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CGIAR Systemwide Livestock Programme Report 2003

Searching for Synergies in Livestock Research

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Systemwide Livestock Programme

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'We can spare you food, but we can’t spare you fodder.' – Farmer in Andhra Pradesh, India, speaking to SLP project researchers
Since the Systemwide Livestock Programme (SLP) last reported to its stakeholders, the focus of its activities has changed in two important and interrelated ways. The programme’s first generation of projects emphasised the development and dissemination of feed and natural resource management technologies in four major ecoregions, namely East Africa, Latin America and the Caribbean, West Asia–North Africa and the Sahel. These projects demonstrated that, while such technologies had high potential, they required careful targeting to certain, often quite narrowly defined, conditions if they were to be introduced successfully. Needed were the research tools and methods that would allow these conditions to be defined and identified. The first change in the Programme’s focus was therefore a shift in favour of a global approach to the development and application of these tools and methods, which included the use of geographical information systems (GISs) and simulation models. This approach was pursued by developing an Internet portal known as the virtual SLP (vSLP).

The second change consists of a shift into descriptive research on production systems. At first sight, such a shift could court the accusation that the SLP is putting the clock back: after more than 25 years of a farming systems approach to livestock research, why return to what is normally considered to be the first step in the research cycle? But there are crucial differences between today’s descriptive research and the diagnostic approaches of the 1970s. Those early surveys focused almost entirely on micro-characteristics of farming systems, to the exclusion of broader policy considerations. They also consisted mainly of ‘snapshots’ of systems, failing to capture the way these systems evolve over time.

The evolution of cropping systems has been relatively well researched. The results have taught researchers that, for example, the introduction of bunds or of transplanting into an irrigated rice system will catch on with farmers only if the cropping system is ready for such innovations.

Surprisingly, but perhaps understandably, given the persistent underinvestment in livestock research over more than 30 years at both the international and the national levels, this job had not been done for the livestock component of mixed crop–livestock systems. Hence, there is little understanding of the factors that drive the evolution of these systems. Do they, for example, evolve in response to such factors as access to markets and labour availability, as cropping systems do? Or do other factors, such as agroclimate, outweigh these influences? And how universal are the factors: are the same ones at work across nearly all production systems, or do they differ from one system to the next?

The result of these knowledge gaps is that many of the innovations that could do so much to improve both the productivity and the sustainability of mixed crop–livestock systems remain poorly targeted. Researchers and extensionists are equally at fault in this, eagerly recommending the introduction of their favourite fodder crop simply because the soil and weather conditions look right for it. All too often, despite the participatory approaches of the past decade, they fail to find out whether farmers really need this innovation – in other words, whether the system is ripe for this particular change.
The new generation of SLP projects presented in this report seeks to change all this. By understanding the factors that drive system evolution, these new projects aim to bring about a radical improvement both in the targeting of technical innovations and in the recommendations made to policy makers. If these projects succeed, they will lead to more efficient national agricultural research and extension systems that genuinely achieve impact – making better use of taxpayers’ money.

The need for better targeting of innovations in the livestock sector was never greater than it is today. The livestock revolution – the surge in demand for livestock products in the developing world as incomes rise – is creating new opportunities for small-scale farmers to engage in livestock production as a route out of poverty. The farmer quoted on p. iv of this report epitomises what this revolution can mean for the small-scale producer – a dramatic, demand-driven shift in emphasis from human food to animal feed. But these opportunities are accompanied by some daunting challenges. Not least of these is the challenge of improving the productivity of traditional systems without straining them to breaking point. In some cases the way forward, at least in the short to medium term, lies in the closer integration of these systems’ crop and livestock components. In others, the time for integration has already passed and the need is for greater specialisation, for example in milk or forage production. A better understanding of system evolution can help researchers and extensionists decide what sorts of innovation are appropriate under what conditions.

The complex problems faced by small-scale livestock farmers in the developing world demand a holistic, multidisciplinary approach to research that unites the biophysical and the socio-economic and that crosses sectoral boundaries. This is the raison d’être of the SLP, which was founded in 1995 to strengthen the links between the centres of the CGIAR system with a view to tapping the potential for synergy inherent in their hitherto largely separate crop and livestock programmes. This approach has already achieved a great deal – witness the highly positive report of the external review conducted in 2001 (see p. 3) – but far more remains to be done. I ask all the CGIAR’s donors to support the SLP in its quest to build on the excellent foundations it has laid to date.

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Executive summary

The Systemwide Livestock Programme (SLP) of the Consultative Group on International Agricultural Research (CGIAR) works to alleviate poverty, protect natural resources and achieve food security in developing countries. The SLP builds on and strengthens links between CGIAR centres in order to foster a holistic approach to research and development on livestock production and related issues, with special emphasis on the livelihoods of smallholder farmers.

As demand for crop and livestock products increases, researchers need a deeper understanding not only of how integrated crop–livestock systems work but also of how they evolve over time in response to this demand. This understanding provides the basis for identifying appropriate interventions to meet the SLP’s goals. To acquire it, the SLP conducts or supports research at several locations in Asia, Africa and Latin America, as well as through an Internet portal.

In South Asia, researchers have developed a new typology of mixed crop–livestock systems in India, Nepal and Sri Lanka. The typology reveals the different intervention pathways needed to achieve impact. For example, stall-feeding options using dual-purpose legumes are the best way of achieving impact in areas where land is scarce, whereas common property resources for grazing will continue to be used where this constraint does not exist. In Southeast Asia, village and household surveys were conducted on mixed rice-based farming systems in five countries at different stages of economic and agricultural development. Initial analysis reveals the importance of strong government policies in helping to promote the livestock sector, particularly in terms of mechanisation and market access. Once the analysis is completed, researchers will use the information to identify which trends and interventions best contribute to crop–livestock intensification and sustainable land management.

In West Africa’s dry savannas, a multi-partner on-farm project has achieved considerable success in introducing improved dual-purpose cowpea and sorghum varieties. Participating farmers in Nigeria now have enough food and fodder to cover their needs and have been able to increase their incomes by selling their surpluses. Farmers are now identifying new priorities to work on, including improved feeding strategies and manure collection. Lessons learned are being used to guide research at the project’s new sites in Burkina Faso and Ghana. Researchers from various CGIAR centres and laboratories around the world have collaborated on the Internet through the virtual SLP (vSLP) to develop new livestock modelling and systems analysis tools. These are being freely exchanged and used by partners in Asia and Latin America to advance their research programmes.

The SLP has completed two transregional projects designed to identify the common factors that drive crop–livestock intensification and determine access to markets for smallholders. Working across three continents, the first project looked at farming systems operating at different levels of intensity. Results show that the role played by climatic factors in influencing farm management decisions is not so important as traditionally considered. The intensification of crop–livestock systems typically takes place in areas where labour is relatively plentiful and its cost is low in relation to land. The second project analysed the scale and policy issues that hamper small-scale producers.
Working in Bangladesh, Kenya and the Philippines, the project showed that economies of scale in the purchase of inputs and the delivery of outputs do make large-scale farmers more competitive than smallholders. But surprisingly, despite these constraints, smallholders remain sufficiently profitable to continue to play a role in meeting local demand for livestock products for the foreseeable future. However, policies that promote infrastructure development, feed quality, access to markets and extension services are still needed to level the playing field. Workshops have contributed to the dissemination of these findings.

To help set research priorities, the SLP conducts *ex-ante* assessments to quantify the benefits that can be expected from specific interventions. Since its last report, such assessments have been completed for research on genetically improved dual-purpose cowpea in West Africa and on maize as food, feed and fertiliser in Eastern and Southern Africa. Improved cowpea varieties were found to offer farmers real opportunities to raise their incomes while also improving soil fertility on their farms. In contrast, further genetic improvement of maize appears to offer farmers little economic benefit. The best options to pursue with regard to maize are to expand the use of intercropping and to improve feed quality by combining maize stover with other available fodder. This suggests that investment in extension services would achieve more impact than further investment in genetic research. Nevertheless, more research on the management of manure is warranted, since this might help reverse the steady drain of nutrients from maize fields.

Finally, the SLP has launched a 6-year project on fodder innovations in Nigeria and India. Research focuses on improving the livelihoods of the rural poor by increasing their options for feeding the livestock they keep. Initial results and feedback on the dual-purpose cowpea, sorghum and groundnut options selected by participating farmers are encouraging.

Future SLP work will continue to focus on the improvement of food–feed crops as a basis for raising farm incomes in the short term while improving the long-term sustainability of production systems. While strong partnerships have been developed and the opportunities for synergies are growing, additional funding is needed to realise the full potential for impact from this research.
Searching for synergies in crop–livestock research

In most developing countries, agriculture is the engine of economic development. Within this sector, growth in livestock production has outpaced growth in crop production for more than 20 years and looks set to continue to do so. This is a response to a profound shift in demand known as the livestock revolution: as urban populations and incomes rise, diets diversify and people eat more meat and dairy products. The livestock revolution creates new opportunities for small-scale farmers to raise their incomes by increasing the productivity of their animals. But can they grasp these opportunities? In many traditional production systems, the priority that continues to be placed on the production of human food over livestock feed, coupled with the growing scarcity of land, forces farmers to mine the soil, leading to a steady decline in the yields of food staples that undermines food security for the poor. Each new twist in the spiral of decline reduces the options available to hard-pressed farmers and their families, depriving them of the capital and labour they need if they are to switch to new enterprises.

Nevertheless, the synergic nature of crop and livestock production – the fact that each component can improve and sustain the other, leading to long-term gains in the productivity of the whole farm – does offer farmers a way out of the impasse. Increasingly, farmers are turning to the integration of the two components as a strategy for intensifying their production systems sustainably. Simple innovations, such as collecting manure and applying it to crop fields, introducing a forage legume to enrich the diets of cattle, sheep and goats while improving soil fertility, or harnessing animal power to cultivate the land more efficiently or take produce to market, have already demonstrated their potential to raise farmers’ incomes and improve the long-term health and viability of their farms. But far more needs to be done – both to promote the introduction and spread of such innovations and to strengthen the services needed to support and sustain a more productive, market-oriented livestock sector.

If there is one message that researchers need to take away from all this, it is that crop and livestock production can no longer be
looked at as if they were divorced from one another. Plant breeders in particular need to bear this in mind as they work with farmers and others to define their breeding objectives: far too much crop improvement research in the past has focused on increasing the grain yield of food staples while neglecting the importance of the crop residues for feeding animals. But that is not the only—nor, arguably, any longer the most important—field in which researchers need to broaden their perspective. The livestock aspect needs more sophisticated consideration across a whole range of natural resource management issues, from land degradation to the conservation of biodiversity. And that is not to mention policy making and institution building—two equally important fields in which livestock are still, all too often, considered as a separate and relatively unimportant item, if they are not left off the agenda altogether.

It was in order to pursue the synergies implied by closer integration of its crop and livestock research that the Consultative Group on International Agricultural Research (CGIAR) established the Systemwide Livestock Programme (SLP) in 1995. The SLP was intended to provide a platform for partnerships in which the CGIAR centres focusing on crop or natural resource management issues would be able to make significant contributions to livestock research, which remained the primary responsibility of the International Livestock Research Institute (ILRI). An external review commissioned by the CGIAR’s Technical Advisory Committee (TAC) in 2001 found that the SLP had been highly successful in meeting this objective (see box overleaf).

The SLP began its work during the second half of the 1990s, with three large ecoregional research projects based at different CGIAR centres in Eastern Africa, Latin America and the Caribbean, West Asia–North Africa and the Sahel. Focusing initially on feed and natural resource management issues, a consortium of partners in each ecoregion sought to introduce fodder crops and trees into farming systems, improve the management of rangeland and promote improved soil fertility and forest conservation through the use of herbaceous legumes.

As these projects evolved, SLP researchers recognized that greater impact could be achieved through local technology adaptation and dissemination rather than by transferring supposedly ready-made
technologies across ecoregions, the results of which were, with a few notable exceptions, disappointing. A more effective strategy for targeting specific interventions to local conditions was needed. Developing such a strategy required a better understanding of how crop–livestock systems evolve and of the opportunities to intensify them by integrating their components so as to increase both system productivity and sustainability. A new family of

External review: SLP delivers impact through collaboration

The SLP’s 2001 external review, which was conducted by an Expert Panel, considered the programme’s objectives, activities and performance. Specifically, it asked whether, given the relatively high transaction costs incurred by the SLP, the programme was achieving results that could not have been achieved in other, less costly ways.

The Panel concluded that the SLP is an excellent initiative, well worth the effort of all involved, and that its overall benefits will probably greatly exceed its costs, especially if it continues to enable its members to function as a ‘research system rather than a set of independent agricultural research centres’.

According to the Panel, SLP funding had met its objective in helping to catalyse productive research on livestock feeds, natural resource management and relevant policy issues. The most measurable results were the widespread on-farm trials and related farmer adoption of enhanced dual-purpose crop species. The SLP’s early years were found to have been particularly effective in accomplishing inter-centre collaboration, the chief benefit of which was that it brought together the critical mass of expertise needed to address complex issues. However, the Panel identified the need for closer collaboration with other systemwide programmes, such as the Soil, Water and Nutrient Management Program (SWNMP).

The Panel found that, although some inter-centre collaboration would still have taken place without the SLP, it would probably have done so more slowly and in a less focused way. This would have delayed the impact of research on the livelihoods of poor people.

Given the paradigm shift of research towards an integrated systems approach, the need for the SLP would remain strong. The Panel was convinced that, given more support from investors, the SLP could do an even better job in the future. It recommended a funding level of US$3 to 4 million per year.

The Panel’s complete report and recommendations are available on-line at: http://www.vslp.org/vslp/
projects emerged using farm characterisation to assess farmers’ needs, constraints and opportunities.

Through these projects, SLP partners have gained a better understanding of how crop–livestock systems work and of what drives their intensification. Knowledge of how, when and where to intervene to achieve the greatest impact is already being applied, with encouraging results. As more and more farmers test and adopt new technologies, new dissemination strategies are being developed to scale up the results.

The success of these projects could not have been achieved without the hard work of SLP partners at both international and national levels. But it is more than hard work that makes these partnerships effective: the excellent working relationships developed over nearly a decade of the SLP’s existence have helped to foster a shared understanding of the vital part livestock have to play in agricultural and economic development throughout the developing world. This understanding lays the foundations for the increased impact that can be expected from the partners’ work over the next decade.
Crop–livestock integration: 
A path out of poverty

Urbanisation, rising incomes and population growth in the developing world are leading to a significant shift in food consumption habits. Market demand for an increasing array of livestock products continues to grow. One of the most effective ways of meeting this demand is to intensify production systems by integrating their crop and livestock components, since the outputs of one activity are inputs for the other. Over the past few years the SLP has embarked on a series of projects designed to understand what promotes sustainable intensification in mixed crop–livestock systems and how to target interventions so that these really meet farmers’ needs. Four such projects are presented here.

In South Asia, SLP partners developed a new typology of mixed crop–livestock farming systems as a basis for characterising these systems for various agro-ecological, socio-economic and technological factors. The typology has pointed to distinct patterns of intensification in different areas, indicating the need for different types of intervention. In Southeast Asia, monographs and surveys were completed on rice-based production systems in five countries at different levels of economic development. The aim was to identify broad trends and phases in the intensification of mixed crop–livestock systems. In the dry savannas of West Africa, researchers expanded their work on enhancing crop–livestock systems through the use of improved dual-purpose crops. This project has been so successful that farmers are now investigating new feeding strategies to make better use of the extra fodder produced, while SLP partners pursue efforts to scale up the project’s results and transfer them to other areas and countries. Finally, an Internet-based collaborative workspace on animal agriculture has been created. Here, new research tools and methods are being developed and used to predict animal performance under varying environmental conditions.

Defining crop–livestock systems in South Asia

Small-scale mixed crop–livestock systems dominate agriculture in South Asia. As these systems become more market-oriented, they tend to display a wider range of plant and animal species and
to become more advanced technologically. And, as population growth and urbanisation contribute to changing patterns of consumption, livestock are increasingly viewed as not just a source of food but also a way out of poverty. Due to the increasing shortage of land, most of the rising demand for livestock products will have to be met not by increasing the number of animals but by raising their productivity. In India, small-scale and landless farmers use only 34% of the country’s arable land yet account for 46% of its cattle, 51% of its sheep and 57% of its pigs. In neighbouring Bangladesh, the figure for cattle is as high as 65%. As the market for livestock products expands, helping to diversify sources of income and employment, livestock holdings are becoming a more equitable source of economic development than are landholdings. The challenge, as mixed crop–livestock systems intensify to meet the new demands placed on them, is to help realise the full potential of these systems by disseminating appropriate new technology that raises productivity while protecting the natural resource base.

In many parts of the region, these systems are still held back by the poor productivity of traditionally managed livestock and the relatively low uptake of new technologies. Blame can
in part be attributed to the ‘blanket’ approach used to transfer technology: researchers and extensionists have seen small-scale mixed crop–livestock production as a single homogenous system, ignoring regional diversity and complexity. The limited availability of feed and fodder, the lack of infrastructure (especially roads linking farmers to markets) and inadequate access to breeding or health services have further constrained system development. Also, livestock research has typically focused on component technologies developed within single disciplines, leading to a low success rate in the introduction of new technology because the needs of the system as a whole have not been taken into account. A multidisciplinary approach that recognises the interactions between crop and livestock production, and the different patterns of animal ownership and management among different groups of livestock keepers, is more likely to achieve impact.

To aid the process of developing and disseminating more appropriate and better-targeted technology, the SLP’s South Asia project developed a holistic crop–livestock system typology that can be used to identify regions or zones with similar systems. The project brought together two international centres – the International Livestock Research Institute (ILRI), which had already gathered information on the factors that influence change in mixed crop–livestock systems, and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), which had expertise in the region’s most widely grown crops – with various national partners with expertise in livestock research and development.

On the basis of earlier studies by India’s National Centre for Agricultural Economics and Policy Research (NCAP), the scientists participating in the project first identified six major agro-ecoregions: hot and arid, semi-arid, irrigated subhumid, high-rainfall humid, subhumid to humid coasts, and subhumid to cold and arid mountains. The high-rainfall humid zone was subdivided into low-irrigation and high-irrigation subzones. Next, the scientists identified and built in the key agricultural and socio-economic variables, such as population density and access to market, that influence the choices made by farmers in these agro-ecoregions.
These system profiles were developed for some 20 crop and five or six livestock activities each in India, Sri Lanka and Nepal. Areas with similar crop and livestock activities were then grouped together to form zones (Figure 1). Finally, the scientists linked productivity constraints and the processes of intensification and technology adoption to socio-economic, agroclimatic and institutional factors.

The study confirmed that, in all three countries, increased livestock productivity can best be achieved through the better targeting of specific interventions rather than the use of a blanket technology transfer approach.

India provides several good examples of why targeting matters. In the country’s semi-arid tropics, cereal residues of low nutritive value form the bulk of animal feed. The scarcity of productive land makes farmers reluctant to devote terrain exclusively to fodder crops. Interventions designed to increase livestock productivity in this zone should therefore focus primarily on the improvement of...
dual-purpose crop varieties and the cost-effectiveness of existing supplementation technologies.

In contrast, land is less of a constraint in the high-rainfall low-irrigation humid zone, where the human population is lower and both feed and water are often common property resources. Rainfed rice is the dominant crop, with its residues being widely used as fodder. Due to rice straw’s poor nutritional quality, supplementing it with local grasses or green fodder is an option well worth pursuing in this zone. Improving the rights and access of the poor to common property resources and establishing institutional mechanisms for linking small-scale producers to markets via cooperatives would also help.

In the high-irrigation humid and temperate zone, land is once more a constraint as these zones tend to have higher population densities, smaller farms and fewer common property resources. Here the introduction of stallfed dairy animals is an attractive option. Extension interventions in these areas could promote the use of crossbred cows and buffaloes and the introduction of high-yielding fodder varieties. Mechanisation is gradually reducing the use of draft animals.

Several regions of India combine small land holdings with high rural poverty rates. Farmers here have fewer resources and income-earning opportunities. Animal nutrition and health interventions probably offer the best returns. Because livestock are kept for multiple purposes, gains could also be made through genetic selection to improve local breeds.

In Sri Lanka, the typology shows that differing agro-ecological and socio-economic factors have created a clear pattern of regional specialisation in livestock species and outputs. Dairy farming is more important in tea estate systems and coconut plantations, whereas meat production (other than poultry) is more highly valued in rainfed rice systems. This creates wide variations in animal management, from open access grazing systems to intensive stallfed market-oriented systems requiring high inputs of labour and capital. Arguably, policy interventions should seek to strengthen such specialisation, which is widely seen as the way forward for small-scale farming throughout the region. But there are also arguments for retaining some degree of diversification in
these systems to spread risk and safeguard farmers’ incomes when times are hard. Growth of the cattle and goat sectors has been limited by high labour costs and low milk prices. Technology adoption rates in these sectors are low and falling, as more and more farmers move into commercial poultry production, which enjoys strong government support.

One likely source of productivity gains is the encouragement of supplementary feeding. This is especially suitable for dairy farmers, who depend at present almost entirely on shrinking areas of pasture and on the residues of crops grown on their own farms. The urea treatment of straw was widely promoted for decades, but high capital costs prevented it from being adopted by smallholders. An alternative option, for which there appears to be growing demand, is urea–molasses mineral blocks. These can certainly help to meet the nutritional requirements of cattle, but poor or unreliable molasses supply has hindered production. High start-up costs combined with poor government support have also discouraged small-scale entrepreneurs. New policies are needed to encourage both commercial and farmer-level block production. Rice bran, an important locally available feed ingredient, is widely available on the market but of varying quality due to poor milling methods. Replacing outdated milling technology and introducing bran quality as a breeding objective in rice improvement programmes would do much to enhance feed quality.
The livestock revolution experienced in India and Sri Lanka has not yet occurred in Nepal, where the urban population is still relatively low (12%) and a high proportion of people (43%) live on less than US$1 per day. In other words, the population remains heavily reliant on agriculture and the purchasing power of consumers remains low. Nevertheless, there is scope for the better targeting of interventions to address the regional disparities identified among the country’s nine crop–livestock zones.

As in other South Asian countries, meat and milk production in Nepal are closely linked to urbanisation. Poultry meat and dairy production are growing rapidly in peri-urban areas. A few farmers have responded to the growing demand for milk by starting small-scale semi-intensive commercial dairy enterprises. However, low milk prices fixed by the government and ‘milk holidays’ during the flush season have prevented the sector from becoming sufficiently profitable and have discouraged the majority of would-be producers from entering this market. As a result, the government needs to import skimmed milk powder during the lean season in order to meet demand. To increase the profitability of dairying, government policy needs to be revisited with a view to ending price controls on milk.

In Nepal’s hill zones, infrastructural and institutional development would alleviate some of the constraints faced by dairy farmers, who currently have poor access to roads and cannot reach the few milk chilling centres located in these zones. In addition, increasing pressure on land combined with deforestation and open access grazing on steep hillsides have contributed massively to soil erosion and declining soil fertility, putting further pressure on feed resources. Measures such as community forestry, planting fodder tree crops and growing grasses and fodder crops on uncultivated land should be promoted.

Finally, in the more densely populated low-lying zones, crop residues and byproducts are important sources of feed. Interventions focusing on their nutrient content and on livestock feeding strategies should be implemented. To arrest the depletion of soil nutrients at the same time as improving feed quality, leguminous fodder crops should be introduced into cropping systems.

Of special note in all three countries is the growing importance of the pig and poultry industries, particularly the latter, which has
undergone rapid intensification throughout South Asia (Figure 2), often as a result of a favourable policy environment in addition to strong demand from urban consumers. In some cases the private sector has entered into innovative contracts with small-scale producers, helping to protect their interests by absorbing their production and marketing risks. Given their high projected growth rates, targeting interventions in the pig and poultry sectors over the next few years could significantly improve the livelihoods of poor producers.

The study showed that technology adoption, and hence livestock productivity, is low in all three countries. Raising productivity will require better access to roads and markets, in addition to a detailed and comprehensive understanding of land, labour and capital constraints. Without sound institutional and policy support, even the best technological interventions will never be widely adopted. No single intervention is broadly applicable in any one region, because regions tend to straddle agro-ecological and socio-economic zones, which often form a patchwork according
From the Projects

to local variations in altitude, soil conditions, temperature and rainfall as well as infrastructure development and market access. More careful targeting is therefore vital if small-scale farmers are to adopt new technologies and increase the profitability of their livestock enterprises.

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**Increasing productivity in Southeast Asia’s rainfed rice-based systems**

Rice accounts for 50% of the annual per capita calorie intake of people in Southeast Asia. Demand for this staple will continue to rise strongly as the region’s human population rises. But income growth and urbanisation are creating an even stronger surge in the demand for livestock products. The vast majority of the animals that must meet this additional demand are found in rice-based farming systems, which are dominated by smallholders. The intensification of these systems – a major source of income and employment for millions of rural people – is thus an attractive development path for nearly all countries in the region. How intensification takes place on small-scale farms is a major factor determining food security and income growth for the poor, as well as the health of the region’s agro-ecosystems.

In 2000, the International Rice Research Institute (IRRI) submitted a joint project proposal with ILRI aimed at improving researchers’ and policy makers’ understanding of this process. The project would identify possible responses to the challenge of

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**Project partners and their strengths**

- **International Rice Research Institute (IRRI)**
  Rice breeding, regional networks

- **International Livestock Research Institute (ILRI)**
  Livestock systems research, nutrition, socio-economic research

- **National research institutes and universities (Cambodia, Indonesia, the Philippines, Vietnam, Thailand)**
  Crop and livestock research, local expertise, on-farm activities
intensification and the consequences of different intensification paths (see box). Working in partnership with a number of national research groups, the 3-year project began in January 2002 with support from the SLP.

The project looks at smallholder farms of no more than 1.5 hectares where rice is the predominant crop. The aim is to identify appropriate technical and socio-economic interventions that can boost the productivity of both the rice crop and the livestock component. Cambodia, Indonesia, the Philippines, Vietnam and Thailand were selected for inclusion in the study due to their varying stages of economic development and crop–livestock system evolution. Thailand and Cambodia, at opposite ends of the study’s development spectrum, merit particular comparison.

The first phase of the project comprised two activities. First, five country monographs were developed. In the light of varying economic and technological advances, these present a broad

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**What role for livestock in lowland Southeast Asia?**

The central issue on which the project will shed light is whether mixed crop–livestock systems in Southeast Asia will develop and spread or will be replaced by more specialised production systems. Specific questions to be answered include:

- Are changes apparent in the role of animals in rice farming households? If so, what are they and to what degree are they occurring?
- Does raising livestock compete with rice cultivation in the use of household labour and other resources? What factors influence the allocation of resources?
- What is the relative influence of technology development, government policies and changes in demand on the evolution of rice-based systems?

The answers to these questions will help the project verify or disprove the following hypotheses:

- Mixed crop–livestock systems are a strong tool for poverty alleviation and are most effective in areas where other opportunities for increasing incomes are limited
- Economic growth leads to a long-term decline in crop–livestock integration
- Government policies, as well as new technologies, can influence the direction of livestock development in favour of small-scale producers
picture of the characteristics and development trends of rice-based systems within each country. Second, survey data were analysed to ascertain the socio-economic and policy factors influencing farm household decisions on production activities.

In Thailand, the surveys revealed that over half of all farmers (59%) no longer own any draft animals and that a further 33% use their draft animals almost entirely for off-farm activities, such as transport (Table 1). Crop and livestock production remain integrated on only 8% of farms. Former government policy discouraged animal use and promoted more capital-intensive forms of mechanisation, which have been widely adopted in both irrigated and rainfed areas. The high cost of labour, attributed to the need for additional workers on the country’s larger farms and to competition with other growing sectors such as tourism, has further encouraged mechanisation. Farmers have shifted from large ruminants to pig and poultry production, another change made possible by the rapid rate of mechanisation. However, the mechanisation policy is now being reversed: the government is increasingly concerned about the sustainability of crop production and the environmental impact of specialised large-scale livestock enterprises and now feels that re-integrating livestock into mixed crop–livestock systems can provide the diversification and system stability needed to buffer fluctuations in world markets.

<table>
<thead>
<tr>
<th>Country/Groups</th>
<th>Group 1: With draft animals used on-farm</th>
<th>Group 2: With draft animals but not used on-farm</th>
<th>Group 3: No draft animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cambodia</td>
<td>82</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>South Vietnam:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Long-an province</td>
<td>22</td>
<td>78</td>
<td>–</td>
</tr>
<tr>
<td>An Giang province</td>
<td>95</td>
<td>5</td>
<td>–</td>
</tr>
<tr>
<td>Philippines:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nueva Ecija</td>
<td>62</td>
<td>30</td>
<td>8</td>
</tr>
<tr>
<td>Northern Samar</td>
<td>83</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>Thailand</td>
<td>8</td>
<td>33</td>
<td>59</td>
</tr>
</tbody>
</table>

Table 1. Percentage of farm households in different crop–livestock systems. Source: IRRI, 2003
In Cambodia, much remains to be done to foster and develop the country's agriculture. Infrastructural development in terms of irrigation, road networks and market facilities has been minimal, severely constraining gains in productivity. In the three villages surveyed under the SLP project, farm size and income were considerably smaller and lower than in Thailand. Farming systems are primarily rainfed, mechanisation levels are low and farmers retain their traditional practice of fallowing. Most farmers operate at subsistence level, with patterns of consumption that have remained largely unchanged for decades. Crop–livestock integration remains high (82%) and farmers continue to have a high regard for their livestock, which provide valuable draft power and financial security. Farm animals can be sold quickly for cash to meet household expenditures or solve an emergency. Small numbers of pigs and poultry are kept in order to provide a basic cash income. In short, Cambodia’s production systems are more reminiscent of Africa than of the rest of Asia.

In Vietnam, two studies were conducted: one in the southern province of An Giang, the other in northern Long-an province. These provinces form a marked contrast, comparable to Thailand and Cambodia respectively.

In the south, the government is encouraging small-scale dairy production as an intensification path in areas close to urban centres where traditional cattle–rice systems used to prevail. Draft animal use is now limited to 22% of farms and cows are kept primarily for milk, which is sold locally as well as being consumed by the family. Farmers alternate the cropping of improved high-yielding rice with traditional rice varieties that produce lower yields but have better taste and cooking qualities. The government is also encouraging specialisation in pigs and buffaloes, while some farmers are integrating new options such as shrimps or ducks with their rice enterprise. Land holdings are relatively large, mechanisation is relatively far advanced and access to markets is good.

In the north, there are strong parallels with farms in Cambodia. The smaller farms in Long-an have a high degree of integration (95%) between crop and livestock enterprises, with draft animals almost universally used to cultivate rice fields. There are fewer examples of livestock diversification or specialisation and household incomes remain low. Near Hanoi, crop–livestock integration is
mainly a combination of rice and pigs, the shift into pigs being a response to local market demand. Small numbers of cattle are also kept for small-scale dairy production.

Surveys in the Nueva Ecija and Northern Samar regions of the Philippines also revealed marked contrasts between farming systems, particularly with regard to mechanisation. For example, irrigated systems rely primarily on cultivation using tractors, whereas in rainfed areas, which account for two-thirds of the country’s farmland, farmers rely on animal draft power to prepare the land and use crop residues to feed their animals. Livestock are seen as more affordable than tractors and provide financial security above and beyond their draft power and marketable supply of milk. Earnings from the sale of animals play a strong role in buffering fluctuations in household income. Livestock are also a status symbol.

The survey results point to two interesting phenomena. Firstly, farmers who use their animals for draft cultivation or milk production are more technically efficient than those who own draft animals but use them only for off-farm activities such as transport. This can be attributed to the falling share of rice and the rising share of livestock in total farm income. Secondly, the data on income suggest that Filipinos turn back to agriculture in times of economic slowdown or recession. Such information could be helpful for government policy makers as they devise measures
for mitigating the negative effects of recession on the livelihoods of the poor.

No data are yet available for Indonesia, as work in Lamongan and Indramayu – the two districts of Java where surveys were conducted – was only recently completed. However, government policy is currently encouraging the integration of cattle and rice production as a development path. Consequently, rice straw enrichment technology, such as urea treatment, is being promoted as a means of enhancing feed quality and hence animal performance.

General trends identified throughout the region include the diversification of income sources through the expansion of dairying and the cultivation of crops other than rice. The gulf between production systems in Thailand and Cambodia illustrates how crop–livestock integration, after first increasing, gradually reduces with economic development. Infrastructure promotes market access and integration with the broader market economy, decreasing price variability in different regions. It opens up choices for farmers, who may intensify and/or diversify either their crop or their livestock enterprises. The nature of development, and the rate at which it will occur, will vary greatly according to the policy environment in each country, in addition to the farmer’s distance from urban centres. Pig and poultry production were not included in the study, but are expanding rapidly in most parts of the region.

There is scope for designing and implementing policies that will ensure that the poor are not shut out of the new markets emerging as a result of the livestock revolution. However, this does imply dismantling policies that distort the market in favour of the larger-scale producer. Special efforts will be needed to provide farmers in more remote areas with accurately targeted technology and information designed to help them access local markets.

Funding is being sought for the project’s second phase. This will focus on rainfed areas, where scientists and farmers will explore and test new technologies aimed at strengthening the links between crops and livestock, with special emphasis on nutrient management.
Improving crop–livestock systems in West Africa’s dry savannas

Characterised by sandy soils with low fertility and unpredictable rainfall, West Africa’s dry savannas are home to over 108 million people, 22 million cattle and 65 million sheep and goats. Meeting the rising demand for food in this highly populated area has implications for the sustainability of agriculture, as farmers respond by shortening or eliminating fallow periods and expanding crop production onto marginal lands. The declining productivity associated with these changes could spell disaster for the region’s food security. Enhancing the integration of crop–livestock systems offers the best hope of reversing the decline in productivity as the basis for building both a more prosperous future for farmers and a healthier farming environment.

In 1998, ILRI, ICRISAT and the International Institute of Tropical Agriculture (IITA) joined forces with national research institutions to begin testing new dual-purpose (food and fodder) crop varieties – a key technology in the quest for sustainable intensification – with farmers in northern Nigeria. Using farmer

**Project partners and their strengths**

- **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)**
  - Pearl millet, sorghum, groundnut
  - Cropping systems, farmer participatory research, modelling

- **International Institute of Tropical Agriculture (IITA)**
  - Cowpea, maize, cassava, soybean
  - Socio-economics and natural resource management

- **International Livestock Research Institute (ILRI)**
  - Livestock production, income generation, nutrient cycling, crop residue management
  - Livestock-related policy and institutional issues

- **National research institutions/extension services**
  - Crop improvement, crop residue and manure management
  - Development of fodder resources
  - Links with farming communities
participatory research to understand and address smallholders’ constraints, the scientists identified ‘best-bet’ cropping and other options for further development and evaluation on-farm (see box). Successes here have led the scientists and farmers to seek out new areas where further productivity gains can be achieved. In 1999, with funding from the SLP, the project was extended to include Mali and Niger. A broader set of research topics was addressed, with a growing list of partners. In 2002, additional funds were obtained by the SLP from the Danish International Development Agency (DANIDA) to consolidate the activities already initiated and to extend the work into Ghana and Burkina Faso.

Much on-farm research in the past has focused solely on the results for specific objectives (e.g. improved grain yield) rather than the multiple objectives pursued by farmers (e.g. better livestock as well as human nutrition). Under the SLP project, scientists complemented on-farm technology testing with socio-economic studies designed to better understand the trade-offs associated with the management decisions taken by individual households.

Farmers in Bichi, Nigeria, where the project first began, tested dual-purpose cowpea and sorghum varieties, together with other options. After several years of evaluating these varieties, they
have abandoned most other options, including their local crop varieties. Delighted with the quality and quantity of both food and fodder produced by the dual-purpose varieties, farmers have shifted their attention away from the system’s food crop component to livestock feeding strategies designed to make the best use of the additional and more nutritious feed they now have available. They are particularly interested in stall-feeding for their sheep and goats, as this facilitates manure collection, promotes weight gain and reduces both theft and feed waste. In response to these benefits, 80% of farmers stated that they would probably limit their use of extensive grazing in the future and pen their animals for longer periods.

Cowpea, groundnut and sorghum residues are the most common types of fodder in northern Nigeria, as throughout much of West Africa’s dry Savanna zone. Farmers tend to feed groundnut early in the dry season and cowpea later, as it stays palatable for longer. Both of these feeds are supplemented with wheat bran, but this is often fed intermittently, in amounts of up to 2 kilogrammes. Trials in the 2002–2003 season showed that farmers can use their feed resources much more efficiently: amounts as small as 300g each of cowpea fodder and wheat bran, fed daily, gave the best productivity results in terms of weight gain and manure production. This finding is especially relevant for women, who have frequent access to bran while processing food crops.

In Niger, sheep fattening, timed so that the animals can be marketed at major festivals during the dry season, is an important source of cash for most farmers, especially women. Broader participation in this market can be attributed in part to the increased availability of fodder resulting from the options being tested under the SLP-supported project. In 2003, scientists conducted sheep fattening trials comparing different cowpea and pearl millet bran levels used to supplement a basal diet of *Hibiscus* residues or *Zornia* hay. Results once again indicated that feeding strategies using smaller quantities of feed supplements contributed most effectively to weight gain.

In Mali, farmers from the Fana and Koulikoro regions evaluated a number of BB and BB+ treatments. In Fana, farmers compared sorghum yields in the traditional cereal–cotton rotation with those obtained from an improved rotation with nitrogen-fixing
legumes, such as improved dual-purpose cowpea or groundnut. Despite poor rainfall in 2002, average yields of both sorghum grain and fodder were generally twice as high in the rotation that had included cowpea the previous year as in the traditional rotation. Near-drought conditions in Koulikoro resulted in very low sorghum yields, while an infestation of the parasitic weed *Striga gesnerioides* meant that local cowpea plots produced no grain at all. However, these conditions highlighted several noteworthy features. In particular, cowpea fodder yields were almost five times higher from the improved variety than from the local variety. Sorghum grain yield differences were less striking, although the improved *MaliSor 92-1* variety yielded more than the local or the improved *CSM 388* variety. Farmers attributed this to its faster time to maturity, which minimises drought impact. Farmers decided to retain the improved cowpea variety and the shorter-duration sorghum variety *MaliSor 92-1* for further testing.

Activities in Ghana and Burkina Faso were concerned mainly with site characterisation and the design of feeding and composting trials.

In Burkina Faso, farmer discussions and planning meetings were held in Namanéguéma and Pobé districts to establish initial research objectives. Work will focus on the strategic feeding of legume fodder. Participants are able to build on the results of past research on nutrient management conducted under a regional ILRI-led project funded by the International Fund for
Agricultural Development (IFAD) and Canada’s International Development Research Centre (IDRC).

In Ghana, three communities each in the Bakwu-East and Tolon-Kumbungu areas were selected for feeding trials using whole cottonseed – a new technology for farmers in the region. Three options were studied: stall-feeding a combination of cereal and legume residues, stall-feeding a combination of cereal residues and cottonseed, and extensive grazing. Animals took at least 2 weeks to adjust to eating the cottonseed and generally did not perform well. Performance was much better on the farmers’ extensive grazing treatment, due to the plentiful supply of local crop residues following the harvest. In general, farmers appreciated the improved health of their animals as well as the ease of manure collection and reduced incidence of theft due to stall-feeding. Farmers in all communities identified lack of veterinary care, poor soil fertility and the high cost of fertiliser as critical constraints to productivity gains. Over the trial period, the number of farmers, particularly women, participating in discussions has increased – an encouraging development.

Project results emphasise the importance of starting small in order to promote understanding and learn from farmers. Only 11 farmers participated in the first trial in Bichi, in 1998. By 2003, over 700 farmers in northern Nigeria had adopted best-bet technical options and new management practices (i.e. improved rotations) developed under the expanded project. This growth in the number of participating farmers opens up new opportunities to explore the institutional mechanisms and other issues that are
critical to scaling out. The role of women in the management of livestock and natural resources is emerging as an important issue as more and more community-level women’s groups are being formed. The management of small ruminants, traditionally kept by women, is a research topic well worth pursuing.

The unavailability of credit hampers the scaling-out effort in all study areas. However, income levels in Nigeria, where project activities have been going on longest, have increased sufficiently to enable rising numbers of farmers to afford inputs, even at the start of the growing season, when cash reserves are traditionally low. Many farmers elsewhere still rely on inputs distributed free of charge by the project, which the project later seeks to recover in kind. Comparisons across sites in different countries may reveal the factors that are conducive to better credit availability.

Scaling-out issues are also being addressed through other SLP projects. Results from this project are feeding into the design of new work on fodder innovations in Nigeria and India (see p. 51).

Workshops, meetings and farmer group discussions designed to ensure the transfer of the project’s results have been held in all five countries. Participants at the Niger workshop examined various promising fodder options and the project team subsequently produced a video to highlight some of the livestock fattening strategies developed.
In July–August 2003, a project tour and workshop for donors and scientists provided an opportunity to bring together lessons from the field with information on the methodologies and technologies available at each project site. A new proposal for a third 3-year phase from 2004 to 2006 has been developed and submitted to donors.

A virtual laboratory on systems analysis

As the SLP has broadened its partnerships both within and beyond the CGIAR system, the challenge has been to meet the need for greater information exchange and research collaboration while still containing transaction costs. In response to this challenge, the programme has created an Internet-based collaborative workspace – the virtual SLP (vSLP).

Now in its third year, the vSLP aims to promote the analysis of mixed crop–livestock systems through comparative studies, the standardisation of data sets and the creation of simulation models. The virtual laboratories (vLabs) that constitute the core of the vSLP have allowed scientists around the world to pursue their research objectives more efficiently by providing simple interfaces through which to handle data collection, analysis and interpretation. Collaboration through the vSLP has helped users from a wide range of institutions develop and test new research tools and methods on-line. For example, a number of animal production simulation models have been produced and validated in this manner. Created by synthesising state-of-the-art knowledge in livestock science and technology, the models are useful tools for identifying profitable options among the different feeding strategies used in different production systems. The models currently available cover buffaloes, dairy and beef cattle and pigs. Others in the pipeline will cover llamas, yaks and camels, as well as a general ruminant model.

To take an example, the buffalo model was created by the Centro Internacional de la Papa (CIP), ILRI’s Crop–Animal System Research Network (CASREN) and a number of national research and educational institutions in order to simulate milk production from this species. Initially developed in a password-protected area, the model was subsequently posted on the publicly accessible vLab, where it has been downloaded and tested by scientists,
academic staff and students in Thailand, the Philippines and Latin America. Users have provided feedback on simulation problems, thereby contributing to an improved version of the model.

The flexibility and user-friendliness of the software used in the models helps users identify research gaps, make appropriate management decisions, facilitate extension work and conduct training. Colleagues in tropical Asia, for instance, have improved their capacity for assessing livestock productivity by using these models and incorporating a climate sub-routine to predict the availability of feed resources.

Use of these models is translating into on-farm impact as researchers, extension workers and other users draw on them to address feed constraints. For example, farmers participating in Tropileche, a consortium of institutions in Latin America seeking to solve feed problems in order to increase milk and meat production, are using the models to investigate the potential of leguminous trees to increase milk productivity. The consortium is led by the Centro Internacional de Agricultura Tropical (CIAT).

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Project partners and their strengths

- **Systemwide Livestock Programme (SLP)**
  Impact-oriented livestock research

- **Strengthening Partnerships for Livestock Research (SPLR) (a programme of ILRI)**
  Web-based information management and dissemination on livestock-related subjects

- **Centro Internacional de la Papa (CIP)**
  Web-based information management and dissemination on natural resources issues

- **Centro Internacional de Agricultura Tropical (CIAT) (Tropileche consortium)**
  Smallholder dual-purpose livestock production in Latin America

- **Crop–Animal System Research Network (CASREN) (a programme of ILRI)**
  Improvement of crop–livestock systems in Southeast Asia

- **National universities and research stations (Costa Rica, Chile, Peru, Ecuador, Panama, Colombia, Bolivia)**
  Applied and adaptive research, local knowledge and contacts
To promote the use of these decision-support tools, conventional dissemination methods such as training workshops and face-to-face interactions are used in addition to on-line tuition. Five workshops have been held to strengthen the existing network by bringing together key researchers, extension agents and university professors from Asia and Latin America who had already collaborated virtually. Participants provided feedback to strengthen the versatility of the models, which they are now using in their respective work environments. Additional training workshops held in Asia and Latin America have targeted both researchers and extension workers. Workshops included a training session on the science behind the tools and on how they were built, in order to foster trust in the robustness of the models. Several participants later conducted workshops within their own institutions to promote the use of systems analysis tools among their colleagues. In some institutions, these tools are becoming a powerful means of learning about crop–livestock issues.

The vSLP offers further opportunities for professional growth, collaboration and partnerships through jointly implemented research projects. Users wanting to develop new research projects can create a collaborative password-protected area where they can securely share data and information, write documents and access software tools. Users are first invited to participate in a research group. Discussions among participants are then initiated using document writing software (a tool available in the vLab) that helps formalise and systematise discussions. Once tasks have been assigned and accomplished, data are shared and analysed by all users and the results are debated. The group continues to collaborate on-line until the research objectives have been met.

Three-dimensional virtual environments offer innovative ways of learning about the links between different environmental components. The vLab includes a 3-D area where people can discover existing environments or submit their own ones (http://inrm.cip.cgiar.org). The 3-D area features a watershed which users can tour, looking at the topography and the rate of erosion in relation to local rainfall and vegetation cover. Users can simulate the trade-offs between different kinds of land use, touring the watershed anew to view the level of soil erosion in response to a change in management practices.
Working with the University of Edinburgh, ILRI and Biotecnología Agropecuaria S.A. (BTA), researchers at CIP developed a virtual farm for use as a training tool. The ‘virtual farmer’ inherits a farm with paddocks, livestock, equipment and money. He or she must make weekly management decisions and learn to cope with the challenges of running a successful farm. Every decision has a fixed cost, which is deducted from the farm’s bank account. Prices and other parameters can be changed to reflect changes in the real world. Currently only available on CD-ROM due to its large file size, vSLP partners plan to make the virtual farm available to on-line universities in the near future.

Although the vSLP has successfully contributed to the creation of new research tools and methods and has also facilitated information exchange and collaboration, some gaps in its scope and applications remain. Largely due to staff constraints, little work has taken place in Africa to promote the exchange of tools and information with local researchers. It is still possible for interested CGIAR centres in the region to replicate the experience obtained by partners in Asia and Latin America. Reaching people who do not have access to the Internet is another hurdle the vSLP would like to overcome. In the coming year, the vSLP will complete its work on the remaining simulation models and data sets and move into a more aggressive dissemination phase.

Visit the vSLP at: http://inrm.cip.cgiar.org/vlab/
South–south lessons on system intensification and market access

Drawing on its strong relationships with the CGIAR centres, the SLP has supported two projects that cut across ecoregional boundaries to glean transregional lessons that will inform future livestock research and development efforts.

In the first project, the SLP has worked with a wide range of partners in Asia, Africa and Latin America to identify the common factors that drive intensification across different crop–livestock systems. Despite differences between regions, the results have shown that factors such as labour costs and market access are universal in their influence on farmers’ management decisions and that the role played by climatic factors is not so important as once thought. Likewise, poor planning and policy measures consistently harm the interests of small-scale producers.

The second project, conducted in Kenya, Bangladesh and the Philippines, aims to identify what can be done to improve the livelihoods of smallholder livestock producers by analysing the policy and scale factors affecting their productivity. This project, which is not yet complete, has shown that, although often disadvantaged compared to large-scale producers, smallholders are more competitive than had previously been supposed and are likely to remain in the market for livestock production for the foreseeable future.
Transregional analysis of crop–livestock systems

Economists predict that livestock production in developing countries will continue to expand and intensify to meet rising demand from urban consumers. Yet they are typically unable to say where, when and how this will take place. Will growth in the sector occur primarily in peri-urban or in rural areas? Are fertile soils and good growing conditions for forage crops a prerequisite? Researchers have largely overlooked the factors driving the evolution of mixed crop–livestock systems, and innovation within them – a gap which the first two projects described in this report are trying to bridge (see pp. 5–18).

As part of its strategy for maximising the global impact of research on livestock, the SLP therefore undertook a transregional analysis of crop–livestock systems, with the aim of identifying the common factors that drive their intensification and expansion. Quantifying these relationships across regions will help policy makers and researchers devise more effective interventions

Project partners and their strengths

• International Livestock Research Institute (ILRI)
  Geographical information systems (GISs) and databases for Eastern Africa, expertise in livestock

• International Institute of Tropical Agriculture (IITA)
  GIS and databases for West Africa, expertise in tropical agriculture

• Centro Internacional de Agricultura Tropical (CIAT)
  GIS and databases for Latin America, expertise in tropical agriculture and dual-purpose livestock production

• University of Peradeniya (Sri Lanka)
  Extensive networks throughout South Asia

• BAIF Development Research Foundation (India)
  Local field-level presence in South Asia

• National institutions (Latin America, sub-Saharan Africa, Asia)
  Applied and adaptive research, national and local knowledge and contacts
targeted to farmers’ real needs. Supported initially from SLP core funds, the project was funded in its final stages by Germany’s Gesellschaft für Technische Zusammenarbeit (GTZ).

The SLP’s comparative advantage for this kind of analysis is its ability to build on the capacity of different CGIAR centres around the world. Each centre is able to enrich the project through its own regional networks and contacts.

The main centres involved in this project are CIAT in Latin America, IITA in West Africa and ILRI in Eastern Africa. These partners first developed a conceptual framework to identify and quantify the different factors driving intensification and how these factors interact with one another. The researchers then conducted a three-step analysis, using data collected at increasingly detailed system levels. Firstly, at the village level, researchers looked at the overall crop–livestock system to understand how this evolves and to identify the relationships between the factors that drive intensification. Secondly, through farm-level analysis, the patterns and relationships identified at the first level were tested using household, agroclimatic, infrastructure and market data. Activities at the third level – the individual household – consisted of modelling and testing the factors influencing farmers’ decision-making and the consequences of those decisions – particularly how they determine the patterns identified at the first two levels. The analysis focused mainly on systems where milk is an important output.

A key tool in the analysis is a household utility model with indicators of crop intensification, livestock intensification and crop–livestock interactions. The model establishes a set of basic principles that help predict household decisions in response to changing prices and other variables. Using the techniques of utility maximisation, the model indicates whether or not farmers should seek to intensify their enterprises, depending on the prices they face, their access to markets, agroclimatic conditions and other factors. At each level of analysis, data from different sites are ‘pooled’ to reveal common patterns and a single analysis is then conducted on them. Lastly, the researchers use the results of the analysis to suggest planning and policy interventions that will improve livelihood opportunities for the rural poor while protecting the environment.
The intensification of livestock production is not driven solely, nor in some cases even predominately, by factors associated with land and its availability. Researchers often assume that agroclimatic characteristics, such as soil fertility and rainfall, are the primary factors that determine the nature and evolution of all mixed crop–livestock farming systems. However, this largely ignores a number of socio-economic factors that are also important determinants for farmers (see project reports on p. 5 and p. 42). A local increase in population density, for example, may contribute either positively or negatively to labour costs. In Southeast Asia, such increases are commonly matched by an increase in infrastructure development and job opportunities, thereby driving up the cost of labour. In most of Africa, where infrastructure development and migration to cities are more limited, local increases in population density translate into a flooded local market of surplus workers, which keeps labour costs low. Choices are, then, not strictly land bound, as farmers will decide whether or not to adopt a technology or to modify their farms on the basis of opportunity costs – especially labour availability and market access. An important objective of this study, therefore, was to distinguish between the effects of changes in population density and the effects of changes in labour costs.

Fifteen countries in sub-Saharan Africa, Asia and Latin America were selected for the first, broad level of analysis. Forty-eight sites with a wide range of climatic characteristics and of degrees of intensification were surveyed. Farmer group interviews were used in conjunction with data on human and ruminant population densities and climatic characteristics.

Results for the most part confirmed the predictions of the conceptual framework, indicating that decisions to intensify are primarily driven by market access and the relative costs of labour and land. Agroclimatic factors play a less decisive role. Higher levels of interaction between the crop and livestock components of a system were found in areas where labour is relatively cheap. Moreover, the use of planted fodder in all three regions is closely linked to the low opportunity cost of labour due to the work and time required to grow and harvest it for livestock feeding (Figure 3). However, this knowledge is rarely applied by researchers and extension workers, who continue to recommend fodder cultivation on the basis of climatic zone, disregarding the strong
negative effect of high labour costs. Similarly, stall-feeding is still promoted in areas where land is not yet scarce but labour is, whereas the analysis showed that this technology is unlikely to be adopted or even to prove effective under these circumstances. Stall-feeding may, or may not, bring other benefits besides increased efficiency in feed utilisation and manure collection, such as reduced exposure to diseases and uncontrolled breeding. For all these reasons, a thorough assessment should be made to ensure its applicability before efforts are invested in its promotion.

Participating scientists used linear regression techniques coupled with geographical information systems (GISs) to predict the level of crop–livestock interactions between 2000 and 2025. Results highlighted a number of areas in Asia (particularly China) and South Africa where the sustainability of mixed crop–livestock systems will come under threat. The degree of interaction between crops and livestock is likely to decrease in these areas, as labour costs will rise faster than population density. As labour becomes scarce, smallholders will probably shift towards specialised crop or livestock activities that involve fewer on-farm interactions. An example is the planting of Napier grass, a specialised fodder, instead of maize planted for both food and fodder. Some of these activities may have negative environmental consequences.

For the second level of analysis, five countries were selected: Colombia, India, Kenya, Niger/Nigeria and Sri Lanka. Some
7790 households were geo-referenced and road networks were used to determine market access. Three road types were identified: tarmac, all-season and dry-season roads. The researchers assessed farmers’ choices related to intensification both on an area-specific basis and for all data sets combined. The results showed that common driving forces are at work in the majority of the case studies: households were more likely to have intensified their production system and diversified their sources of income by integrating their crop and livestock enterprises if they had easy access to roads and were located in areas of high population density. Farmers’ level of education also stood out as a factor determining decisions to intensify.

Four of the countries analysed at Level 2 were used in the third and final level of analysis, the exception being Colombia. Surveys and interviews were carried out regularly over a 1-year period to capture the biological, social and economic factors affecting farmers’ decisions. Results again showed that farmers’ choices are determined largely by the opportunity cost of labour and by market incentives, confirming the conceptual framework’s predictions.

This study has confirmed what should have been known and acted on long ago: that policy makers, researchers and extension workers need to understand and target the real needs of smallholders before they intervene to meet those needs. Interventions must be driven by demand, not supply. This knowledge is being applied in new SLP projects on fodder innovations (see p. 51). As primary beneficiaries, farmers will profit through improved farming system productivity resulting from the adoption of better targeted interventions. Policy makers also stand to benefit by applying this knowledge to future policy planning and implementation.

Project scientists are now conducting further data analysis before finalising their recommendations to planners and policy makers. The recommendations will emphasise the need to improve market access through the building and improvement of roads and to target interventions, especially on-farm fodder production, carefully if public-sector investments in research and development are not to be wasted. The next phase of the project, supported by the Dutch Ecoregional Fund, will run to 2005 and will work with policy makers to translate knowledge into impact through the improved use of modelling applications.
Policy and scale factors affecting smallholder livestock production

In many parts of the developing world, growth in the dairy and poultry sectors has opened up new income-earning opportunities for poor households. Yet, even as small-scale livestock production expands, there is a risk that misguided policies may distort the market in favour of large-scale operations, shutting out the smaller operator. To find out what policy makers can do to create a more level playing field, the SLP provided funds for a joint project between ILRI and the International Food Policy Research Institute (IFPRI).

Project scientists conducted case studies with national partners in Bangladesh, Kenya and the Philippines. These countries were selected because they represent a continuum of livestock production systems: Kenya has a large dairy and a small pig sector, with slow market growth, whereas the Philippines is the mirror opposite, having rapid growth and small dairy but large pig sectors. Bangladesh is roughly in the middle of the continuum. The project first looked at input and output costs, market outlets and product characteristics among small-scale and large-scale producers, as a basis for comparing the two groups. Next, the roles of operational efficiency, transaction costs and policy subsidies were examined to determine their effect on profitability at different scales of production.

Project partners and their strengths

- **International Food Policy Research Institute (IFPRI)**
  Policy research on agriculture, including livestock
  Analytical and statistical methods

- **International Livestock Research Institute (ILRI)**
  Knowledge of small-scale farming
  Expertise in designing and conducting surveys

- **National partners (Bangladesh, Kenya, the Philippines)**
  Local knowledge and contacts
  Survey design and implementation
In Kenya, scientists assessed the status of the dairy and poultry sectors in Nairobi, Central and Rift Valley provinces – three intensive livestock-producing areas. Inefficiency was prevalent throughout both sectors. In the dairy sector, farmers are making up to 36% less profit than they could be. As the size of operations increases, so too does efficiency and profitability. Larger dairy producers tend to be better endowed with land and capital, enjoy better access to support services (e.g. credit and extension) and often use high-yielding technologies. Typically, they spend more on livestock feed than do small-scale producers. They also receive higher prices for their milk due to their proximity to urban centres and good roads. Intriguingly, however, differences in efficiency and profitability between the two scales of production are not very large, suggesting that small-scale producers are likely to remain active players in the market for the foreseeable future, despite the disadvantages they suffer as a result of policy distortions.

One area in which policy makers could intervene to level the playing field is in stabilising and increasing milk prices, which tend to be lower than the world average at present. Refocusing extension services so that these target small-scale producers would also help. At present, 63% of dairy producers receive no advice at all from extension, with a high proportion of these being smallholders. Co-operatives are an effective means of making small-scale dairy farmers more efficient, helping them not only to market their milk but also to access information and veterinary inputs. Policy makers could usefully introduce measures to develop co-operatives and promote membership of them. Other constraints facing the dairy industry include the high cost of inputs and inadequate access to credit.

Inefficiency is also a major problem in the poultry sector. Again, large-scale operators perform better, earning 74% of potential profits compared to 52% and 50% in small- and medium-scale farms respectively. Elements contributing to inefficiency are similar to those in the dairy sector and include long distances from urban centres, bad or non-existent roads, poor extension services and the unavailability of credit. Disease outbreaks and the high cost and variable quality of concentrate feeds also play important roles. Farmers on all scales are increasingly vaccinating their birds against Gumboro disease, which has become a major problem in
recent years. Although large-scale producers received up to three times more extension visits per year than small- and medium-scale operators, 45% of producers had received no extension visits at all in the past 12 months. Providing more effective extension services to small-scale farmers would contribute tremendously to their profitability.

In Bangladesh, the study identified several policy interventions that could help small-scale operators participate in the expanding milk market. The profitability of dairy operations was found to be influenced by factors such as cattle breed types, economy in feed purchases and choice of market outlets, as well as access to credit and extension.

In the Manikgonj, Pabna and Shirajgonj districts, farms with crossbred dairy cows were compared with farms that had local cows. On farms of all sizes, crossbred cows produced twice as much milk as local breeds. Of note was the fact that, because of better feed quality, local cows on farms that predominantly had crossbred cows produced up to 1 litre more milk per cow per day than local cows on farms that predominantly had local cows. In addition, crossbred cows produced approximately the same milk yield whatever the farm size, whereas local cows on small farms produced lower yields than local cows on larger farms.

Distance to market or milk sale outlet increases with the size of the operation for both farms with crossbreds and farms with local cows. However, economies of scale play a large role in terms of feed purchases and access to external services: larger farms tend to pay lower prices for feed than smaller producers because of the larger amounts they purchase; they also have better contacts with extension and veterinary services.

Farms with more crossbred cows in the total dairy herd were found to be more efficient and typically possessed more pasture land. Although farms with local cows were generally less productive than farms with crossbred cows, their productivity increased with education levels, herd size and area of pasture land. Profitability on both types of farm was affected by wage rates and the price of dry roughage and concentrate feeds, as well as by the estimated cash value of the total herd. Designing policy interventions that ease constraints in each of these areas and targeting such
policies to smaller farms, which face more challenges than their larger counterparts, could well make the whole dairy sector more efficient. Current government policy emphasises crossbreeding, to produce larger numbers of higher-yielding animals. This is a good first step, but the other services needed to support the spread of small-scale dairying also need to be strengthened.

Poultry production in Bangladesh was analysed in two districts – Gazipur and Kishorganj. Economies of scale were found to exist for both broiler and layer enterprises. Although initial capital investment was higher in large than in small farms, medium- and large-scale farmers were able to reduce their operating costs through better management of the flock in terms of the number of batches produced per year and lower costs for day-old chicks, veterinary treatments, transport and labour. Because of their higher costs, small-scale farmers are facing stiff competition from large farms. Medium- and large-scale farmers also had better extension contacts, leading to fewer losses. Targeting extension programmes and input services to smallholders could have a high payoff. For example, broiler smallholders, currently operating at only 70% efficiency, could improve their profitability substantially if they were simply to make better use of the technology they already have.

In the Philippines, smallholder livestock production contributes significantly to household incomes among the poor in peri-urban areas. The project compared smallholder pig producers with commercial farms and non-livestock-producing households in order to understand the impact of existing policies on small-scale producers. Contrary to expectations, the scientists found that smallholders are not being driven out of this sector and that, under certain enabling conditions, they could remain competitive for some time to come.

Pig production remains predominantly a small-scale activity conducted at household level. With an average of 56 animals each, a third of all smallholders have a livestock holding that exceeds the upper limit for a ‘backyard’ activity – 20 adult and 40 young animals – as defined by the Bureau of Agricultural Statistics. These ‘larger’ smallholders, who have expanded entirely through their own efforts to respond to market demand, suggest there is scope for new policy measures that aim for equitable growth by targeting support to smallholders seeking to grow their enterprises.
To obtain young stock, smallholders typically rely on other smallholders rather than on specialised breeders and thus own pigs of unknown genetic stock. They also tend to pay retail prices for feed that is of unreliable quality and are dependant on public-sector veterinary services. This has consequences for the marketability of their produce. Smallholder pig farmers in Southern Luzon, for example, find it difficult to sell pigs through the high-value formal marketing channel in Manila. Buyers cannot be sure that high-quality feeds or proper veterinary care have been used, increasing the risk of ending up with an inferior meat product. Yet despite such constraints, the project’s results showed that most of these smallholders – all except the very smallest – find alternative markets and do not have lower profits per unit of output than large-scale producers. The average profit per animal unit actually falls as the scale increases.

Profits per animal are more sensitive to transaction costs among small-scale than among large-scale producers. Feed, which accounts for at least two-thirds of production costs, is also cheaper for large-scale producers, who are able to make bulk purchases and to mix their feeds to obtain a higher quality product and hence a better market price. Nevertheless, the economies of scale achievable by larger-scale producers are, so far at least, not sufficient to shut smallholders out of the market. Smallholders tend to value their labour at a lower than market wage rate and can thus remain competitive as they are prepared to make lower profits. They will continue to be in business for some time to come. And pig production will continue to offer a route out of poverty for many peri-urban poor people.

The project organised a number of outreach and policy workshops. A workshop for policy makers was held in Kenya in June 2001. In October 2002, ILRI, IFPRI and the Department of Livestock Services in Bangladesh held a workshop to share their case study findings and discuss issues related to the development of the livestock sector. And a month later, a similar workshop was held in the Philippines. All these workshops were well attended by stakeholders from government, the private sector, non-government organisations (NGOs), donor agencies and extension services. Deliberations in Bangladesh were summarised in a workshop proceedings. Results from both the Bangladesh and Kenya
case studies were presented at a panel session on Livestock Industrialisation: Trends, Impacts, Causes and Policy Options, held at the Twenty-fifth Conference of the International Association of Agricultural Economists (IAAE) in Durban, South Africa.

As project partners begin sharing their results with stakeholders in the study countries, it is becoming clear that there is a real thirst for information of this kind as a basis for improving policy making. At the Bangladesh meeting, for example, the Minister of Livestock Development emphasised the importance of the poultry and dairy sectors in his country and challenged the participants to come up with tangible recommendations that governments can pursue. He asked that ‘realistic policies be framed, appropriate strategies devised, supportive institutions developed and an army of professionals deployed to promote these sectors in the greater interests of the nation’. If all developing countries were to show this level of commitment, their livestock sectors could deliver real gains in poverty alleviation and equitable economic growth.
Overcoming feed scarcity improves livelihoods

In areas where human population is rising and land is scarce, dual-purpose crops can simultaneously meet the food needs of small-scale farming families and the feed needs of their livestock. Healthier human populations can achieve higher incomes by selling surplus crop and livestock products. Recognizing the contribution such crops can make to development, SLP partners have worked on a number of food–feed projects in Africa and Asia.

Since its last report, the SLP has completed two assessments of the impact of research on dual-purpose crops in order to establish its priorities and ensure the best possible returns to donor investments. The first was on improved cowpea in West Africa and was based on the results of research in the dry savannas of northern Nigeria. This study identified many positive impacts, indicating a strong rate of return to investment. The second examined maize as food, feed and fertiliser in Eastern and Southern Africa and found that impact on livestock productivity could, for the most part, best be achieved through investment in extension services rather than in more research.

Finally, a new 6-year project on fodder innovations to meet livestock feed constraints began in India and Nigeria, applying lessons learned from previous SLP projects and other work.
**Dual-purpose cowpea improvement in West Africa**

Despite low productivity (500kg/ha), cowpea is widely cultivated throughout West Africa and is highly valued by farmers due to the multiple roles it plays in integrated crop–livestock production systems. Cowpea grain is a nutritious food for humans, while the haulms make an excellent livestock feed. Grain production in Nigeria, where the crop is most popular, has risen by over 400% in the past 40 years. The haulms are easily stored once harvested and can be sold during the dry season to provide much needed income. As a leguminous shrub, cowpea also limits soil erosion and contributes to soil fertility through nitrogen fixation. Finally, the rotation of cowpea with cereal crops reduces the seed bank of the parasitic weed *Striga*, which can devastate sorghum, pearl millet and maize stands.

West Africa, home to 240 million people or almost 40% of sub-Saharan Africa’s population, is experiencing rapid agricultural intensification driven by continuing population growth and urbanisation. Intensification on this region’s fragile soils – low in nitrogen, phosphorus and organic carbon – has increased the demand for fertiliser. Animal numbers are rising to meet the growing demand for meat and milk. As these trends continue, cowpea’s role in production systems is likely to expand. The crop’s extensive cultivation in the region, as well as its multiple uses and benefits, made it an obvious choice for the assessment of improved

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**Project partners and their strengths**

- **International Institute of Tropical Agriculture (IITA)**
  Plant breeding and genetics

- **International Livestock Research Institute (ILRI)**
  Systems analysis, crop–livestock modelling, GIS

- **University of Georgia**
  Modelling of crop growth

- **Kano and Jigawa Agricultural and Rural Development Authorities**
  Knowledge of local farming systems, on-farm research and extension
dual-purpose varieties, since this technology is merely a modification of a well known crop grown using existing farmer practices, providing a perfect setting for a ‘before and after’ study.

The technology had been developed and tested by two CGIAR centres. IITA had bred the new varieties and demonstrated that they could produce both more grain and more fodder than local varieties without the use of expensive insecticides to control the insect pests that had attacked the previous generation of improved varieties. ILRI had joined the research effort to examine fodder quality and to gauge the impact on livestock productivity. Both centres had worked with national partners to encourage adoption and the new varieties were thought to have spread widely through parts of northern Nigeria, where the SLP study was conducted (Figure 4).

The study’s main objectives were: to identify the economic, social and environmental benefits of improved dual-purpose cowpea; to value these benefits, as well as the costs of developing and disseminating the technology, so as to measure the potential returns to the investment; and to establish baseline data for future impact assessments. The project partners – IITA, ILRI, national institutions and universities – integrated various research methods, including participatory surveys at community and household

Figure 4. Socio-economic domains and improved dual-purpose cowpea adoption, Kano and Jigawa States, northern Nigeria. Source: ILRI, 2002
levels and a combination of a GIS and a newly developed crop growth model to establish the technology’s potential performance and coverage.

The project’s first activity was to hold community workshops in Bichi and Minjibir, two villages in Kano State, northern Nigeria. These villages were selected because they seemed likely to reveal different attitudes to the crop as a function of different distances from markets: whereas Bichi has good market access, Minjibir is more remote. In combination with household interviews held separately with farmers’ wives, the workshops identified the benefits of improved cowpea varieties perceived by farmers and other family members at the plot, household and community levels. The project subsequently focused on the two most important benefits cited by farmers: increased food availability and higher income.

To predict the technology’s future impact, further data on adoption rates were collected, together with information on who was...
From the Projects

adopter and why. Market access and human population density provided the conceptual framework that determined where this research should be conducted. Using GIS tools, the researchers selected 80 communities in Kano and Jigawa States for additional surveys, establishing four socio-economic domains for comparison (see box p.44).

The survey results showed that the three most important factors affecting uptake are the socio-economic domain, livestock population density and the price received for improved cowpea grain relative to the grain or haulms of local varieties. Communities with higher human populations and good market access consistently showed higher adoption rates than other areas. However, even in such villages, certain households continued to use local varieties. Adoption levels for varieties producing large amounts of fodder were also higher in areas where livestock population density was, or was perceived to be, high. The improved varieties increased adopting farmers’ incomes, which in turn led to further uptake.

To throw light on the reasons behind varying adoption rates within a given community, as well as how farmers obtain information and new technologies and how they use them, the scientists conducted additional household surveys in four villages, each representing one of the socio-economic domains. Interviews were conducted separately with men and women, and with poor and rich households.

The results supported the findings from the village-level survey but further revealed that farm and herd size also influenced uptake, although household wealth and labour availability apparently did not. This suggests that even relatively poor farmers are able to adopt new varieties and benefit from their use. Farmers emphasised the multiple benefits related to the fodder and soil fertility enhancing aspects of the improved varieties rather than higher grain yields alone. But their responses varied according to socio-economic domain. In the HPHM domain, farmers mentioned the sale of surplus grain as a benefit, whereas in the LPLM domain, improved fodder use and storage were cited more often. The new technology brought benefits for both women and men: cowpea is a good source of protein for small ruminants, which are traditionally under women’s care and are sold by women to
meet household needs such as school fees or medical expenses. In addition, many women process surplus grain into snack foods, which they sell on roadsides or in village centres.

Using GIS, the researchers extrapolated the survey findings across West Africa to simulate the expected spread of both local and improved cowpea varieties. To predict grain and forage yields under different agro-ecological and management conditions, the partners developed a new computer model, CROPGRO-Cowpea. In keeping with the multiple uses of the improved varieties, the model was designed to calculate total biomass production rather than grain yields alone. To account for the effects of weeds, insect pests and diseases, which are not included as model variables, the yields predicted by the model were divided by three to provide a more realistic forecast.

The researchers used the productivity improvements predicted by the growth model to estimate the total value of adoption within each recommendation domain, using an economic surplus model. They then compared this value with estimated research and extension costs, using a 20-year time-line. This exercise showed that the economic benefits of the technology paid for the costs of developing and disseminating it within 3 years. The rate of return on investments in dual-purpose cowpea was estimated at 71%, with the net present value of the research and extension effort predicted to be US$ 606 million. This high rate of return makes a strong case for continuing cowpea research and dissemination in the region.

The project’s integrated research approach provided practical lessons for researchers, policy makers and other stakeholders. The multi-partner collaboration fostered by the SLP helped to close the ‘feedback loop’ from farmers back to researchers and extension workers, revealing, among other things, that traditional extension in Nigeria is not effectively disseminating new technologies or knowledge to farmers in more remote areas. This suggests the need to strengthen existing or create new institutions. Research networks with an interest in cowpea could facilitate scaling up and dissemination throughout the region – if they could marshal the necessary resources. New research approaches such as best-bet interventions (see p. 20) are also worth exploring as an alternative means of assessing the local suitability of the technology,
prelude to its more widespread adoption. There is a clear need for further monitoring of the adoption process as it evolves, including exploration of the newly revealed benefits for women.

Maize as food, feed and fertiliser

Governments in Eastern and Southern Africa have long afforded high priority to research on maize because of this crop’s major contribution to food security for a high proportion of the region’s population. Planted on 15.5 million hectares across the region, this food staple provides a minimum of 25% of total calorie intake for over 80 million people. Research has understandably focused largely on breeding new, high-yielding varieties and on the agronomic practices needed to optimise the grain yield and nutritional value of these varieties as human food. But the intensification of mixed farming systems combined with the shrinking area devoted to traditional open-access grazing have created the need to consider maize crops as a source of feed for ruminants as well as food for humans. And, as soil fertility continues to decline throughout much of the region and farmers remain unable to purchase expensive inorganic fertilisers, interest in the role maize could play in restoring soil fertility has increased.

To help guide future research on maize in the region, ILRI joined forces with the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) to carry out an ex-ante impact assessment. The project, funded by the SLP and implemented from 1999 to 2001, aimed to identify the management practices for maize that, if promoted, would contribute to higher and more stable grain and fodder yields while protecting the natural resource base. Research into improving the crop’s biomass and using this to provide feed

Project partners and their strengths

- **International Livestock Research Institute (ILRI)**
  Animal nutrition, mixed crop–livestock systems

- **Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)**
  Maize breeding and agronomy, maize-based systems research
for livestock and to restore soil fertility (either through manure/compost or through direct incorporation) was conducted as a basis for assessing the trade-offs with the human food benefits realised through the development and dissemination of conventional high-yielding varieties bred to produce grain alone.

The study looked at maize production and use in Kenya, Malawi, South Africa, Tanzania and Zimbabwe. These five countries together account for 73% of the maize grown in Eastern and Southern Africa. The scientists participating in the project used a GIS and satellite imagery together with case study information and secondary data to characterise the various maize-based production systems found in these countries. Defined in terms of maize cropping density and human population density, four systems were identified: small-scale intensive, medium-scale intensive, medium-scale semi-intensive and medium-scale extensive. For each system, the impact of future interventions on soil fertility, fodder quantity and quality, animal health and productivity, human nutrition and other factors was assessed. For fodder quantity and quality, both genetic and management intervention pathways were assessed (Figure 5).

![Figure 5. Relationships between system components and intervention pathways in maize-based farming systems. Source: ILRI, 2003](image-url)
The scientists conducted simulation modelling using the CERES maize and CROPGRO models to evaluate grain and forage production once the effects of each intervention had been quantified. They also used milk production and soil fertility modelling tools to assess the impact of interventions on these indicators. Finally, interventions were assessed across different systems using ILRI’s economic surplus model with a 20-year time-horizon (Figure 6). Information from these modelling studies was scaled up to the national level in each country.

Results from the economic surplus modelling pointed to the potential for achieving substantial benefits through improved livestock feeding, particularly for smallholders in the more intensive systems. Dry maize stover as a basal feed during the dry season is very important in all four systems, but its poor feed quality limits the options for improving its contribution to livestock productivity when fed alone. Used in combination with better quality feeds, such as Napier grass, maize stover can, however, deliver higher milk and meat production for the smallholder. Projected returns are strongly linked to effective extension and are conditional on whether or not adoption costs are a constraint to uptake.

Figure 6. Parameters needed to assess the costs and benefits of interventions in maize-based systems using ILRI’s economic surplus model.
Source: Adapted from Randolph et al., 2001
Intercropping is already widely practised in Eastern Africa, but less so in Southern Africa. Promoting this practice more widely would produce substantial benefits – second only to those produced by better feeding strategies. Intercropping with nitrogen-fixing legumes, such as cowpea or pigeonpea, improves soil fertility and hence raises subsequent crop yields. Medium-scale extensive systems, with their larger fields, stand to benefit most from this practice.

The sizeable investment costs associated with these first two options are offset by the considerable potential impact they offer to smallholders. Farmers’ incomes should both increase and become more stable over time, as their production systems become more diverse and sustainable.

A third option is improved green fodder management, which could provide attractive benefits for small- and medium-scale intensive systems. The use of weeds collected within maize stands for feeding livestock showed reasonable returns in the form of increased milk and maize production, despite additional labour costs. These returns are attractive because they can be achieved without investing in research and with a minimal extra extension effort. However, the potential benefits from this option are difficult to quantify as they vary due to unpredictable levels of weed infestation. Another option, which would largely replace the use of weeds, is high-density initial sowing of the maize crop followed by thinning as the crop matures and feeding the thinnings to livestock. High-density sowing has little impact on final grain yields at harvest and this option provides additional high-quality fodder, which in turn boosts milk production.

Farmers could realise considerable economic benefits by rotating maize with improved fodder crops such as Napier grass. However, cultural resistance to replacing a staple food crop with fodder, as well as questions as to what this could mean for long-term food security in the region, make this an unviable option in all but a few highly favoured areas. The benefits of increased milk yield are offset by the negative impact on overall maize yields.

Many farmers in Eastern and Southern Africa manage manure inefficiently. Manure is often applied only to cash crops, leading to the mining of nutrients from maize fields – a trend that could
have serious consequences for the crop’s long-term sustainability. Research has shown that improved manuring is effective in replenishing soil nutrients and improving both yields and yield stability over the longer term. However, the potential benefits of improved manure management are not easily quantifiable and are offset by relatively high extension and on-farm adoption costs. Further research on this intervention is needed, as the conclusions reached by the SLP study are highly sensitive to the study’s underlying assumptions. In contrast, further investment in breeding for improved feed value appeared to offer few benefits. The modelling exercise suggested that a small increase in fodder digestibility would lead to only modest increases in milk production – too modest to warrant the high investment costs.

Information from this impact assessment has helped prioritise and target research and extension activities. Similarities in the maize-based systems of surrounding countries suggest that results in the five countries covered by the study would broadly apply to the rest of the region. One noteworthy finding is the fact that the number of viable intervention options is lower in the early stages of system intensification. The potential benefits from interventions are much greater for small- and medium-scale intensive systems with good market access. Viable options for medium-scale semi-intensive and medium-scale extensive systems are limited by the greater costs associated with them. With the exception of improved manure management, results point to the limited contribution that new research can make to improve the productivity of the maize component in mixed crop–livestock systems. In contrast, investments made in more and better extension could yield significant benefits. The need for increased extension efforts in the region is almost universal, being found across all systems. Future investment should focus on this clear need for further extension and the dissemination of existing technologies.

Enhancing livelihoods through fodder innovations

The inability of small-scale producers to feed their livestock adequately throughout the year, and particularly during the dry season, remains the most critical constraint to increased livestock productivity throughout most of the developing world. Improved fodder options, including crop residues, forage crops and pastures
as well as shrubs and trees, can effectively address this constraint. However, when introduced on their own, these options offer incomplete solutions to farmers. Research has shown that creating a favourable environment for the uptake and dissemination of new fodder technologies requires holistic, multidisciplinary approaches that take into account the needs of the whole farming system, especially the need to keep labour costs low and to ensure surplus produce can be marketed — but need to ensure a ready supply of planting materials and advice on how to manage the new technologies, which may be required to enhance soil fertility and to control soil erosion or weeds and insect pests, as well as to boost animal productivity. The mechanisms, partnerships and processes required for scaling up must also be included. Such approaches are being pursued through an SLP-supported project funded by the UK’s Department for International Development.

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### Project partners and their strengths

- **International Livestock Research Institute (ILRI)**
  - Livestock feed resources and nutrition, nutrient cycling, scaling up
- **International Institute for Tropical Agriculture (IITA)**
  - Cowpea breeding
  - Socio-economics and natural resource management
- **International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)**
  - Pearl millet, sorghum, groundnut
  - Cropping systems, farmer participatory research, modelling
- **Centro Internacional de Agricultura Tropical (CIAT)**
  - Tropical pastures and legumes
- **World Agroforestry Centre (ICRAF)**
  - Tree fodder species
- **National partners (India and Nigeria)**
  - Mixed crop–livestock systems, on-farm research, local knowledge and contacts
- **Non-government organisations (India and Nigeria)**
  - Development work, local knowledge and contacts
Managed by the SLP, with ILRI as the executing agency, the project works with a wide range of partners, including farmer and community groups, national research institutions, NGOs and the private sector, in addition to other international research centres. By building on existing partnerships and by tapping farmers’ knowledge of whole-farm approaches, researchers aim to: produce reliable information on fodder options for both poor livestock producers and associated service providers (such as feed manufacturers); enable the scaling up and out of fodder innovations through institutional alliances; and establish and strengthen the production and dissemination of seed and other planting materials. Lessons on the partnerships and processes that support participatory research and development geared to the adoption and dissemination of fodder innovations will be drawn out for the purposes of transregional analysis.

India and Nigeria both have large populations of poor livestock keepers living in areas that are chronically short of livestock feed. They also share rapidly growing markets for livestock and livestock products, in addition to fodder. Past research in these countries has revealed exciting opportunities for transferring technologies, in addition to research approaches and methods, and for scaling-up activities to achieve widespread impact (see box overleaf).

The project’s first activity was to conduct country studies on existing fodder work as a basis for identifying opportunities to link with ongoing projects and to create a coalition of national and local partners. Next, through stakeholder workshops, coalition partners identified ‘pilot learning sites’ for project implementation in a range of agro-ecological zones and production systems. Sites were selected on the basis of their population of rural poor, existing feed constraints, access to markets, institutional support services and the potential for scaling up, among other factors.

Partners focused on three agro-ecological zones in Nigeria: the semi-arid zone, the subhumid Northern Guinea savanna zone and the subhumid to humid derived/coastal savanna zone. Two to three villages in each zone were selected, concentrating on areas where fodder interventions had previously been tested by
IITA and ILRI. In India, the partners selected sites in Andhra Pradesh that were associated with existing work on watershed development conducted by the Andhra Pradesh Rural Livelihoods Project and ICRISAT. The sites cover three production systems: a mixed crop–livestock rainfed system, an irrigated cropping system with an important livestock component and a common property resource system involving extensive grazing.

At each site, the project fosters demand-led activities through participatory approaches. Farmer focus group meetings, field visits and village-level stakeholder workshops were held to collect

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**India and Nigeria: How do they compare?**

Nigeria has Africa’s largest human and livestock populations, with most of the livestock owned by smallholders. Yet, due to low livestock productivity, the country must import large quantities of milk and meat to meet demand. Improving livestock productivity could have a significant impact on the incomes of large numbers of smallholder farmers. Work in northern Nigeria has demonstrated the considerable potential of fodder innovations. High-yielding dual-purpose varieties of cowpea and groundnut have been developed and disseminated through the collaborative efforts of IITA, ICRISAT, ILRI and national partners. Besides higher grain yields, these varieties produce more fodder with a high protein content and good digestibility. Farmers in pilot sites are rapidly adopting these varieties and experimenting with crop rotations to maximise their impact on other important factors such as soil fertility and the control of weeds and insect pests. Nigeria’s well established extension and research–extension liaison services make it an ideal country in which to locate the project in terms of facilitating the project’s dissemination and scaling up objectives.

With 200 million smallholders owning up to 70% of the country’s livestock, India offers similar opportunities to increase the incomes of the poor by enhancing livestock productivity. Grain and fodder are equally important in the country’s mixed farming systems, creating a favourable environment for the introduction of dual-purpose crops. Improved dual-purpose pearl millet, sorghum and groundnut cultivars are already grown in peninsular India and have the potential to be widely adopted in other areas of the country. Researchers are also attempting to transfer improved dual-purpose cowpea, given the excellent results achieved in Nigeria. India’s well established seed sector, together with growing private-sector involvement in the development and marketing of dual-purpose cultivars, also creates a favourable environment for impact.
information on what farmers were feeding their livestock, what they viewed as their major feed-related constraints and how these constraints could be addressed. Based on this information, the partners worked with the farmers to identify a range of best-bet fodder innovations from which they could select to match their needs.

In Nigeria, 145 farmers in seven villages across the three agro-ecologies selected dual-purpose cowpea. As cowpea is the major grain legume in the project area, a cowpea–sorghum crop rotation was promoted. Individual farmers sowed their selections on small plots (up to 0.4 ha or one-sixth of their total land holding) and managed the crop themselves. In addition, the community allocated land for a larger demonstration plot, allowing a wider range of options to be evaluated. In India, 118 farmers in 11 villages selected sorghum, pigeonpea and cowpea options. Researchers and extension workers supported farmers with advice as they tested these options, either on their own farms or in demonstration plots. In both countries, scientists are monitoring the performance of different options for their impact on poverty reduction. Data on production are being collected for comparison with local technologies so that farmers can select the options they wish to pursue (see box overleaf). Project activities in 2003 were implemented on a fairly small scale, but the plan is to scale out in 2004 on the basis of lessons learned and the identification of new pilot learning sites by partners.

At each pilot learning site, the partners are encouraging farmers to produce their own seeds and other planting materials. This will contribute to future scaling-up efforts and ensure that the process of innovation is sustained after the project has moved on. Farmer seed production plots will be established in 2004, while additional seed will be sourced from the private sector, national research institutes and other partners.

In semi-arid Nigeria, the proximity of farmers to the locations of previous projects, together with the conducive institutional environment, facilitated the direct distribution of seeds to farmers. At all pilot sites, the partners are studying the processes and pathways that increase dissemination and are most suitable for scaling out. Comparing the success and failure of alternative approaches across sites and systems will provide important lessons, allowing the
development of guidelines for future activities. Although it is still too early to identify the most promising options over the longer term, it is possible to identify certain precursor elements that favour adoption. For example, significant early adoption was realised at some sites in Nigeria due to an appropriate mix of options with up-front credit and significant extension partner involvement.

In 2004, the project will explore links with other existing activities at ICRISAT, ILRI and IITA and will begin activities in collaboration with CIAT, which has extensive experience of farmers’ fodder-related problems in Latin America and the Caribbean and, to a limited degree, in Asia and sub-Saharan Africa. The partners will engage in transregional analysis as a source of further contributions to the development process. As more funds become available, activities will expand into China, Ethiopia, Kenya, Nicaragua, Syria and Vietnam.

### Preliminary results at India’s pilot learning sites

At the four pilot learning sites, researchers identified 118 farmers who were willing to provide detailed information on livestock production trends, management practices and constraints, in addition to other household data. From August 2003 to January 2004, the researchers visited the farmers at fortnightly intervals to collect data through informal interviews.

For the main rainy-season trials, farmers selected two improved sorghum hybrids, CSH 16 and CSH 18, to grow as an intercrop or as pure stands. Early farmer feedback indicated that both hybrids outyielded the local variety in terms of both grain and fodder. The farmers preferred CSH 16 to CSH 18 because it grew taller and they felt its fodder would be of better quality.

During the post-rainy season, when a second crop is grown on residual soil moisture or under irrigation, farmers tested four dual-purpose groundnuts (ICGS 11, ICGS 44, DRG 12 and ICGV 89104) and a local variety. In terms of pod yield, all the dual-purpose varieties outyielded the local variety, while for haulms, yields were comparable. Although the differences in yields were insignificant, farmers’ ranking of the improved varieties differed across village sites. For example, farmers from Mahabubnagar village ranked DRG 12 as the best option, whereas Kunool and Ananthapur farmers chose ICGS 44 and Nalgonda farmers ICGS 11. Five dual-purpose sorghum varieties were also compared with the local variety. Farmers ranked DSV 5 and the local as their favourites. Several other food–feed legumes and forages were also tried, with moth bean, lablab and stylosanthes showing promise.
By the project’s end, the partners expect to have enabled some 20,000 poor farmers across the various participating countries and sites to identify and select fodder innovations to match their needs. Most of these farmers will have experienced increased incomes as they gain access to the growing market for livestock products in their area. In addition, local seed systems will have been established or strengthened.
A search rewarded

The SLP and its partners often refer to synergy as an ingredient of their activities. What do they mean by it? And how does it occur?

Synergy is a $1 + 1 = 3$ effect. It’s what happens when the impact of coinciding factors or components is more than the sum of their parts. Scientists first coined the term to describe the stronger than expected action of certain drugs. Cynics might argue that the pursuit of synergistic effects in international agricultural research and development (R&D) is a pipe dream and that the idea is merely the latest in a series of donor fads designed to evade the harsh truth: that the international community is failing to tackle the root causes of poverty and hunger.

The SLP’s experience, documented in this report, testifies to a different truth: that synergies really can enhance the impact of livestock-related R&D. These synergies arise at two levels: they are implicit in mixed crop–livestock systems at certain phases of their development; and they can be achieved within the institutional systems responsible for developing and delivering innovations to livestock keepers.

The synergies implicit in mixed crop–livestock systems are well understood and need not be rehearsed again in detail here. The benefits of manure and traction to crop production and marketing have long been appreciated. So too have those of fodder crops to soil fertility and erosion control in addition to livestock feed. A further benefit that has emerged strongly in recent research (for example in western Kenya) is the effect of certain forage legumes (notably *Desmodium*) in controlling parasitic weeds. This benefit is a striking example of how legumes can improve overall ecosystem health by warding off the pests and diseases that attack continuous cereal monocrops. In all these cases, livestock provide the economic rationale for benefits that accrue, through the feed component, to the environment and to long-term system sustainability.

These multiple benefits give us clues to the kinds of synergy that can be pursued through the institutional systems that supply livestock-related R&D. Technological options geared to multiple objectives – human food and livestock feed, soil fertility gains and the control of pests and diseases in addition to livestock productivity gains – are clearly more likely to succeed than technologies geared only
to a single objective, such as increasing grain yields for human consumption. It is a cliché, but one that bears repeating: only a holistic, multidisciplinary approach that harnesses the contributions of different partners can deliver such options.

As this report has shown, the SLP is delivering just such an approach. Its status as a cross-centre programme in the CGIAR system means that it is perfectly placed to harness the contributions of the system’s hitherto largely separate crop and livestock programmes. Several projects described in earlier sections show how the collaboration between such centres as CIAT, CIP, ICRAF, ICRISAT, IITA and ILRI, fostered by the SLP over the past decade, has brought new expertise to bear on the challenges posed by the development of smallholder production systems. As each centre is drawn into the collaborative effort, it brings with it a web of regional and national partners that can enrich the research process still further.

Another source of synergy for the SLP is the coherence of its portfolio. All its projects relate to the central role of the feed component in mixed crop–livestock systems, thereby allowing a high level of cross-fertilisation between projects. There is a strong emphasis on the study of system evolution as a basis for improving the targeting of feed-related technology in the future. As the project on fodder innovations in Nigeria and India demonstrates, the lessons drawn from these studies can be fed into projects that deal directly with technology development and dissemination. Several of the tools now used to understand system evolution and to predict the impact of new technology in the SLP’s field projects were first developed in the virtual laboratories of the vSLP, a mechanism that greatly increases the efficiency of SLP research.

The SLP’s portfolio also sets up important feedback loops between the technology, institutional and policy aspects of development. The studies of system evolution have revealed the overriding influence of the policy environment on technology adoption, time and again identifying factors such as access to markets as more important than agroclimatic factors in determining the readiness of a system for innovation and change. In many countries it may be that building new roads to link remote and poor rural communities to markets is the single most important action that policy makers can take to foster more equitable rural development. Again, the study on maize has shown that it is the weakness of extension, rather than
lack of research, that most constrains the spread of innovations in the management of this all-important staple food crop. Insights such as these give unmistakeable pointers to donors and policy makers as to where they should invest to maximise the impact of taxpayers’ money.

The jewel in the SLP’s crown is the support it has given to the development of dual-purpose food–feed crops. The successful multi-institutional research that has led to the development and dissemination of these popular new varieties testifies to the importance of the SLP’s role in fostering collaboration between plant breeders and other disciplines in different institutions across the developing world. The surpluses experienced by farmers testing these new varieties have a further knock-on effect in the R&D system, since they stimulate farmers’ demand for new feeding strategies geared to more efficient feed utilisation. And there are positive interactions with management components too, since dual-purpose crops can promote a switch to the use of crop rotations and stall-feeding, leading to further benefits that enhance the whole system. If ever there were a single technology that should be promoted to enhance the productivity and sustainability of mixed crop–livestock systems, it is this one.

Like its partners, the SLP is involved in today’s intense debate on how to scale up the results of the research it supports. Indeed, the SLP’s 2001 external review recommended more efforts to derive lessons in this area – such a critical one if the world is to start winning the war on poverty, hunger and environmental degradation. Though it is still too early for the SLP to have much to say on this subject, several of its projects – and particularly the one on technology dissemination in Nigeria and India – are charged with drawing on their experience to contribute to the debate. And they will also apply lessons learned from others. In time, the exchange of experience on this issue should lead to the more rapid dissemination of technologies that work.

All this adds up to something more than the sum of the parts. The knowledge and experience accumulated over 7 years of SLP-supported research have created the potential for a more efficient and effective international R&D system – one that, over the next decade, is capable not just of making marginal improvements to the lives of a few rural poor but of dramatically transforming their prospects on a large scale. The pursuit of synergy, then, is no idle dream – it is the very stuff of impact.
Sources


Delgado C. 2003. Systemwide Livestock Programme (SLP) project on interaction of policy and scale factors affecting smallholder livestock production in developing countries: progress report. IFPRI, Washington DC, USA.

Delgado C. 2004. Project overview (draft): Systemwide Livestock Programme (SLP) project on interaction of policy and scale factors affecting smallholder livestock production in developing countries. IFPRI, Washington DC, USA.


**Websites**

CGIAR Systemwide Livestock Programme Website http://www.vslp.org/vslp/

Virtual Lab of the CGIAR’s Systemwide Livestock Programme http://inrm.cip.cgiar.org/vlab
Publications


Annexes


SLP-supported projects and their status

Increasing livestock productivity in mixed crop–livestock systems in South Asia. ICRISAT, ended in 2002.

Sustainable food–feed systems and improved livelihoods of the poor in rainfed lowland areas. IRRI, ends in 2004.


A virtual laboratory on systems analysis in mixed crop–livestock systems. CIP, ends in 2004.


*Ex ante* impact assessment of research on cowpea as a food/feed crop. ILRI–IITA, ended in 2002.

*Ex ante* impact assessment of research on maize as a food, feed and fertiliser crop. ILRI–CIMMYT, ended in 2002.

Enhancing livelihoods of poor livestock keepers through increasing use of fodder. ILRI, first 3-year phase ends in 2005.
Financial statement
(US Dollars)

The investors who supported the SLP between 2001 and 2003 are listed in the income report below. We are grateful to them and also to those who support the CGIAR centres through unrestricted funding.

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¹ Not audited report for 2003.
² The SLP supported all research projects with “Programme Attributed” funds until 2001. In 2002, with the support of Denmark, Germany and the United Kingdom, the Programme established the mechanism of funding research activities through “Project Restricted” funds.
³ Includes US$147,071 for 2004.
⁴ Includes project development expenses and publications in 2001.
## Research and programme development

(US Dollars)

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1 Funds are to support multi-institutional activities. Lead centres are responsible for distribution of funds to project partners.
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Acronyms and abbreviations

BTA  Biotecnología Agropecuaria S.A.
CASREN Crop–Animal System Research Network
CGIAR Consultative Group on International Agricultural Research
CIAT Centro Internacional de Agricultura Tropical
CIMMYT Centro Internacional de Mejoramiento de Maíz y Trigo
CIP Centro Internacional de la Papa
DANIDA Danish International Development Agency
DDG Deputy Director General
DFID Department for International Development
GIS geographical information system
GTZ Gesellschaft für Technische Zusammenarbeit
IAAE International Association of Agricultural Economists
ICRAF World Agroforestry Centre (formerly International Centre for Research in Agroforestry)
ICRISAT International Crops Research Institute for the Semi-Arid Tropics
IDRC International Development Research Centre
IFAD International Fund for Agricultural Development
IFDC International Fertilizer Development Center
IFPRI International Food Policy Research Institute
IITA International Institute of Tropical Agriculture
ILRI International Livestock Research Institute
IRRI International Rice Research Institute
LPG Livestock Programme Group
NARC Nepal Agricultural Research Council
NCAP National Centre for Agricultural Economics and Policy Research
NGO non-government organisation
R&D research and development
SLP Systemwide Livestock Programme
SPLR Strengthening Partnerships for Livestock Research
SWNMP Soil, Water and Nutrient Management Program
TAC Technical Advisory Committee (of the CGIAR)
vLAB virtual laboratory
VRI Veterinary Research Institute
vSLP virtual SLP
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