of exotic breeds to increase productivity Many people, scientists and farmers alike, believe that indigenous breeds are not productive, that they are incapable of contributing to increased agricultural production, they are, in a word, redundant Yet ILRI's studies have shown that this is not true, indigenous breeds can be as productive as 'exotic' breeds under improved smallholder management where their adaptation to the environment gives them an advantage over the 'exotic' animals Most 'exotics' have been developed for use in intensive production systems, mostly in temperate climes, and need very high levels of inputs—particularly feed and veterinary care—to produce at anywhere near their best

What is the most effective way of preserving endangered breeds? Gene banks holding eggs and sperm in deep freezes? Herds and flocks kept in living 'gene banks'?

Again, neither These are partial answers, but they lead to 'fossilisation' of the breed—they preserve the breed as it is, but remove the opportunity for the breed to continue to respond to the ever-changing farm environment Again, the answer lies with farmers—as long as farmers keep these breeds on their farms and keep selecting them to meet their evolving needs, these breeds will remain 'current', they will continue to meet farmers' demands in an ever changing world

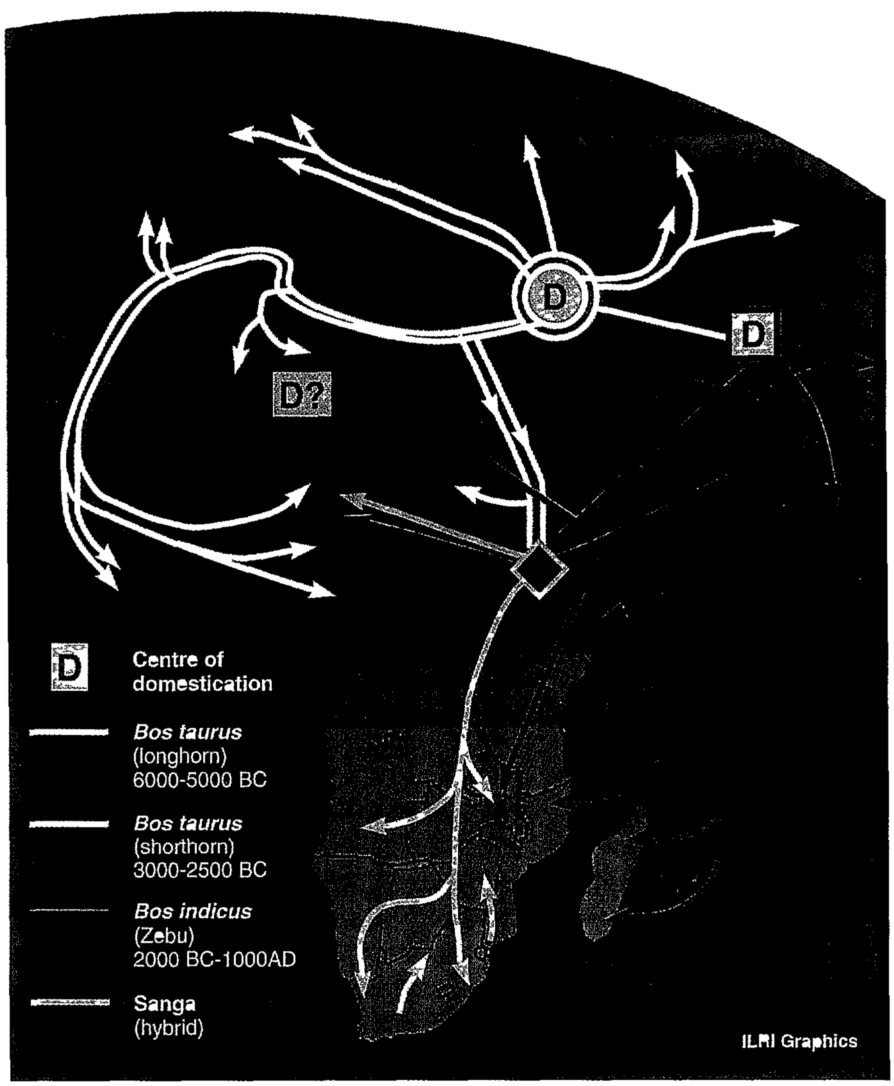
Characterising livestock breeds in the developing world—ILRI's role

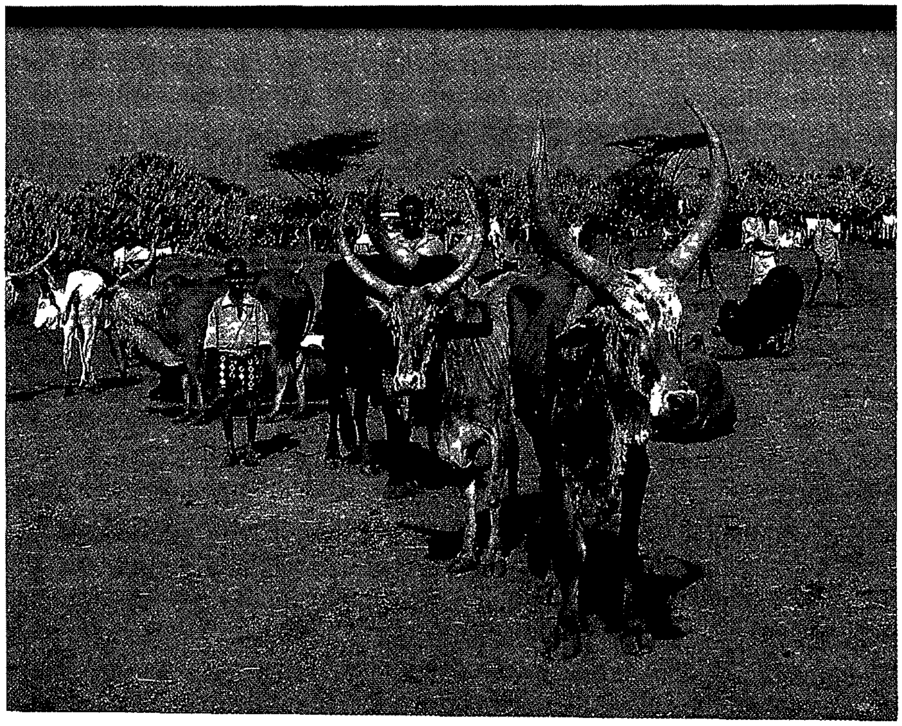
A key issue in working with any genetic resource is the need to know what one is dealing with Are all the breeds actually different from one another? How much genetic difference is there between populations? Does one need to conserve all the breeds to capture all the genetic variation or can one aim to protect just a few representative populations?

In a project started in 1995, ILRI scientists set out to answer some of these questions for cattle types found extensively throughout eastern and southern Africa Using a set of 20 genetic markers, they characterised 15 East African zebu breeds or types and 15 breeds that have traditionally been classified as sanga or sanga × zebu intermediates Sanga breeds are thought to have originated from crosses between zebu type cattle (humped breeds) and taurine type cattle (humpless breeds similar to those found in Europe and elsewhere), with a common origin, possibly in the Horn of Africa

The results clearly show that all 15 East African zebu breeds are closely related, with surprisingly little genetic difference between them They are, however, clearly distinct from African and European taurine breeds and from Asian zebus These are preliminary

Origin and migration routes of domestic cattle in Africa





results, based on a limited number of breeds and only a few markers However, they indicate the potential value of such studies in developing conservation strategies If the differences between breeds turn out to be negligible, as determined using a larger number of loci spread throughout the genome, this might suggest that the 'breeds' could be pooled in any use and conservation strategy This would reduce the complexity and cost of the conservation effort

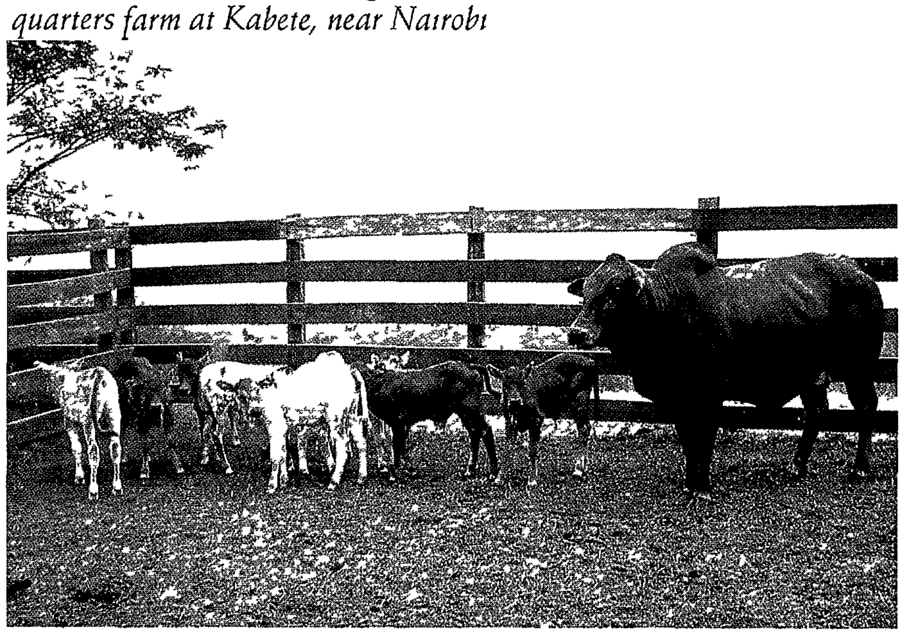
The sanga and sanga × zebu group turned out to be much less homogenous, with two clearly distinct groups emerging The breeds from the Horn of Africa are mainly of zebu origin and geneti cally are very similar to the East African zebu breeds, while the southern African sangas are predominantly taurine and hence markedly different genetically both from the northern sangas and from the East African zebus These results challenge the notion of a common and crossbred origin of all the breeds today classified as sanga They also suggest that the original sangas were of taurine origin, with the zebu blood being introduced after the sangas had spread out across Africa

Most authorities believe that Africa's earliest cattle were taurine (i e humpless) and that they came to Africa from the Near East about 7000 years ago Zebu cattle came to the continent much later, a few zebus arrived in about 1500 BC, while a major wave of introductions occurred in about 670 AD at the time of the Arab invasion of Africa Many of the original taurine 'African' breeds have been crossed with zebus over the centuries This process has usually employed mating zebu bulls with taurine cows, ensuring a rapid spread of the 'intruder's' genes

A study by ILRI in 1997 aimed at determining the proportion of zebu blood in apparently taurine breeds still found in West and southern Africa ILRI scientists used a genetic marker found on the Y chromosome (the male sex chromosome) that can be used to distinguish between Y chromosomes from taurine and zebu breeds

The results showed that in West Africa the proportion of zebu blood decreased from north to south This finding is much what might have been expected from the current distribution of zebu

N'Dama calves born to surrogate Boran mothers at ILRI's headquarters farm at Kabete, near Nairobi



and taurine populations in the region Taurine breeds in West Africa include the N'Dama, well known for trypanotolerance or tolerance of the disease trypanosomosis Zebu cattle generally show little sign of trypanotolerance Hence, zebu cattle are more commonly found in the more arid northern parts of this region and tend to be excluded from the humid, more forested southern parts where trypanosomosis risk is higher

This finding has a clear implication for scientists working with trypanotolerant taurine breeds in West Africa if they want 'purity' in their potential subjects, they should look towards the southern populations

Among the southern African sanga populations the proportion of zebu blood declines from east to west, as might have been expected given the introduction of zebus from Asia This finding suggests that sanga breeds in western parts of southern Africa may have more in common with taurine breeds found in West Africa than those found on the east coast

Disease resistance and protecting the environment

One of the key features of indigenous tropical livestock breeds that ILRI is focusing on is disease and parasite resistance or tolerance Controlling diseases and parasites is a major problem for smallholder farmers in the developing world Losing an animal can be a catastrophe for them, but they often do not have access to the vets or the drugs they need to help them protect their animals And even if drugs are available, they may not work, drug resistance is increasingly common in trypanosomes, gastro-intestinal worms and many other disease-causing organisms

A better route, both for farmers and for the environment, is to identify and use animals that are naturally resistant to pests and diseases This reduces the farmers' costs—fewer drugs and less lost productivity—and protects the environment by reducing the need for harmful chemicals and drugs

The N'Dama, a humpless cattle breed from West Africa, is well known for its trypanotolerance ILRI's studies over the years have demonstrated that this is an inherited trait, one that can be selected for within N'Dama populations in the search for more productive, more trypanotolerant animals

But traditional selection programmes require huge numbers of animals and intensive selection if they are to make progress Moreover, with a trait such as trypanotolerance, selection is fraught with difficulties The scientist or breeder may have to wait until an animal is several months old before exposing it to the disease in an effort to determine its tolerance The environment—climate, feed availability, many other factors—also affect an animal's ability to respond to disease, hence the results of such programmes may be difficult to interpret, how much of the tolerance is innate in the animal and how much is related to its environment?

But now, as reported in *ILRI 1996 Out of Africa, into a global mandate*, ILRI is using the latest molecular genetic techniques to refine and speed the process of identifying disease-resistant animals and developing animals that combine disease resistance and greater productivity

Working with laboratory mice, ILRI's scientists have identified three regions of the genome—the animal's complement of chromosomes—that carry genes for trypanotolerance And as an eight-year experiment comes to fruition, apparently similar regions have been identified in N'Dama cattle and ILRI's scientists have identified molecular markers associated with these regions that can be used to facilitate trypanotolerance breeding programmes

By working with mice, ILRI's scientists have been able to progress rapidly to advanced intercross lines This has allowed them to achieve an unprecendentedly high degree of definition in the genetic 'map' showing the location of the trypanotolerance genes 'The definition is so good that we are now starting to analyse the specific stretches of DNA these genes are on, in our search for the genes themselves,' noted Dr Alan Teale, leader of this research area at ILRI

Recent developments in related research are highlighting the role in trypanotolerance of TNFα, tumour necrosis factor alpha, a biological messenger molecule with diverse effects on immune responses This molecule was identified as possibly having a role in trypanotolerance during earlier mapping in mouse populations Scientists at the National Institute for Animal Health (NIAH) in Tsukuba, Japan, bred a strain of mice that does not have the gene for TNFα, and in trials these mice have proved to be hyper-susceptible to trypanosomosis ILRI and NIAH are now trying to determine the precise role of TNFα in trypanosomosis, with a scientist from NIAH working at ILRI

In a new development, ILRI is now starting a project to map genes for resistance to gut worms in sheep The institute has established a breeding flock of crosses between the Red Maasai sheep breed—which earlier ILRI studies showed to be resistant to worms—and susceptible Dorper sheep This breeding programme started in 1997, so it will be several years before resistance genes are mapped to any degree of accuracy

Building for the future on the foundations of the past

The world's diverse animal genetic resources have taken millennia to evolve into their current complex diversity Only by making sense of that diversity will we be able to preserve valuable genes for future generations to use The modern tools of biotechnology provide us with the weapons we need to win this battle They also provide us with the means to make fuller use of what nature, with human intervention, has provided—the myriad combinations of genes that are represented by today's livestock breeds and types

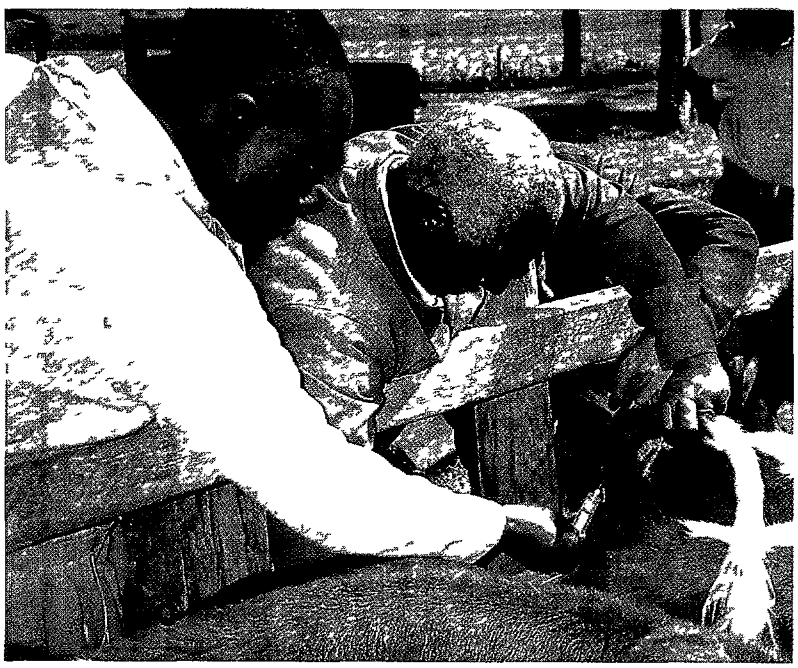
Aspects of biotechnology research at ILRI

By the year 2025, the world's population will have increased by around 60% to some 8 5 billion About 90% of this increase will be in developing countries Unless the efficiency of food production can be increased through sustainable agricultural intensification, poverty, starvation and environmental degradation will increase The most promising way to achieve sustainable increases in food production is through the wider application of modern technologies, such as biotechnology, that offer the prospect of major increases in both plant and animal productivity

Biotechnology began when man started artificially selecting and breeding plants and animals to enhance their desirable characteristics, particularly to improve food production Subsequently, biotechnological exploitation of micro-organisms resulted in processes to produce bread, beer, antibiotics and many other fermentation products that are used by people around the world

Biotechnology harnesses the tools of nature in controlled and novel ways to identify and change the genetic make up of plants, animals and micro-organisms Modern biotechnology has been built on the understanding of the molecular basis of genetic variation This knowledge can be applied in ways that greatly speed up the natural processes of genetic selection and mutation Biotechnology now offers unprecedented opportunities for harnessing the genetic potential of plants and animals in unique ways that enhance agricultural productivity and hence increase food security for people

Taking blood from a cow to identify a parasite infection New diagnostic tests being developed at ILRI are quicker, more accurate and easier to use than traditional diagnostic tools



At ILRI, biotechnology is primarily being used in the development of new improved vaccines and diagnostics for tropical diseases of livestock and in the characterisation, utilisation and improvement of animal and plant genetic resources

The success of this work will contribute to the achievements of ILRI's wider goals, which are

- more efficient and sustainable food production
- plants and animals adapted to local conditions and resistant to local diseases
- fewer but more productive livestock
- less pressure on fragile lands
- reduced chemical control of pests and diseases
- improved ecosystem health

Biotechnology and disease diagnosis

Diagnosing parasitic diseases can be difficult, especially if one wants to know precisely which parasite species is responsible Most current methods of diagnosing livestock diseases are labour intensive and require good equipment and facilities and well-trained, experienced people to identify the pathogenic organisms concerned Biotechnology offers prospects of better, more accurate diagnostic tests that are cheap and simple to use The simple home pregnancy test kits used world-wide are a good example

ILRI has applied biotechnological methods to obtain antigens that can be used in specific and sensitive diagnostic tests for tick-borne diseases of livestock (see *'Diagnostics and epidemiology'*, this report) Faster, more accurate and more sensitive than traditional tests, these new generation tests are also cheaper, easier to use and better suited to the situation of national programmes than older testing systems

Biotechnology and vaccines

The goal of scientists working to overcome disease problems is a vaccine that is cheap to generate, easy to deliver and gives widespread protection against disease Current vaccines against vector-borne diseases rely on infection of animals with live organisms, often in combination with drugs to protect the animal from the disease while its immune system deals with the infection Such vaccines are expensive and require a lot of high-technology resources often unavailable in developing countries Laboratories have to maintain, propagate and control the quality of vaccine cell lines Delivering the vaccine to the end user requires a cold chain to preserve the vaccine and supplies of often highly expensive drugs The products of biotechnology, in contrast, should simplify matters The goal is products that are cheap to produce and maintain and simple to store, transport and administer For example, new-generation vaccines are commonly lyophilised—freeze dried—to form a powder that can be stored at room temperature no more cold chains The vaccine is reconstituted by adding water to the powder as the vaccine is needed Simple, cheap, safe to use and highly effective

ILRI has an extensive programme of research into the development of subunit vaccines against East Coast fever and trypanosomosis Already it has a first-generation vaccine against ECF in field trials (see *'Potential vaccine enters field testing'* in *ILRI 1996 Out of Africa, into a global mandate*) and is developing second-generation vaccines using live delivery systems (see *'Live vaccine delivery systems for East Coast fever'* in *ILRI 1995 Building a global research institute*) The first-generation vaccine is based on a protein found on the surface of the organism that causes ECF and stimulates an antibody-based immune response to the parasite as it invades the host The second generation vaccines are targeted at a later stage of the parasite, once it has invaded the host's white blood cells, and stimulates a response from cytotoxic T cells Developing these vaccines relies heavily on the tools of biotechnology

An electron micrograph showing the flagellar pocket of a trypanosome Recent research by ILRI and its partners suggests that antigens in the flagellar pocket may provide the basis of a vaccine against trypanosomosis

The key to the development of such a vaccine is the identification and isolation of specific components (antigens) of the causative organism that induce immunity without inducing pathogenic effects and causing disease ILRI is using biotechnology to identify, characterise and isolate target antigens that can be tested as candidate vaccines Once a potential target antigen is identified within a disease organism, the gene responsible for its expression is isolated from the organism and inserted into a vector system such as a bacterium (*Escherichia coli* is commonly used) The vector or carrier of the antigen gene can be grown in laboratory culture, producing large amounts of the antigen, which can be isolated and tested as a candidate vaccine ILRI has isolated such antigens from the organisms that cause several major diseases of livestock in Africa and the developing world These antigens are now being tested at ILRI for their efficacy as vaccines

Tsetse transmitted trypanosomosis is one disease where the biotechnological approach may bring a solution This disease has steadfastly resisted scientists' efforts to develop a vaccine against it—but recent results from research by ILRI and its partners offer real prospects for progress towards an effective vaccine against trypanosomes The stumbling block for past efforts to develop a vaccine against trypanosomes was the parasite's ability to 'clothe' itself in different surface coats As the host's immune system produces antibodies against proteins on the parasite's surface coat, trypanosomes with a different surface protein appear As the host develops an immune response to the new protein, a new variant appears, and so on almost *ad infinitum*, with the parasite always one step ahead of the host's immune system Eventually, the animal, weakened by the continuing infection, succumbs to the disease

But some proteins on the parasite's surface have to remain the same—receptor molecules that allow the parasite to capture and take in nutrients from the host's blood Most of these receptors are concentrated in a structure called the flagellar pocket

New procedures for purifying these receptors have recently been developed and in initial trials with the purified antigens over 80% of immunised animals were consistently protected against a lethal trypanosome challenge, while all of those that were not immunised succumbed to the disease Work is now underway to identify and characterise these receptors The next step will be to isolate the genes for these protective antigens and use them to develop what will, ILRI hopes, be an effective anti-trypanosomosis vaccine

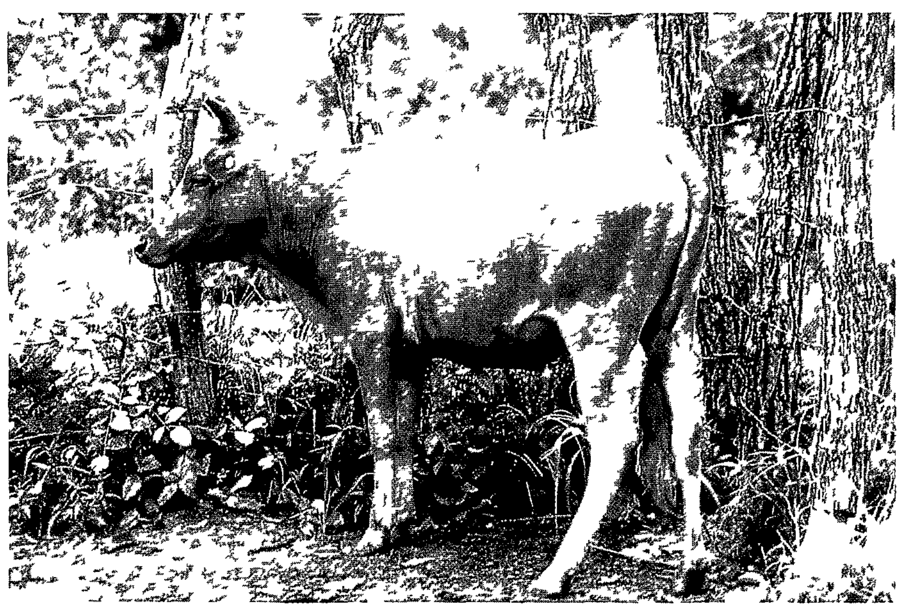
In the doldrums only a year or two ago, scientists working to develop a vaccine against trypanosomes are now confident that a vaccine is, indeed, a possibility

There are also similar expectations at ILRI that a recombinant vaccine can be developed to control another major disease of cattle in Africa, the tick-borne disease East Coast fever A first generation vaccine for this disease is already under field test (See *'Potential vaccine enters field testing'*, in *ILRI 1996 Out of Africa, into a global mandate*)

Biotechnology and animal breeding

Farmers and stockbreeders have been altering plants and animals for millennia, ever since hunter-gatherers first settled and domesticated crops and livestock They developed new livestock breeds by selecting and crossing those ani-

An N'Dama cow, one of many breeds that ILRI is studying using tools provided by biotechnology



mals that best suited their needs, those with higher milk yields or larger size This was, in essence, the beginning of biotechnology

Over the years, plant and animal breeding became more scientific as our knowledge of genetics developed from its beginning with Gregor Mendel in the late 19th century Yet the end result remained the same—plants and animals that better suit our needs

But traditional selection methods improve productivity only very slowly In the past, the approach was able to keep pace with increasing food demands In the future this will not be the case Unprecedented human population growth demands a much faster increase in livestock productivity than has been achieved before, especially in the case of ruminants These animals are particularly valuable in large areas of the world, where they are the only species able to convert the cellulose-rich feeds that are available into meat, milk, hides, wool, manure and tractive power

Biotechnology offers tools that allow us to achieve rapid increases in productivity Genetic markers (see *'Marker-assisted breeding pro grammes'* in *ILRI 1996 Out of Africa, into a global mandate*, and *'Making sense—and use—of genetic diversity'* in this report) help breeders identify those animals that carry desirable genes without having to wait and test them—often a long and painstaking process Earlier identification of the animals that have the desired characteristics means that breeders can keep fewer animals and apply a much greater 'selection pressure', weeding out less promising animals The end result is smaller, cheaper breeding programmes and faster progress The process is the same as that used since animals were first domesticated, it is only the tools that differ

In a similar vein, the same types of tools that help scientists develop more efficient breeding schemes are used by those interested in identifying and conserving the world's genetic resources ILRI has used molecular genetic tools to study the range of genetic variation represented by the Napier grass collection in its forage gene bank (see *'The grass is always greener '*, in *ILRI 1996 Out of Africa, into a global mandate*) and is using them to do the same for African livestock breeds (see *'Making sense—and use—of genetic diversity'* in this report)

Africa's buffalo are able to control trypanosome infections, something cattle are unable to do Recent research has identified how the buffalo are able to do this, opening new avenues for trypanosome control measures

Biotechnology and tapping wildlife resources

Cattle are relative newcomers to Africa—they arrived on the continent only about 7000 years ago—so they still have not adapted to many of the parasites and diseases found in Africa But many of the continent's large mammals evolved with those same diseases and have long learned to live with them If we can find out how these other species deal with the diseases, we may find ways to use this information to protect cattle against these diseases

One area that is showing great promise is studies on the ability of African buffalo to eliminate trypanosomes from their blood This ability lies in the interplay between two blood enzymes, xan thine oxidase, which produces hydrogen peroxide as a by product of its action, and catalase, which converts hydrogen peroxide to water Hydrogen peroxide effectively poisons trypanosomes at very low concentrations African buffalo have higher levels of xanthine oxidase in their blood than most cattle, and lower levels of catalase Recent experiments have shown that, during the control of a trypanosome infection in African buffalo, xanthine oxidase activity remains at a high level but catalase activity decreases, returning to normal after the parasites are elimin ated Parallel experiments in cattle showed no change in the activities of these enzymes during infection of both trypanotolerant and suscep tible breeds

Scientists are now looking for the mechanisms that control these changes in enzyme activity in the buffalo, in the hope that the knowledge can be applied to developing cattle that are able to withstand the disease This work is part of a collaborative project between the University of Massachusetts, ILRI and the Kenya Agricultural Research Institute

Potential for impact

The technologies and products that ILRI is developing will be delivered through national programmes and, where appropriate, in association with commercial partners The research capacity and technologies developed can also be applied in a wide range of other diseases of both animals and man For example some of the techniques and products may have diagnostic or therapeutic values that can be utilised in human medicine

Improved vaccines will reduce farmers' reliance on chemical control, reducing harm to the environment The application of biotechnology in animal breeding and health will allow intensification of livestock production and, in the longer term, enhance productivity in ways that cannot be achieved through conventional approaches The new technologies offer the possibility of providing enough food to meet the demands of the world's growing population and of alleviating the poverty that population increases bring

Biotechnology and smallholder farmers

These are just some of the ways in which ILRI is using the tools of biotechnology to address problems faced by smallholder farmers in the developing world The tools may be high-tech, but the goal is simple, appropriate products that will help put more food on the plates of poor people The food crisis facing the developing world needs solutions today and ILRI is using all the tools at its disposal in its efforts to develop such solutions

Smallholder dairying—intimate links between people and livestock

The statistics in support of livestock are impressive Nearly 2 billion people—a third of the world's population—derive at least some of their livelihood from farm animals, nearly one person in every eight depends almost entirely on livestock Domestic animals meet more than 30% of people's food and agricultural needs But livestock are more than just food They also provide

- manure for fertiliser and fuel
- draft power that helps boost crop production and transport the products to market
- hides and fibre for clothes

Smallholder dairying demonstrates all these functions and more in the enduring relationship between livestock and people

In Africa as a whole, smallholder dairying generates more regular income than any other rural enterprise Globally, the market value of milk production is second only to rice in the arid and semi-arid tropics of South and South-East Asia, second to beef in the subhumid tropics and subtropics of South and Central America and exceeds all other food commodities, including coffee, in the warm humid tropics of South and Central America With such numbers behind it, dairying obviously contributes enormously towards alleviating poverty and improving food security in the tropics, and yet there is much potential for increasing that contribution, as has been demonstrated by 'Operation Flood', the smallholder dairy development scheme in India

In Africa as a whole, smallholder dairying generates more regular income than any other rural enterprise

Dairying improves human nutrition and health

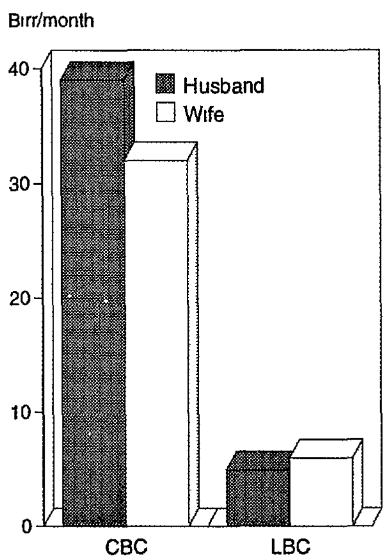
But dairying can do more than just increase farmers' incomes—it can improve the nutrition and health of all members of the household, as recent studies in the African highlands illustrate

Previous farm level studies have shown that adopting crossbred

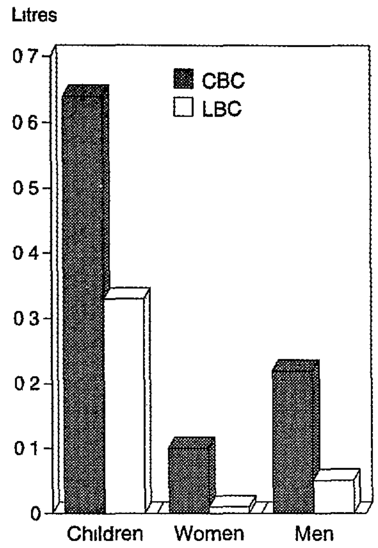
cows and the associated package of improved feeding and management strategies increases milk production and household income What they did not show, however, is how the changes affect the nutrition and health of individuals within the households This gap in our knowledge is being addressed in a collaborative project involving the Ethiopian Institute of Agricultural Research, the Ethiopian Health and Nutrition Research Institute (EHNRI) and ILRI, funded by USAID

'One of our key concerns is that milk may be seen as a "cash crop" as yields increase', said Mirjam Steglich, an ILRI graduate student registered at Humboldt University in Germany who was involved in the study under the supervision of Barry Shapiro, an ILRI agricultural economist 'When this happens, men tend to take over marketing the "crop" and women may lose control of the income And women tend to spend their income on food and the household, whereas men may have other priorities This study will tell us more about what is happening in these households as they adopt dairying' Early results show that cash income from dairying increases dramatically in households with crossbred cows (71 birr per month, compared with only 11 birr per month in households with only local cows) and that both men and women benefit almost equally—men's income from dairying was 39 birr per month, compared with 32 birr per month for women

Data collected by the EHNRI show that introducing crossbred cows can markedly improve human nutrition and health Two years after the introduction of crossbred cows, stunting of children (height for age) is only about half as prevalent in households with the crossbred cows (26%) as in those with only local cows (47%) Stunting is a measure of chronic malnutrition and is generally related to poverty, chronic ill-



Keeping crossbred dairy cows dramatically increases cash income from dairying, with women benefitting as much as men (CBC=households with crossbred cows, LBC=households with only local cows)



Households with crossbred cows (CBC) consume much more milk than those that keep only local cows (LBC)

ness and inadequacy of food There was little evidence of infectious diseases among the sample households but there was a large difference in dairy income between those that kept crossbred cows and those that did not This suggests that the reduction in stunting is related to increased income from dairying rather than reduction in disease

Even immediately after crop harvest, when food availability is greatest, milk consumption in households with crossbred cows was more than double that in households with only local cows Children consumed most milk, followed by men, then women

Another study started recently in East Africa, carried out by ILRI in close collaboration with the Kenya Ministry of Agriculture and the Kenya Agricultural Research Institute (KARI), has also shown dramatic effects of dairying on household income Households at the Kenya coast with crossbred cows earned more than one-third

A smallholder dairy farm at the Kenya coast Recent results indicate that households with crossbred dairy cows have monthly incomes nearly 21 times those of households with local cows

of their cash income from dairying, compared with only 6% for households with local cows Even more dramatic was the difference in actual household income—households with crossbred cows had monthly incomes nearly 21 times those of households with local cows (7318 vs 347 Kenya shillings)! This work is funded by the Impact Assessment Evaluation Group of the Consultative Group on International Agricultural Research (CGIAR)

Spreading the benefits

Some people have criticised development efforts directed at dairying, on the basis that dairying needs a large investment to get started and hence benefits only 'richer' farmers Yet research by ILRI and its partners clearly demonstrates that dairying is far from being the preserve of the 'rich' but rather is attractive to smallholders and moreover gives a wide range of spin-off benefits that permeate the whole community For example, a survey of farming households at the East African coast showed that ownership of crossbred cows was quite evenly distributed across income categories and size of land holdings

This same research also showed that farmers with dairy cattle employ more people than those who do not keep dairy cattle At the Kenya coast, for example, house holds with crossbred cows employ more full time labour than households without crossbred cows (1 5 labourers compared with 0 2) They also employ more part-time labour (1 9 vs 1 3) And not only do owners of crossbred cows employ more people, they also pay them more (1335 Kenya shillings a month compared with 856 shillings a month for those employed on farms without crossbreds)

The extra labour is needed to help care for the cows and to maintain the Napier grass grown to feed them Many of the people hired to work on the dairy farms come from the poorest sector of

the community, dairying offers one of the few employment oppor tunities in many of these rural areas

The dairy subsector is also creating new market opportunities and jobs in service industries Since the advent of smallholder dairying in Kiambu District, in central Kenya, a market has developed for Napier grass 'Several million dollars worth of Napier are traded annually between highland farms these days,' notes Steve Staal, the ILRI economist in the smallholder dairy research team working closely with KARI and Kenya's Ministry of Agriculture in a pro ject largely funded by the Department for International Develop ment (DFID), UK Some farmers in the region now specialise in producing feed for dairy cattle

While not everyone can get into dairying, many people nonetheless can benefit from the opportunities it provides Milk processing, for example, is a growth 'industry' in many parts of the developing world 'In The Gambia there are women who buy a few litres of milk each day from Fula cattle herds, ferment it and then take it to Dakar [in neighbouring Senegal] twice a week on the bus to sell it,' points out Jon Tanner, an ILRI animal nutritionist Poor, landless people also get involved in the manure marketing chain in semi arid East India, collecting manure from grazing areas or farms with a surplus and selling to farms that need it as fertiliser

In much of the developed world, manure is seen as a problem, a 'waste' that has to be disposed of By contrast, in much of the developing world manure has high value as a marketable commodity—as is the case in the East African highlands—and may well be the primary reason for farmers to keep livestock 'In some cases the manure produced by these smallholder dairy units may be worth twice as much as the amount the farmer makes from selling milk,' states Tanner, who leads the nutrient management research funded by the Canadian Inter national Development Agency (CIDA), DFID and the Rockefeller Foundation

Borana women taking milk to market Selling dairy products is a major source of income for many pastoral people like the Borana

With manure being such an important 'product', nutrient cycling is a key element of the research carried out by the smallholder dairy team (see *'Livestock and nutrient cycling maintaining a balance'* in this report) Recent studies in the East African highlands show that farmers now rank soil fertility decline as the second most serious problem they face (after the supply of water) The role of live stock and their manure in combating this problem is important and growing in the developing world, especially where governments are being forced to reduce or eliminate subsidies on inorganic fertiliser

ILRI's ecoregional teams, work ing closely with their national and regional partners, are looking at ways to improve nutrient cycling and one obvious way lies in ma nure management 'Harvesting' urine and putting it on cropland assumes increasing importance where livestock are stall fed and never graze the fields 'Half the nitrogen excreted by livestock is in their urine, so we have to get it back to the field somehow,' says Tanner Some of the approaches being tried are not particularly radical or dramatic—covering manure pits to pre vent loss of nitrogen to the air, better urine collection systems, using bedding and refused feed to absorb and trap the urine—but they may make a crucial difference in the fight to restore soil fertility and ensure the good crop yields that are the foundation of food security of some of the tropics' poorest people

Complex systems, complex answers

Describing the approach to dairy research taken by ILRI and its partners is difficult, as the projects have to look at the web of interactions between livestock, the farming systems they are part of and the physical, social and economic environments they operate in Efforts focus on improving the performance of the overall system, rather than on improving livestock production *per se* 'The dairy element is the entry point,' notes Tanner, 'but it is not the end of the story'

One of the crucial lessons that this approach is teaching ILRI and its partners is the need to keep an open mind and not blindly 'import' concepts and ideas from the developed world

'This was emphasised by a recent survey by a graduate student, a Ministry extension officer working with the Ministry/KARI/ILRI team,' says Tanner The survey is designed to determine what technologies farmers have adopted, to what extent they have adopted them and why they adopted the ones they have Western dairy economics dictates that farmers should aim for yearly calving, a calving interval of 365 days, in order to maximise income But is that what these farmers want or do they have different production objectives?

The initial study found that, while the farmers are looking for high daily milk yields just like any dairy farmer anywhere in the world, they are not motivated to shorten calving intervals 'They would rather have low levels of milk every day than go through the process of drying off and having a calf regularly,' notes Tanner Even one or two litres a day is better than nothing—if the farmer dries off the cow for six weeks there is no milk coming in, no income And there is a 50 50 chance that any calf that is born is going to be male, and there is a poor market for bull calves in the smallholder dairy areas What appears at first sight to be poor management is, in fact, a rational and deliberate response by the farmers to their circumstances

A web of interactions, a network of partners

This complex, systems oriented approach to research is demanding for the research institutes involved, looking as it does at a web of interactions rather than focusing on any one aspect of the dairy system ILRI and its partners therefore have a big challenge, understanding the relationships linking each component of these smallholder dairy systems, from animal feeding and management through to milk processing and consumption studies And they must consider the influences of international dairy trade policies, aspects which are being looked at, to understand the competitiveness of the dairy sector at international, national and local levels And not only in one location—the programme operates in several sites in East and West Africa, and is strengthening its links into Asia and has activities in Latin America

Why go to all this trouble? Because the demand for milk and dairy products from rapidly urbanising populations in the tropics and changing balances in world trade have created great opportunities for smallholders to produce more milk more profitably, if they are given the right technical, policy and institutional support These opportunities are challenges for the people in the research and development community, challenges that are closely tied to the needs of the smallholder farmers they are dedicated to helping

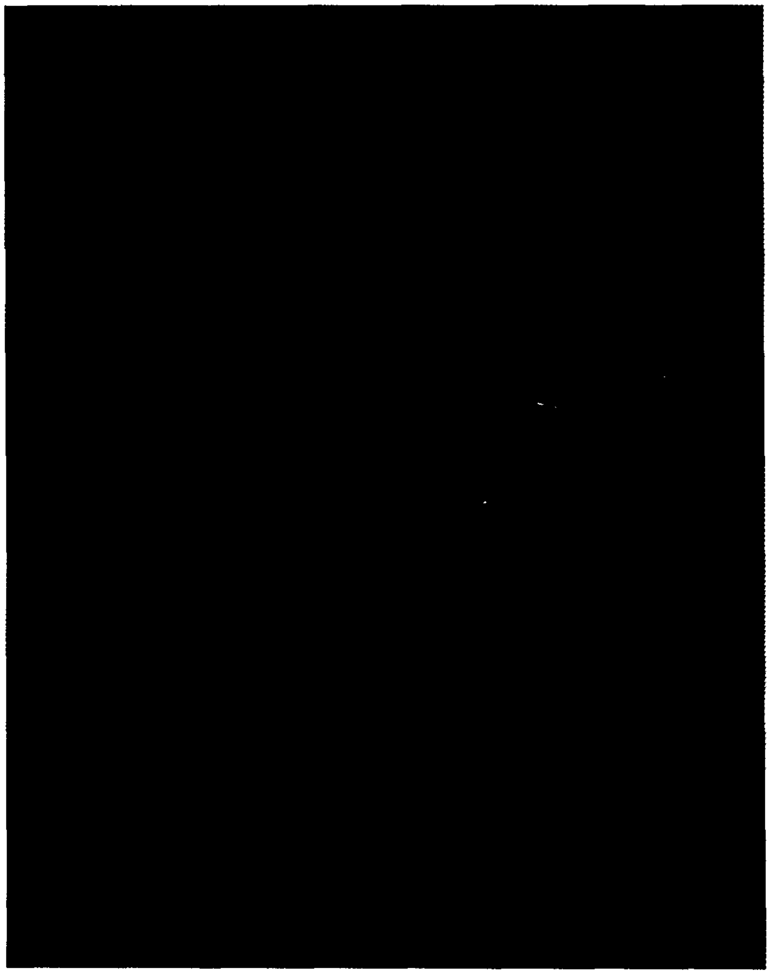
Diagnostics and the environment

Diagnostic tests are essential tools for those studying or trying to control diseases ILRI is now able to provide a range of reagents that give im proved diagnosis of blood-borne parasitic diseases of livestock

Defining the problem

If you want to define accurately a disease problem, you need good diagnostic tests If you then develop a strategy for controlling the disease—vaccines or maybe a combination of vaccine and management practices—you still need diagnostics to monitor the effect of the control programmes Ultimately, veterinarians and farmers need cheap, simple diagnostic tests that they can use on farms to help them protect and treat animals

Using fluorescent microscopy for diagnosis Biotechnology is providing better, faster diagnostic tools for scientists studying livestock diseases



At the research level, ILRI scientists need to have accurate tests for identifying, characterising and monitoring infections in animals These tests need to be both sensitive and specific, sensitive enough to give a reliable indication of the presence or absence of infection and specific enough to be able to identify the particular parasite involved

Specificity is important among the tick-borne diseases affecting livestock in the tropics, for example, there are six different *Theileria* species, two different *Babesia* species, two different *Anaplasma* species and one species of *Cowdria* And in most cases, animals in the field will be infected with several of these

Commonly-applied diagnostic tests are based on the use of fluorescent microscopy Slides are coated with parasite antigen preparations Sera from animals to be tested are placed on these coated slides If the animal is infected it will have antibodies against the parasite and these bind to the parasites on the slide The antigen–antibody complex can be detected under a fluorescent microscope

Therein lies a problem many of the parasites are biologically very similar and share common proteins, or antigens No matter which parasite is on the slide, it is possible that antibodies against another parasite species will bind to it—so-called cross-reaction So the test shows that the animal is infected, but not with what Specificity is very low The problem mainly lies with the antigen preparation, which is crude and contains many cross-reacting elements Although sensitivity may be high, there are problems with specificity and standardisation in diagnsotic tests that rely on crude antigens

A biotechnology approach

Scientists have now moved away from the crude antigen approach and are focusing on dissecting each parasite using modern molecular biology technology ILRI is adopting this approach with the tick-transmitted diseases of livestock The aim is to identify proteins unique to each particular parasite that are also immunogenic—i e animals that are infected 'see' that particular protein and produce antibodies to it

Scientists went out in the field in areas where particular diseases were known to be present and took blood samples from animals that had survived in that environment The assumption was that those animals would have been repeatedly infected and hence would have high levels of antibodies to the particular organism They then tested the sera in a biochemical assay to identify proteins seen by these sera By doing so, the scientists identified unique, parasite-specific antigens that are recognised by naturally infected animals

That provided the antigen The next step was to identify the parasite gene that encodes for the antigen and insert it into a bacterium (*Escherichia coli*) The bacterium is then able to produce the antigen in culture vessels in the laboratory The result the ability to produce large quantities of standard and pure antigen cheaply, efficiently and without the use of live animals

Products available

Since this project started four years ago, ILRI scientists have identified unique proteins for four key parasites *Theileria parva, Theileria mutans, Babesia bigemina* and *Anaplasma marginale* These have been used to develop improved ELISA (enzyme-linked immunosorbent assay) tests specific to each parasite and thus improve the sensitivity and specificity of diagnosis of diseases caused by these parasites

Identifying which parasite an animal is infected with is as simple as placing serum in wells of an ELISA plate coated with a parasite antigen If the animal has antibodies for, say, *Theileria parva*, the antibodies will bind to the antigen in the well of the *T parva* ELISA plate The presence of the antibody/antigen complex is displayed by the use of a chromogen (colour dye), and the plate can be read under a spectrophotometer (an ELISA reader) The whole process can be automated so that the results can be read and analysed by a computer

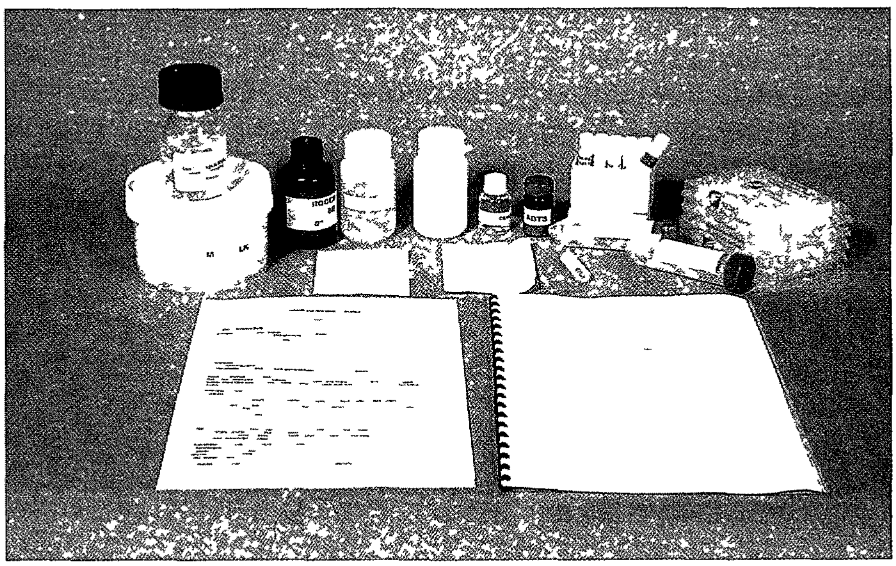
Requests for tests

Many diagnostic laboratories in Africa now have ELISA readers and the tests are now widely used For example, in the past year, ILRI has provided 'kits' that have been used in Uganda, Kenya, Tanzania, Zimbabwe, Madagascar, Swaziland and several countries in West Africa The kits are modular, so that if a requesting laboratory is well established and has the standard laboratory equipment and reagents needed to carry out the test, ILRI need send them only the antigen plates and control sera needed to validate the tests

Building on a resource

Anyone wanting to develop antibody-detection ELISA tests like

ILRI's diagnostic kit for East Coast fever includes all materials needed, together with detailed instructions on their use



those ILRI has been working on first needs a set of defined reference sera or 'standards' to evaluate their test against Building this reference set involves infecting large numbers of animals with each parasite species alone and in combination Sera from these animals are thus known to contain antibodies against a known infection, be it single or multiple Scientists test candidate antigens against the reference sera to determine whether they are 'recognised' by antibodies in infected animals and if so whether such recognition is specific to the parasite in question Only after such tests have shown the antigen to be promising will it be tested under field conditions, where the scientist does not know what infections are present

Building up a bank of such reference sera is expensive and time consuming, but is necessary Once done, however, it is a resource that can be extensively used, one that makes developing further tests much quicker and easier

For example, during 1997 a scientist from the University of York, UK, used ILRI's reference sera to test a candidate antigen for a diagnostic test for *Theileria annulata* This parasite, related to the one that causes East Coast fever (*Theileria parva*), occurs in a broad swathe from southern Spain to China and has a major economic impact on livestock production By testing the candidate antigen against ILRI's reference sera, she was able to determine, in only one month, that the antigen does not cross react with antibodies for any other parasites and hence that the antigen would potentially make a good diagnostic test for *Theileria annulata*

Building the reference set of sera took ILRI several years, but it is now saving the institute and its partners time and money ILRI has also developed links with a European group, the Integrated Control of Tick and Tick-borne Diseases Action Group, to continue building the reference set of sera, making it even more useful

The next phase

The next phase of this work is to develop rapid 'pen-side tests', tests that can be used simply and easily to detect infection on farms The aim is to develop a test similar to that used by millions of diabetics around the world—take a drop of blood, put it on a slide and read off the result seconds later

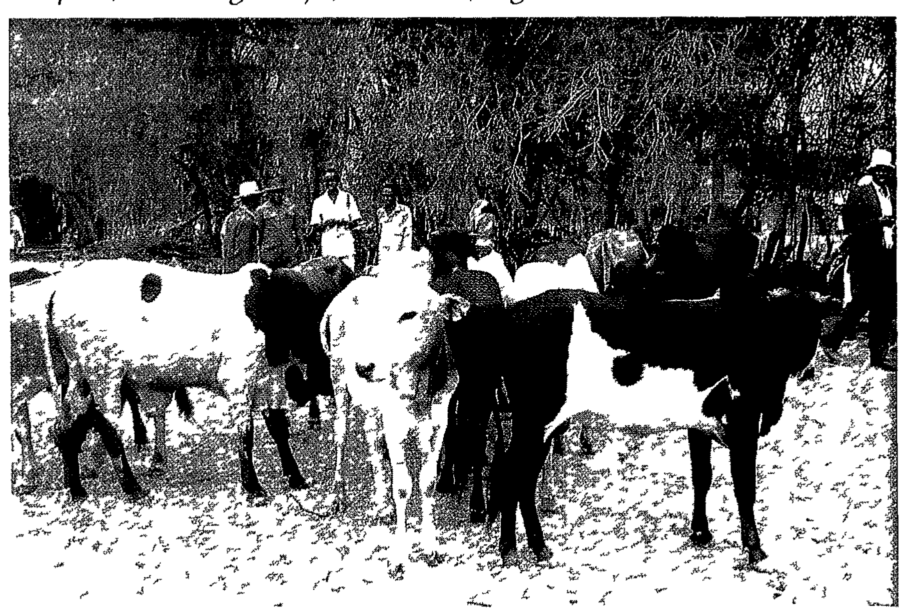
ILRI is in the process of developing links with a number of groups in Europe and the USA to move this work forwards 'The hard work is done,' says Subhash Morzaria, a molecular parasitologist at ILRI 'We have the defined antigens The next step is to adapt them to rapid detection formats so that they can be used at farm level by field workers' This needs technology that ILRI does not have, hence the links with other advanced research institutes ILRI hopes to have sensitive, specific pen-side tests within three years

Tests in the field

Several projects in Africa have been using ILRI diagnostic tests in recent years For example, in a field trial of East Coast fever immunisation in Kenya, national programme scientists are using the ILRI ELISAs to help them decide where animals need to be vaccinated and to monitor the efficacy of the vaccine applied So, for example, if they find that most of the animals they test in a particular region already have high levels of antibodies against *Theileria parva*, there is no need to vaccinate the animals—they have already been exposed to the parasite and should be immune The test thus helps them apply the vaccine selectively

And once the animals have been vaccinated, the trial is using

ILRI's diagnostic test for East Coast fever is in use in several countries in Africa, including Kenya, Tanzania, Uganda and Zimbabwe

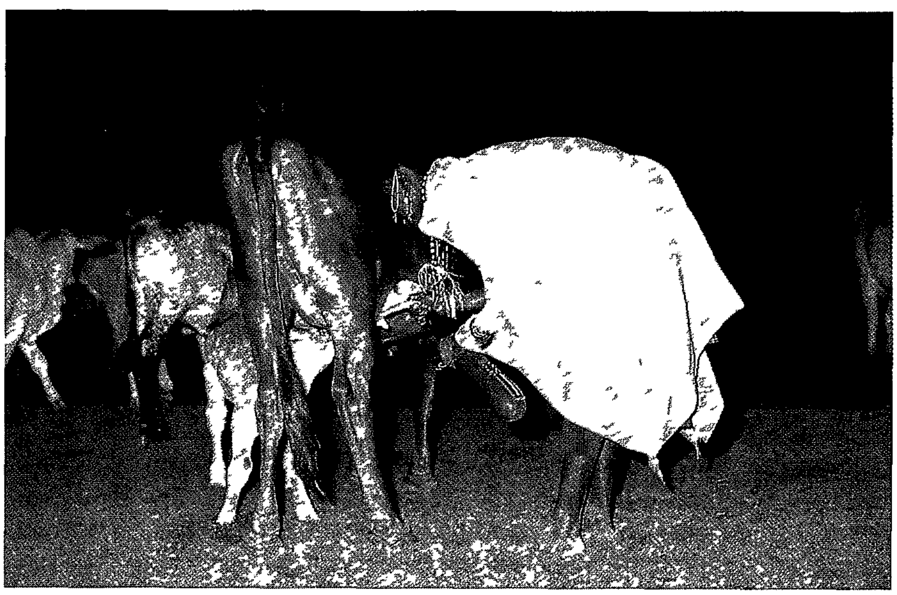


the ELISA test to determine whether the vaccination was successful, if it provoked an immune response So the test can be used to evaluate the success of the delivery of the vaccine as well

Similar immunisation trials are underway in Tanzania, Uganda and Zimbabwe

The scientists running the trial in Uganda are using the ELISA tests to study the epidemiology of tick-borne diseases and the dynamics of these diseases in different farming systems Two surveys have been carried out, one cross-sectional, the other longitudinal, in three key farming systems By monitoring cattle over a long period, the scientists are finding out how soon after birth calves get infected with economically important tick-borne parasites, how often the animals get infected and what effects this has on productivity Their results have already shown marked differences between systems, in one of the systems the calves get infected within a month of being born, in another they stay clear of infection for three to four months Obviously this has radical implications for any proposed vaccination and control programmes in one system one has to vaccinate calves very soon after they are born if the vaccine is to be of any use, while in the other there is a four-month window in which to vaccinate calves

Indigenous breeds of cattle in traditional production systems may have developed immunity to East Coast fever, but more productive exotic animals may succumb rapidly to the disease



Characterisation tools

The other component of ILRI's diagnostics research programme is the development of characterisation tools, tools that allow scientists to identify precisely which strain of parasite they are dealing with

All tick borne disease vaccines currently being used in the field are live vaccines—one infects animals with attenuated or modified parasites that do not cause clinical disease yet induce immunity All well and good, but parasites may undergo antigenic change or sexual recombination, so the parasite is constantly changing and evolving What happens if one introduces a 'foreign' strain of, for example, *Theileria parva* as a vaccine? Does the introduced strain replace the local strain? Does it mingle with the local strain? No one really knows—but ILRI's characterisation tools are helping us to find out

The tools used are genetic markers which identify specific strains and trace changes in the parasite's genetic make up Already ILRI has developed markers for the specific *Theileria parva* parasites used in the East Coast fever vaccine in Kenya and for several other *T parva* strains that may be used in eastern, central and southern Africa ILRI is also developing markers for other species and strains of parasites

An interesting finding that has come out of this work is that the genetic variation in the local *Theileria parva* population is very slight in Zimbabwe, whereas in eastern African countries there is enormous variation in the *Theileria parva* population One implication of this is that vaccination against theileriosis in Zimbabwe may require the use of only one strain of the parasite, whereas in eastern African countries a mixture of strains would be required in the vaccine to provide protection against a number of genetically different parasites

These studies provide scientific rationale for making decisions on the types of live vaccines to be used in different countries

Not a panacea, but useful tools

Diagnostic tests are not a panacea for determining the methods needed to control tick borne diseases The information they provide still needs to be integrated with other information about a production system and with knowledge of farmers' circumstances and intentions Take, for example, the case of cattle at the Kenya coast As these diagnostic tests will show, most of the cattle have high levels of antibodies against *Theileria parva* They have all been exposed to the disease and survived it They have achieved 'endemic stability'—a balance between the parasite and the animals' ability to resist its effects So there is no real disease problem in the area, as long as the situation remains as it is But if farmers start bringing in exotic animals to boost their milk production, they could face serious disease problems—these newly-introduced animals may not have immunity to the disease and could rapidly succumb to it

Diagnostic tests provide useful information about the disease status of animals but the information needs to be used in conjunction with clinical, epidemiological and systems information if it is to be truly useful

Impact of trypanosomosis control

Trypanosomosis has helped shape land use in many parts of Africa over the centuries The disease makes it difficult for farmers to keep livestock in large parts of the continent and, while not precluding human use of the land, reduces agricultural productivity By excluding livestock or limiting their numbers, trypanosomosis and its vector, the tsetse fly, have come to be seen by some as the guardians of Africa's unspoilt environments Some people have expressed fears as to what might happen to the environment if trypanosomosis were to be controlled, for example, through application of a vaccine, or if tsetse fly populations were to be dramatically reduced

Yet people too must come into the picture Africa's human population is growing rapidly, as are its demands for food Trypanosomosis is an obstacle to meeting those demands even from land that is already settled and being farmed A recent review of previous studies, most of which were conducted by ILRI and its partners, indicates that trypanosomosis

- reduces cattle offtake by up to 30%
- reduces milk offtake by up to 40% and
- reduces the work performance of oxen by up to 33%

Even so-called trypanotolerant animals are not immune to the effects of the disease For example, while trypanosomosis reduces calving rates by up to 20% in susceptible breeds it still reduces calving rate by up to 12% in trypanotolerant breeds

Effects of controlling the disease on land use and farming

The Ghibe valley, south-western Ethiopia

ILRI has been studying the effects of tsetse control on land use and human welfare in the Ghibe valley in south-western Ethiopia since the early 1990s The Ghibe valley has been settled for a long time and hence the environment has already been modified considerably by human activities ILRI's ecologists have used aerial photographs and satellite images of the valley to map changes in land use between 1957 and 1993, and have related these changes to what farmers in the area know about changes in their environment

Farmers told ILRI's researchers that trypanosomosis first came to the Ghibe valley in the early to mid-1980s Comparing the aerial photographs from 1971–73 with satellite images from 1987 shows a massive change in land use—a drop of 50–70% in the amount of land that was cultivated in the valley 'Today, you can stand on a ridge and look down into the valley and you see no cultivated fields in the valley, not one,' says Robin Reid, an ecologist working with ILRI 'Look at the aerial photos taken 25 years ago and it is just chock a block with cultivated fields, right up to the river The change is very clear'

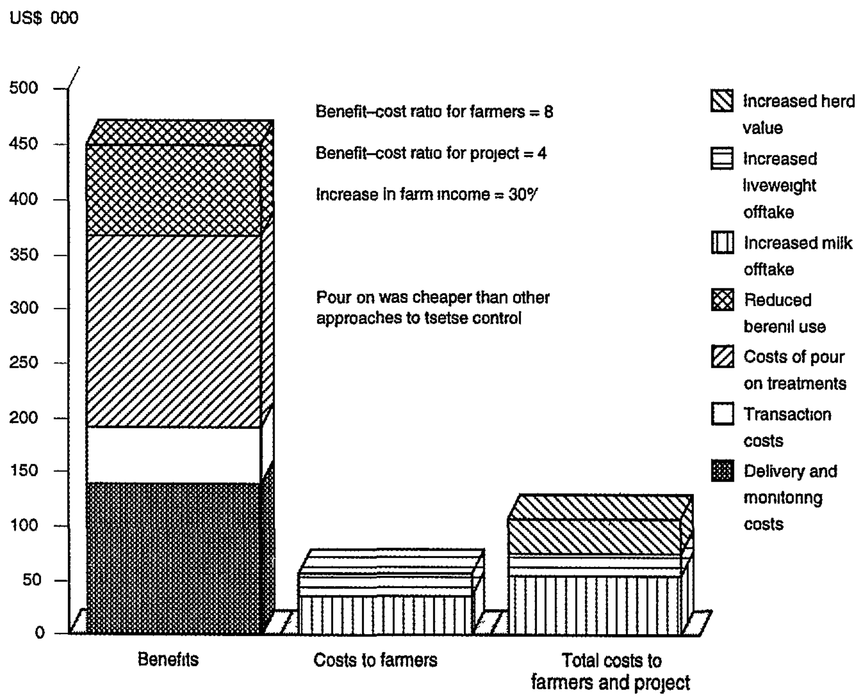
Another feature of the environment in the Ghibe valley is that the predominant vegetation type is not what would be expected from environmental parameters such as rainfall While the area is suited to forest or bush savannah, the land is primarily under grass, with the occasional acacia tree, tree canopy cover is only 6%, compared with 90–100% in a forest It seems likely that the environment has already been substantially altered by human intervention, probably through frequent burning

ILRI's initial research in the Ghibe valley showed a high prevalence of trypanosomosis infections in cattle and a high degree of parasite resistance to all available trypanocidal drugs An alternative to drug treatment was thus needed and ILRI researchers and their collaborators started a programme to control the tsetse flies that transmit the trypanosome parasites

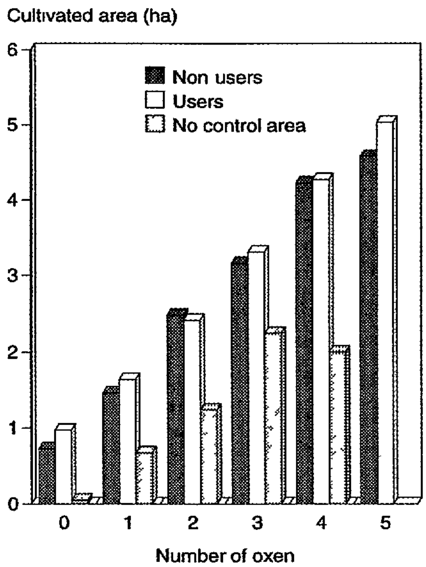
Tsetse control trials were started in parts of the Ghibe valley in 1991 Control methods focused on using insecticide impregnated screens and insecticides applied to animals—pour-ons—to reduce the tsetse populations and keep them at low levels The pour-on trial was particularly successful and popular with farmers The tsetse population is now at only 10% of its pre-control level and the incidence of trypanosomosis has fallen by a similar amount in the control area Farmers perceive that the sustained use of the pour-on reduces trypanosomosis incidence and the problems associated with tsetse flies, other biting flies and ticks Individual farmers have been paying for the treatments, on a cost-recovery basis, since December 1992 Each month between 1000 and 6000 cattle are treated at a cost to the farmers of between US$ 500 and US$ 3000

This sustained control of trypanosomosis has had marked effects on agricultural production and human welfare in the area ILRI's economists have quantified the value of the increased herd growth, increased offtake of live cattle, increased offtake of milk and reduced use of trypanocidal drugs They have estimated that benefits have exceeded the costs borne by farmers by about 800% and have exceeded the total costs to farmers and the project by about 425%

In addition, farmers in the area where the tsetse population has been controlled keep more oxen



The benefits of tsetse control far outweighed the costs over the first five years of a project in the Ghibe valley, south-western Ethiopia

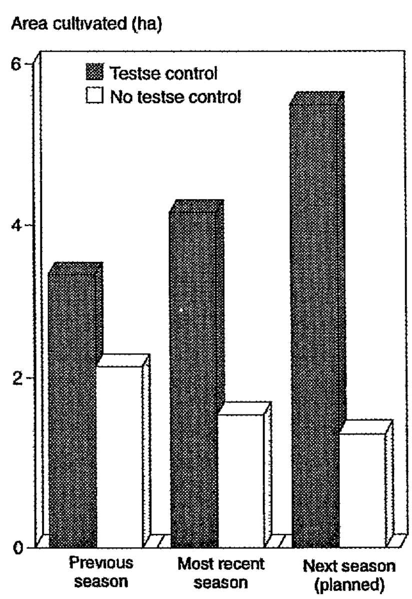


Farmers in an area where the tsetse population has been reduced keep more oxen than farmers in an adjacent area where the fly has not been controlled Moreover, oxen in the tsetse-control area are more productive than those where the fly has not been controlled

than those in an adjacent area where the tsetse population has not been controlled Moreover, the oxen in the tsetse-control area are more productive—each additional ox kept adds nearly a hectare to the amount of land the farmer cultivates in the tsetse-control area, compared with just over half a hectare where tsetse population has not been controlled And because farmers tend to keep more animals where tsetse have been controlled, those without any oxen of their own are able to borrow oxen from their neighbours and cultivate some land with oxen power In the nearby tsetse-infested area, farmers with no oxen of their own cultivate only by hand—a laborious, back-breaking exercise Numerous farmers in group interviews noted that farmers who cultivate by hand tend to cultivate land that has lighter soils, often on slopes, because it is easier to work by hand—but this land is more vulnerable to degradation and erosion than the heavier clayey soils of the valley bottoms Thus, ox-powered cultivation may be helping prevent soil erosion

The overall effect of this on crop production is marked Farmers in the tsetse-control area crop more than two and a half times as much land as those in the neighbouring tsetse-infested area Significantly, they also indicate that they have increased the amount of land they cropped from the previous season and intend to increase more in the future The effects of increasing the productivity of work oxen will not always be the same as this If, for example, the amount of cultivable land were limited for all households, the average household in the tsetse-control area would need one less ox to cultivate the same amount of land as a household in the tsetse-infested area If, on the other hand, there were no other constraint on the amount of land a household could cultivate, a household with a given number of oxen in the tsetse-control area could cultivate about twice as much land as a household with the same number of oxen in the tsetse-infested area

Farmers in the tsetse-control area crop more land than those in areas where the fly has not been controlled

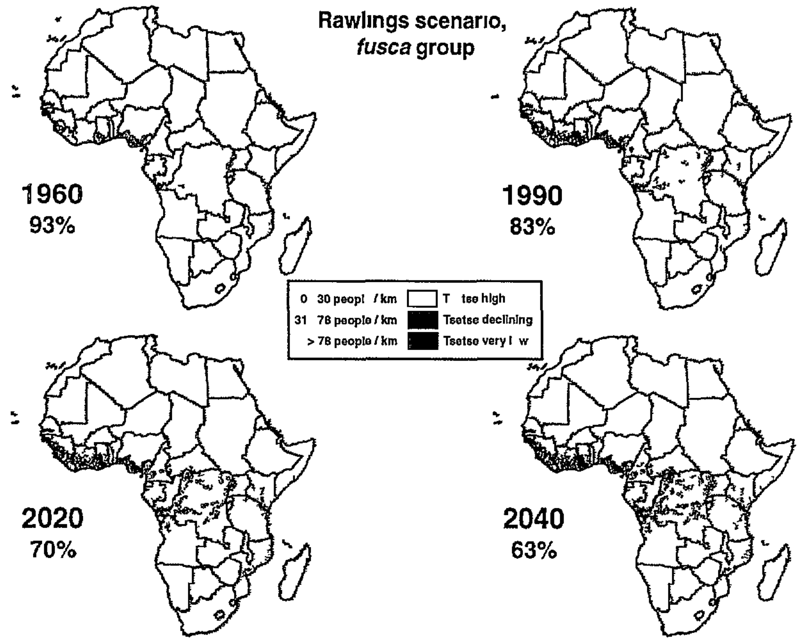


Apart from the direct effects of trypanosomosis, the risk of trypanosomosis also influences farmers' behaviour For example, in Ghibe, farmers in the tsetse-control area bought three and a half times as many cattle in a year and had sale and slaughter rates four times as high as farmers in the tsetse-infested area

In a second area, where tsetse control efforts started in 1994, farmers are already reporting subjective benefits such as their animals looking healthier and being easier to manage although no measurable increases in productivity have yet been found Interestingly, however, there has been no measurable change in tsetse population so far

Projecting future changes

Direct control methods such as insecticide use are not the only mechanisms that affect tsetse populations and hence trypanosomosis incidence Changes in land use, particularly increasing cultivation, and reductions in wild animal populations—food sources for the tsetse flies and reservoirs of trypanosome infection—combine to reduce fly numbers and disease incidence Indeed, clearing bush and reducing wild life populations have both been used extensively in Africa to reduce tsetse infestation Some people have argued that human



Areas infested by the tsetse fly are shrinking but the fly will be with us for many years to come

population growth will eventually control the tsetse fly without additional intervention from control programmes

During 1997, ILRI scientists examined this hypothesis using a geographic information system-based approach The first step was to survey the literature and determine the levels of land-use intensity and human population density at which tsetse populations begin to decline and then disappear They then developed several human population scenarios showing likely levels of human population in 2020 and 2040 These data layers were then overlaid with the distribution of each group of tsetse flies *(morsitans, fusca* and *palpalis)* and areas where tsetse populations may decline were identified

In 1960, 85–95% of the land area in Africa suited to tsetse flies of the *morsitans* group supported healthy fly populations The ILRI study suggests that this will decrease to 50–60% of the originally infested area by 2040—a significant drop but far from the hypothesised total disappearance of the fly The study indicates similar falls in *fusca*-group tsetse flies However, the literature indicates that the population of *palpalis* group tsetse flies is essentially unaffected by changes in human population and hence will change little, if at all

The biggest change indicated by the study is in the proportion of people living in areas with high tsetse populations In 1960 about 25–40% of people in 'fly zones' lived in scattered settlements where tsetse populations were likely to be high By 2040 less than 6% of people are likely to live where fly populations are high

Overall, the study suggests that human population growth will control all species of tsetse fly over about 7% of their current distribution by 2040 Thus, barring the development of a strategic solution, such as a vaccine, trypanosomosis will be widespread in Africa for some time to come However, trypanosomosis risk may fall considerably across a larger area, because the tsetse group that is most susceptible to the effects of human population (the *morsitans* group) is the most efficient of the groups at transmitting trypanosomosis to people and livestock Thus, most of the people and livestock in contact with the fly will be under low to moderate challenge, rather than high challenge 'Partial' disease control measures such as drugs and keeping trypanotolerant livestock are more effective under low to moderate challenge than under high challenge

This latest use of geographic information systems technology complements knowledge derived from a study of where tsetse control would have the greatest benefits to agricultural production and human populations while having least impact on unspoilt environments (see *ILRI 1996 Out of Africa, into a global mandate*)

Building on knowledge

ILRI's research in trypanosomosis addresses all aspects of the disease and its effects, from the environment through to people's lives These studies build on years of knowledge and data gained by ILRI in all aspects of trypanosomosis Bringing together research from across Africa and building on data gathered from a variety of sources, ILRI's research in the field of trypanosomosis is unique and invaluable

ILRI in Latin America

The Latin America and Caribbean region (LAC) is vast, complex and well endowed with natural resources However, it is also a region characterised by high population growth rate, poverty, income disparity and increasing natural resource degradation LAC is home to more than a third of the developing world's cattle and one-seventh of its sheep but only about one-twentieth of its goats This is a new region for ILRI, as the institute moves to fulfil its global mandate, one in which ILRI has as much to learn as to contribute

The first step in planning ILRI's activities in LAC was a regional consultation organised by the Inter-American Institute for Cooperation in Agriculture (IICA), Costa Rica, the International Development Research Centre (IDRC), Canada, and ILRI The meeting was held in San Jose, Costa Rica, in 1995 Participants identified two high-priority ecoregions the high Andes and the tropical hillsides and lowlands

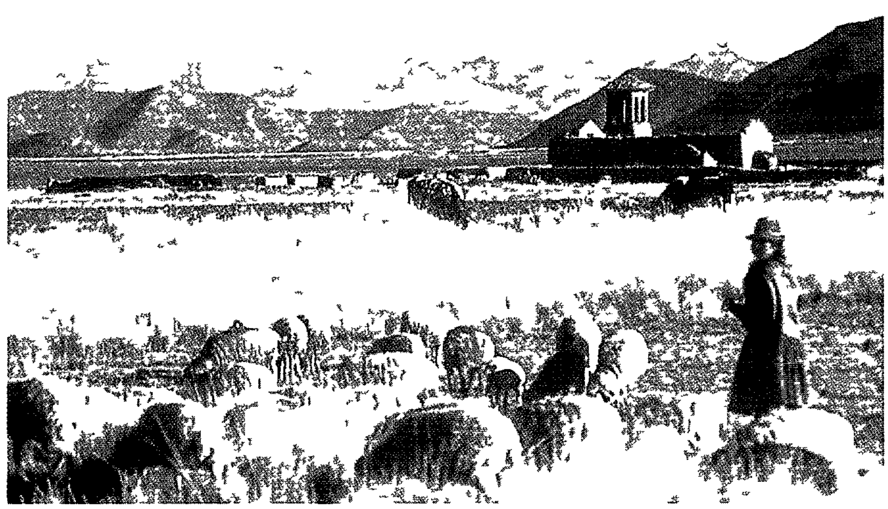
In its initial steps into this new region, ILRI has chosen to associate itself with two successful research and development consortia that have been running in the region for several years These are Tropileche, a consortium of national programmes and advanced research institutes led by the International Center for Tropical Agriculture (CIAT) in Colombia, and CONDESAN, a broader consortium led by the International Potato Center, CIP, in Peru Tropileche focuses on improving smallholder dairy systems in the hillsides of Central America and the forest margins of the Amazon basin, while CONDESAN focuses on mixed crop–livestock farming systems and dairy systems in the high Andes

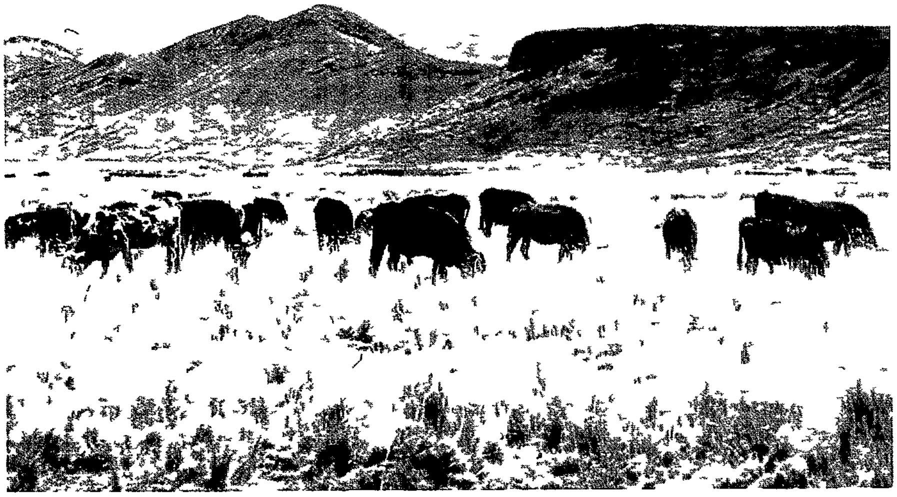
This article focuses on ILRI's involvement in the Andean ecoregion

From sustainable agriculture to degradation and emigration

The Andean ecoregion covers about two million square kilometres in South America, including large parts of Bolivia, Colombia, Ecuador, Peru and Venezuela, and parts of Argentina and Chile It is home to more than 135 million people, most of whom depend on agriculture for their livelihood It is a harsh region, characterised by high altitude and generally low temperatures

This region was home to a flourishing and sophisticated civilisation that lasted until after the Spanish colonisation in the sixteenth century The indigenous cul-





ture had developed highly productive and sustainable agricultural systems, based on efficient soil and water management and integration of crops and livestock However, increasing human population has increased the demand for land and food The traditional production systems have broken down or been forgotten and the region's natural resources are degrading Soil erosion is severe throughout much of the region

Faced with increasing population pressure, the harsh environment and the low productivity of the region's agriculture, many people have migrated from the Andes to neighbouring regions, particularly major urban centres and the humid and subhumid tropical lowlands There, they contribute to the destruction of the Amazon rain forest in their search for land to crop

Thus, the problems of the Andean region are intimately linked with the problems facing much of South America Boosting the productivity of the highland farming systems will have far-reaching economic, social and environmental effects throughout the region

Consortium for the Sustainable Development of the Andean Ecoregion

CONDESAN, the Consortium for the Sustainable Development of the Andean Ecoregion, was set up in March 1992 following a meeting of agriculturalists, social scientists and natural resource management specialists at CIP It currently has more than 60 member organisations, including research and development institutes from Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela, the Inter-American Institute for Cooperation in Agriculture (IICA) in Costa Rica and Cornell University in the USA It is funded by several donors including the Swiss Development Co-operation (SDC), IDRC, the Inter-American Development Bank (IDB), the Directorate General for International Cooperation (DGIS), The Netherlands, Spain, the United States Agency for International Development Collaborative Research Support Program (USAID-CRSP), the European Development Fund (EDF) and several national partners ILRI joined CONDESAN in 1997 and now has a staff member based at CIP

The consortium's research is focused in four main areas biodiversity, water and land use, production systems and analysis of development policies ILRI brings to CONDESAN its experience in integrated crop–livestock systems and in livestock policy analysis On the other hand CONDESAN offers ILRI the opportunity to build on substantial experience in systems research, including the use of computer simulation models to integrate information on livestock and mixed systems, and water sheds Possibilities for transregional analysis and collaboration among different highland ecoregions in the Andes, Himalayas and the African highlands are also being explored

CONDESAN is currently carrying out field research at five bench mark sites, one each in Bolivia, Colombia and Ecuador and two in Peru The sites represent a range of agro ecological zones and agricultural systems found extensively throughout the Andean region Puno (Peru) and Patacamaya (Bolivia) are on the Andean plateau at nearly 4000 metres above sea level, a zone known as the Altiplano The common farming systems at these sites are Alpacas grazed on natural pasture together with bitter potatoes, dairy cattle fed on cultivated and natural pastures with potatoes–barley–oats and quinoa, beef cattle and sheep on natural pastures, and potatoes–barley–pulses together with dairying

Carchi (Ecuador), Cajamarca (Peru) and La Miel (Colombia) are in humid and subhumid valleys between the Andean ranges at about 2700 metres above sea level The main livestock system is dairying on cultivated grasses and legumes, while the main crops are potatoes, barley and legumes

Livestock feature in some 70% of Andean smallholder farming systems, and 80% of livestock products are sold In contrast, crops are almost entirely consumed within the households Livestock thus provide the main source of income in most of these subsistence-oriented farming systems, and hence have a strong influence on income and capitalisation as well as traction and nutrient cycling

Key issues constraining intensification of livestock production in some systems include poor access to markets, lack of access to credit and small herd and flock sizes ILRI research is now addressing these at the five CONDESAN sites and Chimborazo (Ecuador) Complementary activities are being carried out in the tropical hillsides and central highlands This work involves partners in national agricultural research institutes, non-governmental organisations, the private sector and universities

ILRI's partners in livestock-related research include the Instituto Nacional de Investigaciones Agropecuarias (INIAP) and Fundacion para el Desarrollo Agropecuario (FUNDAGRO) in Ecuador, Centro de Investigacion de Recuros Naturales y Medio Ambiente (CIRNMA), Universidad Tecnica de Cajamarca, Universidad Nacional Agraria de La Molina, INCALAC (Nestlé) and Universidad Alcides Carrion in Peru, Universidad de Caldas in Colombia, and Instituto Boliviano de Tecnologia Agropecuaria (IBTA) in Bolivia

Ex ante assessments indicate that farmers need at least five or six appropriately fed milking cows if dairying is to be biologically and economically sustainable A project aimed at promoting market-oriented smallholder dairying is now providing credit to selected farmers to establish or expand perennial and annual forage crops to provide supplementary feeding during the dry season and hence boost milk offtake The credit is operated as a revolving fund—as farmers reimburse the project other farmers are given access to credit

These studies will provide bases for policy recommendations, leading to credit and extension policies that will help promote sustainable animal production in the Andean region

ILRI/CONDESAN is planning to co-ordinate its activities with those of two consortia operating in adjacent ecosystems, Tropileche and CODESU (Consortium for Sus tainable Development of Ucayali, Peru) This will provide a more holistic understanding of socio-economic alternatives for farmers who migrate from one region to another, and will help determine comparative advantages for milk production in the highlands and lowland humid tropics It will also promote exchange of research methods with other ILRI projects, including the use of computer simulation models for *ex ante* assessments of the likely impact of interventions

Great oaks from little acorns grow

These are just the beginnings for ILRI's involvement in the Latin America and Caribbean region, but should provide a strong foundation on which to build ILRI's strengths in livestock policy analysis, animal health, genetics and feed resources offer wide scope for the institute to contribute to developing more productive, sustainable crop–livestock systems in this region

Balancing human needs, livestock and the environment

The way some people talk about the effects of livestock on the environment, it sounds as if livestock themselves decide whether or not to destroy our environment But the fact is, livestock do not degrade the environment—people do

The misperception of livestock as degraders of the environment originates largely in the developed world, where intensive specialised livestock production is the norm Livestock are blamed for a wide range of human ills, from heart disease through to global warming Studies in developing countries have shown that children who do not get enough meat and milk in their diets may end up physically and mentally compromised Animal manure and urine that people in the developed world see as pollutants are vital fertilisers to smallholder farmers in the developing world

In some cases, the misperceptions have led to policies that have exacerbated the negative effects of livestock rather than alleviating them For example, the misperceptions regarding overgrazing in the arid areas have led to measures to control livestock movement and stocking rates, thereby causing more, rather than less, land degradation A better understanding of the complementarity of domesticated and wild animals would have led to greater species wealth and improved well being of local human populations

But finding out what is really known about livestock and their effects on the environment in the developing world and canvassing the opinions, on this topic, of people in the developing world is difficult, time consuming and expensive

In an effort to address these issues, ILRI, the International Development Research Centre (IDRC), the Food and Agriculture Organization of the United Nations (FAO), INFORUM (The Center for Sustainable Agriculture) and the World Bank organised a global consultation on interactions between livestock and the environment This built on an earlier study, entitled 'Balancing Livestock, Environment and Human Needs', carried out by FAO, the United States Agency for International

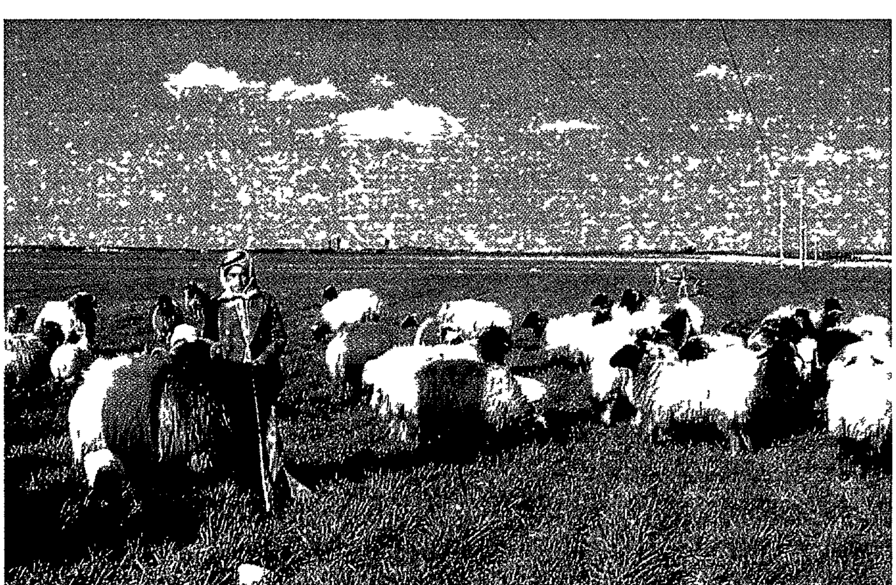
Development (USAID) and the World Bank A key objective was to present the conclusions of the earlier study to a wide range of stake-holders, particularly from developing countries, giving them the opportunity to have their views presented in a global forum

A global electronic conference and more

The consultation comprised an electronic conference involving more than 1000 people from 86 countries around the world, together with local round-table meetings in 27 developing countries The local consultations involved a wide range of stakeholders, including livestock farmers, farmers' groups, government officials and policy makers, teachers, NGO representatives, agricultural and social scientists, environmentalists, extension agents and industrialists Reports from some of the local consultations were shared with participants in the electronic conference The combined consultation provided information on the state of the environment in different parts of the world, some of the forces that lead to pressure on natural resources and the response of society to environmental degradation

An important outcome was the development of specific recommendations for future research and development activities Needs identified by the consultation included development of sustainable agricultural systems for different ecoregions of the world, more holistic approaches toward research and development, and policy recommendations based on broad stakeholder participation

Reports presented to the consultation showed that deforestation, soil erosion, reduced soil fertility, loss of biodiversity, water contamination, waste disposal and greenhouse gas emissions are recognised environmental problems in many regions They also showed broad agreement as to the forces driving environmental degradation increasing human population pressure, micro- and macro-economic policies, cultural values, poverty, communal land tenure, lack of appropriate technology to harmonise production with resource conservation, lack of awareness of the interactions among livestock, the environment and human needs, lack of infrastructure to facilitate marketing, and lack of involvement of local communities in their own development



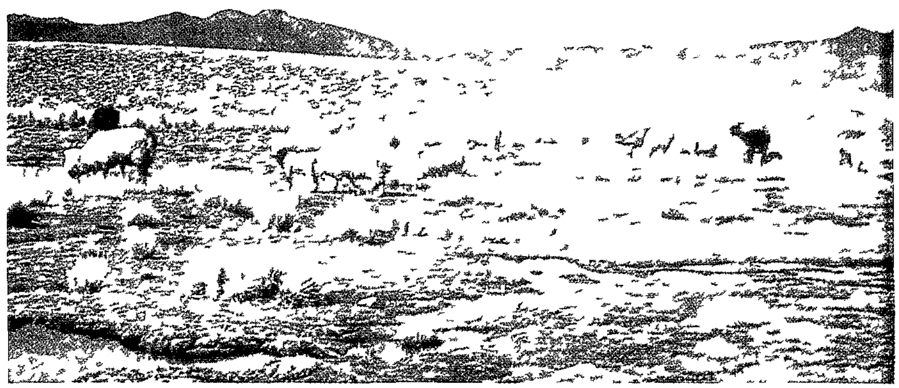
None of the participants in the local consultations explicitly described direct negative impacts of livestock on natural resources However, they did cite overgrazing, overstocking and feeding of crop residues to livestock without returning manure to the land as causes of environmental degradation, but without indicating how much of the observed environmental degradation can be attributed directly to livestock production

Again, while some participants stated that livestock have positive effects on the environment, such as the utilisation of grasslands and crop residues—giving value to resources that would otherwise be wasted—and the beneficial effects that grasslands have on the environment, including carbon sequestration—trapping carbon dioxide from the atmosphere, thus reducing levels of this 'greenhouse gas' —nutrient cycling and arresting soil erosion, they did not quantify them

Most reports indicated a lack of awareness among governments of livestock-related environmental issues Some trends are emerging, such as the creation of government environmental bodies, environmental NGOs and the inclusion of environmental concerns in policy formulation However, there is still too little scientific data to inform policy makers, compounded by the lack of effective interaction between scientists and policy makers

Poor management, not livestock, degrades the environment

The consultations clearly demonstrated that much land degradation and environmental damage that is associated with livestock production is mainly due to population pressure coupled with inappropriate livestock management practices and policies



Key issues raised

Livestock related environmental problems differ markedly between the developed and the developing worlds, a point stressed by the contributions to the consultation

In developing countries, most environmental problems are related to poverty and policies Any at tempt to minimise the impact of livestock on the environment is bound to fail if farmers do not have better economic alternatives Solutions need to try not only to protect the environment but also to encourage more lucrative ways of managing livestock

In contrast, livestock-related environmental problems in developed countries can be solved by tougher enforceable legislation that makes livestock producers pay for any harm their activities do to the environment

The discussion brought out the need for holistic research to better quantify the biophysical and socio-economic interactions of livestock, the environment and human needs As demand for livestock products continues to increase in developing countries, finding the appropriate balance is still an issue In particular, research is needed to quantify the effects of system intensification in developing countries and system extensification or area-wide integration of crop–livestock systems in developed countries

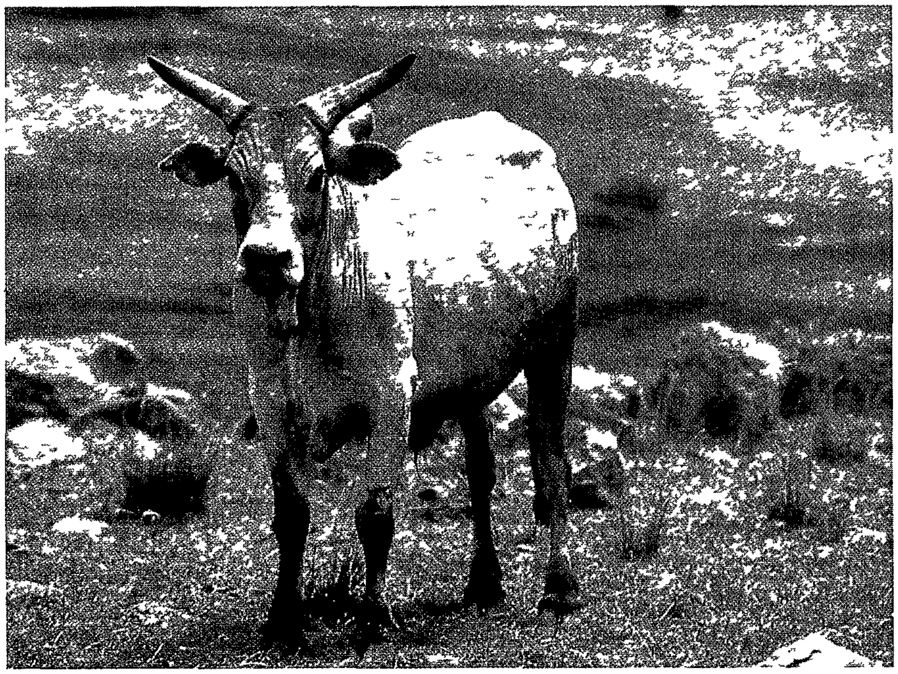
The consultations highlighted several constraints to addressing issues of livestock, the environment and human needs, including

- paucity of information on livestock, agriculture and the environment
- lack of a holistic approach in most of the research dealing with livestock–environment interactions and lack of appropriate indicators of these interactions
- lack of involvement of scientists in the development of policies relating to livestock and the environment
- inconsistent goals of farmers, scientists and policy makers
- lack of use of quantitative data for policy formulation

Lessons learned

The dual nature of the global consultation—electronic and local round-table discussions—proved invaluable in broadening the partici pation of stakeholder groups Participation in the electronic conference was heavily biased towards people based in the developed world, with two-thirds of participants being based in North America and Europe, albeit with a strong interest in the developing world Only 11% of participants were from Africa, the Near East and Asia There was also a strong bias towards scientists (94% of participants), particularly livestock scien tists (45%) This tended to 'skew' the discussions In contrast, partici pation on the round-table disc ussions was much broader, with much greater participation by people at the development, extension or producer levels These face-to-face consultations also, inevitably, drew their participation from those active in the countries where they were held, increasing involvement of those from the developing world

However, integrating the two 'streams' proved difficult given the timing of the consultation and the object of preparing a position paper for a conference held in The Netherlands in July 1997 The original intention was to have a two-way flow of information between the electronic and round table com-



ponents and to have a unified debate of both global and local issues While this proved unworkable, the two components of the consultation provided useful sets of conclusions and recommendations with which to work

Another key lesson learned was that of the need for a well-defined set of issues to be discussed and more active involvement of a moderator to promote full discussion of relevant issues 'We found that once an issue was raised, several people would acknowledge its importance but attention soon moved onto another issue,' said Dr Victor Mares, one of the organisers of the consultation 'This resulted in only superficial treatment of some issues' Similarly, several key issues were not raised by participants and hence did not get discussed Such issues included the importance of women in livestock systems, the role of pastures and grasslands in carbon sequestration, soil protection, water cycling and maintaining soil microfauna populations, the interaction between ecoregions (e g effects on the Amazon region of economic, political and natural resource management in the Andean region), and the consequences of land clearing methods on soil degradation in ranching systems Operating the global con sultation more as a moderated discussion forum might have ensured that the most important topics received the attention needed and that a broader range of issues was raised

The next steps

People around the world recognise the need to balance human needs with protecting the environment Unfortunately, the role, and potential role, of livestock in achieving this balance is poorly understood ILRI needs to play a leading role not only in promoting research into the role of livestock in balancing human and environmental needs but also in informing stakeholders of its findings Policy makers around the world need research-based information on which to build policies that will promote human welfare while protecting the environment for future generations Building on a wealth of experience in environmental and policy research, ILRI and its partners are focusing their efforts on providing such information

ILRI programme areas in 1997

Biosciences Programme

Ruminant genetics

Characterisation, conservation and use of animal genetic resources

Development of disease-resistant livestock

Ruminant health

Molecular basis of pathogenesis and disease resistance

Immunology and vaccine development

Improving livestock productivity through development of subunit vaccines

Development and application of diagnostic tools in disease control and surveillance

Epidemiology and disease control

Ruminant feed resources

Feed improvement for improving livestock productivity

Rumen microbiology for feed utilisation enhancement

Characterisation and conservation of forage genetic resources

Sustainable Production Systems Programme

Systems analysis and impact assessment

Increasing returns to livestock research through systems analysis and impact assessment

Livestock policy analysis

Policy analysis for improving productivity and sustainability of crop–livestock systems

Crop–livestock systems research

Improving productivity and sustainability of crop–livestock systems in the highlands of sub-Saharan Africa and Asia

Improving productivity and sustainability of crop–livestock systems in subhumid sub-Saharan Africa and Asia

Improving productivity and sustainability of crop–livestock systems in semi-arid sub-Saharan Africa and Asia

Improving productivity and sustainability of crop–livestock systems in fragile environments in the Latin America and Caribbean region

Improving productivity and sustainability of crop–livestock systems in West Asia and North Africa

Improving livestock productivity under disease risk

Improving productivity and sustainability of market-oriented smallholder dairy systems

System-wide livestock programme

Strengthening Partnerships with National Agricultural Research Systems Programme

Training and information services

Collaborative research networks

ILRI senior staff in 1997

Directorate General

Hank Fitzhugh, *Director General*
Hugh Murphy, *Director of Administration*
Ralph von Kaufmann, *Director for External Relations*
Margaret Morehouse,† *Human Resources Manager*
Gerard O'Donoghue, *Chief Financial Officer*
Helen Leitch,† *Proposal Development Specialist*
Susan MacMillan, *Public Awareness Specialist*

Biosciences Programme

Programme Director Anthony Irvin

Improvement and Application of Existing Disease Control Technologies

Kenya

Alfred Adema,* *research technologist*
Carol Agufa,* *research technologist*
Sonal Barot,† *research technologist*
Richard Bishop, *molecular parasitologist*
Mark Eisler,[1] *epidemiologist*
Newton Gitire, *research technologist*
Joel Imanye, *technical assistant*
John Kabata, *research technologist*
Alfred Kafwa, *technical assistant*
Noah Karanja, *technical assistant*
Fredrick Karia, *research technologist*
Joseph Katende, *microbiologist*
Sammy Kemei, *research technologist*
Juma Kiundi, *research technologist*
Nelson Kuria, *research technologist*
Stephen Leak, *epidemiologist*
Clement Lugonzo, *research technologist*
Humphrey Lwamba, *research technologist*
Mary Maina, *research technologist*
Phelix Majiwa, *molecular parasitologist*
Jackson Makau, *research technologist*
Rachael Masake, *immunologist*
Peter Mburu, *technical assistant*
Stephen Minja,* *diagnostician*
Deen Moloo, *entomologist*
Subhash Morzaria, *molecular parasitologist*
Joseph Muia, *technical assistant*
Stephen Mwaura, *research technologist*
Reeves Njamunggeh, *research technologist*
George Njihia, *research technologist*

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[1] Salary provided by the UK, Department for International Development (DFID) and the University of Glasgow, and the European Community
Left in 1997
† Joined in 1997

Thomas Njoroge, *research technologist*
Stephen Njuguna, *research technologist*
Joseph Odhiambo, *research technologist*
David Odongo,† *research technologist*
George Oduol, *research technologist*
Ignatius Okumu, *research technologist*
Maurice Owino, *technical assistant*
David Parkin,[2]* *biochemist*
Andrew Peregrine,* *parasitologist*
Rob Skilton, *biologist*
John Tangus, *technical assistant*
Parineete Thathy,* *research technologist*
James Thuo, *research technologist*
Alfred Tonui, *research technologist*
Mary Waithaka, *research technologist*
Delia Wasawo, *research technologist*
Stephen Wasike,* *research technologist*
Jon Wilkes, *cell membrane physiologist*

Development of New Disease Control Technologies

Kenya

Edith Authie,[3] *immunologist*
Keith Ballingall, *molecular immunologist*
Alain Boulange, *visiting immunologist*
Elizabeth Carpenter, *cellular immunologist*
Francis Chuma, *research technologist*
Lynne Elson,† *parasitologist*
Joseph Gesharisha, *technical assistant*
Benson Gichuki, *research technologist*
Lucy Gichuru, *research technologist*
Elke Gobright,* *research associate*
Yoshikazu Honda, *virologist*
Dismus Lugo, *research technologist*
Vittoria Lutje,* *post doctoral scientist, cellular immunologist*
Anthony Luyai, *research technologist*
Niall MacHugh, *cellular immunologist*
John Maloba, *technical assistant*
Guy Mareels,[4]* *peptide biologist*
Yutaka Matsubara,[5]* *pathologist*
John Mburu, *research technologist*
Ferdinand Mbwika, *research technologist*
Declan McKeever, *immunologist*
Francis McOdimba, *research technologist*
Bea Mertens,[6] *immunologist*
Paul Muiya, *research technologist*
Cecilia Muruiki, *research technologist*
Noel Murphy, *molecular geneticist*
Tony Musoke, *immunologist*
David Muteti, *research technologist*
Anthony Muthiani, *research technologist*
Duncan Mwangi,[7] *cellular immunologist*
Waithaka Mwangi,* *research technologist*
Jan Naessens,[8] *immunologist*
David Ndegwa, *research technologist*
Vish Nene, *molecular biologist*
Daniel Ngugi, *research technologist*
James Ngugi, *research technologist*
Catherine Nkonge, *immunologist*
Joseph Nthale, *research technologist*
John Nyanjui, *research technologist*
Tom Olyhoek, *biologist*
Elias Owino, *research technologist*
Pratibala Pandit, *research technologist*
Roger Pelle, *geneticist*
Mara Rocchi, *biotechnologist*
Rosemary Saya, *research technologist*
Baljinder Sohanpal, *research technologist*
Paul Spooner, *microbiologist*
Evans Taracha, *immunologist*
Kathy Taylor, *cellular immunologist*
John Wando, *research technologist*
Stephen Wanyonyi, *research technologist*

Genetics of Disease Resistance

Kenya

Eric Aduda, *research assistant*
James Audho, *technical assistant*
Leyden Baker, *quantitative geneticist*
Henry Gathuo, *research technologist*
Olivier Hanotte, *animal geneticist*
Fuadi Iraqi, *molecular geneticist*
Alice Njeri Maina, *research technologist*
Joel Mwakaya, *research technologist*
Moses Ogugo, *research technologist*
Manassey Omenya, *research technologist*

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[2] Salary provided by the USA, National Institutes of Health
[3] Salary provided by France, CIRAD EMVT Centre de cooperation internationale en recherche agronomique pour le developpement-Elevage at medicine veterinaire des Pays Tropicaux (Centre for International Cooperation in Agronomic Research and Development-Animal Husbandry and Veterinary Medicine in Tropical Countries)
[4] Salary provided by Belgium, VVOB Vlaamse Vereniging Voor Ontwikkelingssamenwerking en Technische Bijstand
[5] Salary provided by JIRCAS Japan International Research for Agricultural Sciences
[6] Salary provided by Belgium
[7] Salary provided by the USA, USAID (United States Agency for International Development) and the University of Florida
[8] Salary provided by Belgium
* Left in 1997
† Joined in 1997

Japeth Sore, *research technologist*
Alan Teale, *molecular geneticist*
Yasmin Verjee,* *research technologist*
John Wambugu, *research technologist*

Ethiopia

Saidou Tembely,* *associate scientist, veterinary parasitologist*

Programme Support

Kenya

Chris Hinson, *laboratory manager*
David Kennedy, *veterinarian*
Bob King, *head of experimental animal units*
James Magondu, *head of fluorescence-activated cell sorter services*
Francis Mucheru, *research technologist, flourescence-activated cell sorter services*
Sonal Nagda, *data analyst*
Christopher Ogomo, *research technologist, electron microscopy services*
John Rowlands, *biometrician*
Clive Wells, *head of electron microscopy services*

Production Systems Programme

Programme Director Hugo Li Pun

Animal/Forage Genetic Resources

Ethiopia

Asebe Abdena, *research technologist*
Dawit Gezahegn,* *research technologist*
Girma Abebe, *research technologist*
Girma Gebre Mariam, *research technologist*
Jean Hanson, *genetic resources specialist*
Jemal Mohammed, *research technologist*
Kahsay Berhe, *research technologist*
Lemma Mekonnen, *technical assistant*
Brigitte Mass,† *geneticist*
Mesfin Shibre,* *research technologist*
Eddie Mukasa-Mugerwa, *veterinarian*
Edward Rege, *animal breeder*
Temeselew Mamo, *laboratory technician*
Mark van de Wouw,* *associate scientist*

Epidemiology and Disease Control

Kenya

Luc Duchateu,[9]* *statistician and modeller*
Onesmus Maina, *research technologist*
John McDermott, *epidemiologist*
Bruno Minjauw,† *epidemiologist*
Brian Perry, *epidemiologist*

Systems Analysis and Impact Assessment

Kenya

Mohamed Baya, *research technologist*
Elamin Elbasha,* *agricultural economist*
Russ Kruska, *geographic information systems specialist*
Onesmus Maina, *research technologist*
Andrian Mukhebi,* *agricultural economist*
Andrew Odero, *research technologist*
Onyango Okello, *research technologist*
Robin Reid, *ecologist*
Emmanuel Tambi,[10] *agricultural economist*
Philip Thornton, *systems analysist*
Elizabeth Wangui, *research technologist*

Ethiopia

Negussie T/Michael,* *senior research technologist*
Tesfaye Legesse, *research technologist*
Woudyalew Mulatu, *project supervisor*

Improving Livestock Productivity Under Disease Risk

Kenya

Guy d'Ieteren, *animal scientist*
Brent Swallow, *agricultural economist*
Winnie Luseno, *research technologist*
Nancy McCarthy, *agricultural economist*

Improving Productivity and Sustainability for Smallholder Dairy Systems Smallholder Dairying

Kenya

Matthew Kenyanjui, *research technologist*
Liston Njoroge,† *research technologist*
David Njubi, *senior computer programmer*
Amos Omore, *research officer*
Steve Staal, *agricultural economist*
Jon Tanner, *animal nutritionist*
William Thorpe, *animal scientist*

Ethiopia

Abebe Tessema, *research technologist*
Aberra Adie, *technical assistant*
Azage Tegegne, *research officer*
Victor Umunna, *animal scientist/station manager*

[9] Salary provided by Belgium, VVOB
[10] Salary provided by the European Union and facilitated by the Organization of African Unity
* Left in 1997
† Joined in 1997

Improving Productivity and Sustainability of Crop–Livestock Systems in the Highlands of Sub-Saharan Africa and Asia

Ethiopia

Abiye Astatke, *research officer*
Kahsai Berhane, *research technologist*
Mohamed Mohamed Saleem, *agronomist*
Mulugeta Mamo, *technical assistant*
Emmanuel Mwendera,* *post-doctoral associate*
Nigist Wagaye, *research technologist*
Wagnew Ayalneh, *senior research technologist*

India

Ercole Zerbini, *animal scientist*

Improving Productivity and Sustainability of Crop–Livestock Systems in Subhumid Sub-Saharan Africa and Asia

Nigeria

Kwaku Agyemang, *animal production scientist*
Asmoah Larbi, *forage agronomist*
Ibrahim Magagi, *animal scientist/research fellow*
Augustine Naazie,* *post doctoral scientist, animal breeding/genetics*
Jimmy Smith, *animal scientist*
Shirley Tarawali,[11] *agronomist*

Improving Productivity and Sustainability of Crop–Livestock Systems in LAC/WANA

Malaysia

Canagasaby Devendra,† *senior associate*

Peru

Carlos Leon-Velarde,[12†] *animal production scientist*

Colombia

Federico Holmann,[13†] *livestock scientist*

Improving Productivity and Sustainability of Crop–Livestock Systems in Semi-arid Zones of Sub-Saharan Africa and Asia

Niger (ICRISAT Sahelian Center)

Salvador Fernandez-Rivera, *animal scientist*
Pierre Hiernaux, *range ecologist*
Eva Schlecht, *post doctoral associate*
Timothy Williams, *agricultural economist*

Improving Productivity and Sustainability of Crop–Livestock Systems in Sub-Saharan Africa Livestock Productivity under Disease Risk

Burkina Faso

J B Mulumba Kamuanga, *agricultural economist*

Feed Improvement for Improving Livestock Productivity

Rumen Ecology

Ethiopia

David Anindo,* *animal scientist/station manager (Debre Berhan)*
Asfaw Yemegnuhal, *senior research technologist*
Dawit Negassa, *research technologist*
Genet Assefa, *research assistant*
Agnes Odenyo, *nutritionist*
Karanfil Olga, *research technologist*
Paschal Osuji, *nutritionist*
Eeva Saarisalo,[14†] *visiting associate scientist, animal scientist/nutritionist*

Policy Analysis for Improving Productivity and Sustainability of Crop–livestock Systems

Ethiopia

Abebe Misgina, *senior research technologist*
Guillaume Duteurtre,[15]* *research associate*
Simeon Ehui, *agricultural economist*
Gemechu Degefa, *research technologist*
Mohammed Jabbar, *agricultural economist*
Joan Kagwanja, *post-doctoral scientist*
Nega Gebreselassie, *research technologist*
Charles F Nicholson,* *social scientist (Rockefeller Foundation Social Sciences Fellow)*
Barry Shapiro, *agricultural economist*
Solomon G/Selassie, *research technologist*
Yishak Mengesha,* *senior research technologist*

Strengthening Partnerships with NARS

Programme Director Michael Smalley

Training and Conference

Kenya

Rob Eley, *education officer*

---

11 50% salary provided by IITA (International Institute of Tropical Agriculture)
12 50% salary provided by CIP (Centro Internacional de la Papa)
13 50% salary provided by CIAT (Centro Internacional de Agricultura Tropical)
14 Funds provided by the Ministry of Foreign Affairs of Finland
15 Salary provided by France CIRAD EMVT
* Left in 1997
† Joined in 1997

Ethiopia

Elizabeth Getachew, *assistant to the programme director*

Training Materials and Methods

Ethiopia

Mohammed El-Habib Ibrahim, *training materials specialist*

Information

Kenya

Damaris Ng'anga, *librarian*

Ethiopia

Azeb Abraham, *librarian*
Carl Erik Schou Larsen,* *research associate*
Marcos Sahlu,* *documentation supervisor*
Pramod Sinha,* *head of information services*

Publications

Kenya

Dave Elsworth, *head of graphics unit*
Peter Werehire, *publications assistant*

Ethiopia

Sourou Adoutan, *French translator/editor*
Paul Neate, *head of publications*
Anne Nyamu, *science writer/editor*
Tekleab H/Michael, *head of pre-print operations*
Wondwossen Girma, *head of printshop*

Networks

Kenya

Sahr Lebbie, *co-ordinator, Small Ruminant Research Network (SRNET)*
Jean Ndikumana, *co ordinator, African Feed Resources Research Network (AFRNET)*

Ethiopia

Ebenezer Olaloku,* *co-ordinator, Cattle Research Network (CARNET)*

Institutional Support

Administrative

Kenya

William Anyika,† *head of engineering*
Mike Craig,* *business manager*
George Kanza, *chief accountant – Nairobi/Addis*
David Kinyanjui, *chief security officer*
Faith Matee , *purchasing officer*
Gacheru Migwi, *chief personnel officer*
Charles Ndungi, *transport manager*
John Ngatti, *Stores Superintendent*
Onesmus Nthiwa, *chief accountant*
Janephar Owino, *housing officer*

Ethiopia

Ahmed Osman,* *assistant personnel officer*
Antonio Silla, *internal auditor*
Asmaru Ayele, *purchasing supervisor*
Asmelash Worede, *catering officer*
Assegid Alemu, *stores supervisor*
Belayhun Wondimu, *chief accountant*
Biscut Tessema, *disbursement and collection supervisor*
Dessalegn Mammo, *chief personnel officer*
Emmanuel Tesfamariam, *budget and procurement officer*
Michael Abebe, *medical officer*
Million Gebreab, *housing officer*
Negussie Abraham, *general accounts supervisor*
Revathi Rao, *manager, housing and catering services*
Chris Robinson, *laboratory manager*
Tadesse Minas,* *assistant personnel officer*
Aguibou Tall, *head of administration*
Tibebe G/Amlak, *national liaison officer*
Wubshet Dessie,† *senior liaison assistant*

Technical

Kenya

Sylvester Kisonzo, *computer software officer*
Jim Scott, *computing manager*
David Wanzala, *building and maintenance supervisor*

Ethiopia

Abeba Goitom, *research technologist*
Abraham Bekele,† *head of computer services*
Ali Mohammed, *research technologist*
Aynalem Tesfahun, *computer programmer*
Beyene Ambaye, *research technologist*
Mamadou Diedhiou, *biometrician*
Hambissa Belina, *computer programmer*
Girmaye Tamiru, *research technologist*
Franco Leone, *physical plant manager*
Mebrahtu Ogbai, *research technologist*
James Ochang,* *senior research technologist*
Solomon Tessema, *computer engineer*
Tekeste Gebre Wold, *laboratory technician*
Tenaye Serekeberhan,* *laboratory technician*
Yimer Ahmed, *laboratory technician*
Yohannes Yehualashet,* *project supervisor*
Zerihun Tadesse, *applied biometrician*

* Left in 1997
† Joined in 1997

Graduate Fellows at ILRI in 1997

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
ANIMAL HEALTH IMPROVEMENT					
Sam Alsford, British	Manchester	PhD	Mechanisms of chromosomal segregation in trypanosomes undergoing cell division	Kenya	1997
Aynalem Haile, Ethiopian	Alemaya	MSc	Breed and nutrition effect on the development of resistance to endoparasites in sheep	Ethiopia	1998
Isabelle Baltenweck, French	Auvergne	PhD	Patterns of intensification in smallholder dairying Spatial analysis of determinants of change	Kenya	1998
Belete Teferedegne, Ethiopian	Aberdeen	PhD	Influence of the foliage of multipurpose trees on rumen micro-organisms and rumen fermentation	Ethiopia	1999
Maira Bholla, Kenyan	Brunel	MPhil	Studies on the mating incompatibilities in populations of tsetse flies (*Glossina* spp)	Kenya	1998
Joram Buza, Tanzanian	Sokoine	PhD	B lymphocyte responses in trypanosome infected cattle	Kenya	1997
Robert Delve, British	Wye	PhD	Implications of livestock feeding management for long-term soil fertility in smallholder mixed farming systems	Kenya	1998
Aladji Diack, Senegalese	Brunel	MPhil	The effect of multiple treatment of cattle that harbour drug-resistant *Trypanosoma congolense* on the infectivity of the parasites for *Glossina morsitans centralis*	Kenya	1997
Appolinaire Djikeng, Cameroonian	Brunel	PhD	Expressed sequence tags of *Trypanosoma brucei rhodesiense* reagents for the derivation of a transcriptional map of the causative agent of human sleeping sickness	Kenya	1998
Ewnetu Ermias, Ethiopian	Alemaya	MSc	Prediction of body fat in fat tailed sheep using tritiated water, body and tail measurements and feed conversion efficiency	Ethiopia	1998
Dirk Geysen, Belgian	Brunel	PhD	*Theileria parva* diversity in eastern and southern provinces of Zambia based on molecular biology techniques	Kenya	1998
George Gitau, Kenyan	Nairobi	PhD	Quantitative assessment of the impacts of endemic stability and instability to tickborne diseases on dairy production in Murang'a District, Kenya	Kenya	1997
Jones Govereh, Zimbabwean	Michigan	PhD	The effects of tsetse control on resource management institutions in the mid Zambesi valley of Zimbabwe	Zimbabwe	1998
Erika Hamilton, American	Massachusetts	PhD	Analysis of factors controlling the trypanocidal activity of Cape Buffalo serum	Kenya	1997

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Rozmin Janoo, Kenyan	Brunel	PhD	Characterisation of GTPases regulating protein trafficking in *Theileria parva*	Kenya	1998
Victor Konde, Zambian	Brunel	PhD	Molecular genetic aspects of isometamedium resistance in *Trypanosoma (Nannomonas) congolense*	Kenya	1998
Delphin Koudande, Beninese	Wageningen	PhD	Opportunities for marker-assisted introgression of trypanotolerance in mice and cattle	Kenya	1998
Chris Laker, Ugandan	Makerere	PhD	Assessment of the economic impact of the bovine trypanosomiasis and its control in Mukono County, Uganda	Kenya	1998
Simon Lillico, British	Glasgow	PhD	Identification and characterisation of procyclic trypanosome genes displaying altered regulation during lectin-induced programmed cell death	Kenya	1998
Leah Ndungu, Kenyan	Pretoria	PhD	The socio economic, infrastructural and policy effects on the demand for, and delivery of, the p67 *T parva* vaccine in small scale, large scale and pastoralist zones of Kenya	Kenya	1999
Margaret Okomo, Kenyan	Nairobi	MSc	Characterisation of genetic diversity of East African cattle breeds using microsatellite markers	Kenya	1997
Deo Olila, Ugandan	Nairobi	PhD	Molecular epidemiology of trypanosomiasis with particular emphasis on drug-resistant phenotypes in Mukono District, Uganda	Kenya	1998
Kevin Oluoch, Kenyan	Nairobi	MSc	Identification of schizont genes located on sub telemeric fragments of the *Theileria parva* genome	Kenya	1997
Beatrice Ondondo, Kenyan	Nairobi	MSc	Interaction of trypanosome cyclophilin with parasite and host molecules	Kenya	1997
Alex Osanya, Kenyan	Brunel	PhD	Contribution to the characterisation of the *Trypanosoma brucei* genome Identification and characterisation of differentially expressed sequence tags	Kenya	1998
Deckster Savadye, Zimbabwean	Zimbabwe	PhD	Sequencing and mapping of *Theileria parva* schizont DNAs and the establishment of a sequence data base	Kenya	1999
Angela Scheer, German	Free U Berlin	PhD	Analysis of the drug sensitivity phenotypes of animal trypanosomes *in vitro* and *in vivo* to isometamidium chloride	Kenya	1997
Malenie deSouza, Kenyan	Nairobi	MSc	Analysis of two putative candidate genes for isometamidium resistance in *Trypanosoma congolense*	Kenya	1998
Pim van Hooft, Dutch	Wageningen	PhD	Development and variation of microsatellite markers in buffalo	Kenya	1997
Lilian Waibochi, Kenyan	Nairobi	MSc	Analysis of polymorphism in the gene encoding the bovine cd45 molecule	Kenya	1998
Jun Wang, Chinese	Massachusetts	PhD	Characterisation of a gene from African buffalo encoding a trypanocidal serum protein	Kenya	1997
Qin Wang, Chinese	Massachusetts	PhD	Analysis of factors controlling the trypanocidal activity of Cape Buffalo serum	Kenya	1997

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Tennyson Williams, Sierra Leonean	Sierra Leone	MSc	Estimating the potential market for new vaccines against theileriosis in eastern and southern Africa	Kenya	1997
PRODUCTION SYSTEMS					
Augustine Ayatunde, Nigerian	Wageningen	PhD	Livestock-mediated nutrient transfers in the semi arid West African landscape	Niger	1997
Alec Bishi, Zimbabwean	Berlin	MSc	Cross-sectional and longitudinal prospective study of clinical and subclinical bovine mastitis in peri urban and urban production systems in Addis Ababa and Debre Zeit	Ethiopia	1997
Wame Boitumelo, Botswanan	Guelph	PhD	Nutritive evaluation of forage legumes	Ethiopia	1999
Carol Cabal, Filipina	Hawaii	PhD	Integrated crop–livestock agricultural systems Impacts on household food security in the central Ethiopian highlands	Ethiopia	1998
Eneyew Negussie, Ethiopian	Technische Munchen	PhD	Characterisation of the indigenous Ethiopian sheep breed for feed intake and fat deposition as adaptive characteristics	Ethiopia	1997
Getachew Gebru, Ethiopian	Wisconsin	PhD	Assessment of feed resource base and the factors that affect access to feed resources in crop–livestock systems in the Ethiopian highlands	Ethiopia	1997
Sandrine Gravier, French	CIRAD/EMVT	MSc	The role of urban small scale dairy processors in the intensification process of peri urban dairy production in Addis Ababa	Ethiopia	1997
Patrick Irungu, Kenyan	Nairobi	MSc	Economic analysis of factors affecting adoption of Napier in high potential Kenyan dairying	Kenya	1997
Alexander Kahi, Kenyan	Hohenheim	PhD	Evaluation of alternative dairy cattle crossbreeding strategies	Kenya	1999
Robert Kaitho, Kenyan	Wageningen	PhD	Nutritive value of multipurpose trees and shrubs as protein supplements to poor quality roughages	Ethiopia	1997
Abdul Kamara, Sierra Leonean	Georg August	PhD	Property rights, risk and sustainable livestock development	Ethiopia	1999
Pokou Koffi, Ivorien	CIRES	PhD	Economic analysis of livestock production with tsetse control, multiple species and multiple breeds	Cote d'Ivoire	1997
Carl Larsen, Danish	DANIDA	PhD	Adoption of dairy–draught technology in a smallholder mixed crop–livestock farming system A case study from Ethiopia	Ethiopia	1998
John Lekasi, Kenyan	Coventry	PhD	Management of livestock excreta for enhanced nutrient cycling efficiency on intensive smallholder farms in the East and central African highlands	Kenya	1999
Mengistu Buta, Ethiopian	Alemaya	MSc	Crossbred cows for milk and traction in the Ethiopian highlands A whole farm evaluation	Ethiopia	1997
Minale Kassie, Ethiopian	Alemaya	MSc	Economics of crop–forage integration and nutrient management intervention in mixed farms in highland Ethiopia	Ethiopia	1997

Graduate Fellows (cont'd)

Name/ Nationality	University/ Institute	Degree	Project Title	Location	End Date
Denis Mpairwe, Ugandan	Makerere	PhD	Development of food/feed production and management options for smallholder dairy production systems	Ethiopia	1998
Constance Mugalla, Kenyan	Penn State	PhD	Livestock production in The Gambia and implications of trypanosomiasis control on the Gambian household	The Gambia	1998
David Mwangi, Kenyan	Wye	PhD	Factors affecting the growth and persistency of companion legumes for cut-and carry Napier grass	Kenya	1999
Gabriel Nakokonya, Kenyan	Bangor	PhD	Herd dynamics of smallholder dairy Assessment of breeding strategies and their implications for herd sustainability and breeding policy in the Kenyan highlands	Kenya	1999
Niftalem Dibessa, Ethiopian	Humboldt	PhD	Sheep production on smallholder farms in the Ethiopian highlands	Ethiopia	1997
Ben Okumu, Kenyan	Manchester	MSc	Ecological and socio-economic impact of using animal-drawn technology for vertisol management in the Ethiopian highlands	Ethiopia	1998
Sarah Ossiya, Ugandan	Texas A&M	PhD	Development of a nutritional profiling system for free-ranging livestock in major agro-ecological zones of sub-Saharan Africa	Niger/ Ethiopia	1998
Iscah Sanda, Kenyan	Wye	PhD	Evaluation and improvement of feeding strategies for feed intake in crop/livestock systems	Kenya	1999
Mamadou Sangare, Nigerian	Prince Leopold Institute	PhD	Optimising the use of feed sources for feeding livestock and recycling nutrients	Niger	1999
Solomon Desta, Ethiopian	Utah State	PhD	Banking livestock capital for pastoral risk management and urban development in Ethiopia	Ethiopia	1997
Mirjam Steglich, German	Humboldt	MSc	Intra-household effects of peri urban dairying	Ethiopia	1997
Kouadio Tano, Ivoirien	Manitoba	PhD	Trypanosomiasis and trypanotolerant livestock in West Africa	Burkina Faso	1998
Jean Paul Vanderlinden, Canadian	York	PhD	Property rights, risk and livestock development in Niger	Niger	1998
Workneh Abebe, Ethiopian	Alemaya	MSc	Assessment of nutritive value and consumer preference of goat milk and milk products	Ethiopia	1997
Yilikal Asfaw, Ethiopian	Berlin	MSc	Epidemiology of bovine brucellosis in peri urban dairy production systems in and around Addis Ababa	Ethiopia	1997
Yoseph Mekasha, Ethiopian	Alemaya	MSc	Impact of feed resources on reproduction performance of dairy cows in peri urban dairy production systems in the Addis Ababa dairy shed and evaluation of non conventional feed resources using sheep	Ethiopia	1998

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Financial Summary

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF ACTIVITY
for the year ended 31 December 1997
(US$ '000)

Revenue	1997	1996
Grant	24,947	24,775
Other income	976	1,195
Total revenue	25,923	25,970
Expenses		
Research	18,038	16,495
Information services	1,230	1,486
Training and conferences	787	897
General administration and operations	3,654	3,967
Board and management	856	787
Depreciation	2,155	2,335
Total expenses	26,720	25,967
Surplus (deficit) for the year	(797)	3

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
STATEMENT OF FINANCIAL POSITION
at 31 December 1997
(US$ '000)

	1997	1996
Current assets		
Bank and cash balances	11,507	14,665
Accounts receivable	986	847
Receivable from donors	5,475	1,999
Inventories	1,205	1,215
Deposits and prepayments	426	338
Total current assets	19,599	19,064
Fixed assets and investment in subsidiary		
Property, plant and equipment	19,250	19,862
Construction work in-progress	209	90
Investment in subsidiary	1,816	1,816
Total fixed assets and investment in subsidiary	21,275	21,768
Total assets	40,874	40,832
Liabilities		
Accounts payable and accruals	4,207	3,765
Payable to donors	2,191	2,237
Funds in-trust	306	195
Staff provisions	1,838	1,628
Total liabilities	8,542	7,825
Fund balances		
Capital invested in fixed assets and in subsidiary	21,275	21,768
Operating funds	6,245	7,042
Capital fund	4,812	4,197
Total fund balances	32,332	33,007
Total liabilities and fund balances	40,874	40,832

INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE
1997 DONOR FUNDING
(US$ '000)

Donor	Unrestricted	Restricted	Total 1997 income
Australia	232	321	553
Austria	175	0	175
Belgium	272	992	1,264
BMZ/Germany	867	661	1,528
Canada	849	33	882
Denmark	863	640	1,503
EU	0	1,440	1,440
France	176	0	176
Finland	461	17	478
IDRC	0	217	217
IFAD	0	235	235
India	37	0	37
Ireland	0	468	468
Italy	0	550	550
Japan	529	939	1,468
Korea	50	0	50
Luxembourg	0	31	31
The Netherlands	261	163	424
NIH	0	14	14
Norway	877	0	877
OPEC	0	35	35
Rockefeller Foundation	0	18	18
South Africa	0	100	100
Spain	10	40	50
Sweden	573	0	573
Switzerland	1,468	409	1,877
UK	0	1,319	1,319
USA	3,000	353	3,353
WHO	0	52	52
World Bank	5,200	0	5,200
Total	15,900	9,047	24,947

Credits

Text Paul Neate

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