6. Strategy for ILRI Research on Feed Resources

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Abstract

The importance of feed in increasing livestock productivity and benefits from livestock is stressed. Four major feed resources are identified: pastures, common property resources, forests, and fallow lands; planted forages; crop residues; and concentrate and agricultural by-products. There is a scarcity of quantitative, country-wide data on the current contribution of these resources to the actual feed budget, and the likely trends in future. Systematic mapping of fodder resources is required, and seen as an integral part of feed research. Research on feed resources needs to contribute to poverty alleviation and production of global public goods, but ILRI also needs to have a competitive advantage in the research field, and the research needs to be cost efficient. Partnerships play a key role in producing synergies from diverse research efforts, and in implementation of research results and output-to-outcome processes. Collaboration between crop improvement and livestock research is seen as a key partnership in achieving the feed-related outputs of ILRI's Medium Term Plan. Although considerable uncertainty exists in terms of quantitative contribution of specific feed resources to overall feed budget, it seems highly probable that crop residue plays, and will continue to play, a central role in sustaining mixed-crop livestock systems in resource-poor areas.

Summary

The major problem for most livestock keepers in developing countries is to adequately feed their animals year-round. The importance of feed in increasing livestock productivity is recognized in the ILRI strategy as an area that needs further research. Feeds research plays an important role in poverty reduction because:

- Without proper technologies, feed production (and disposal of animal wastes) will impose further stress on already degraded natural resources of the poor. This will result in fewer opportunities to enhance the livelihoods of small-scale farmers.
- The needs of poor farmers are usually not met by the private sector, because their lower purchasing power is a disincentive to the private operators. When services are provided they are likely designed to maximize profits to the providers rather than maximize benefits to the poor.

Feeds Research: In feed grains, the following research areas would be targeted: international trade of grain and meat, environmental impact of industrial systems, improved nutritional value of crops, development of the feed industry, and networks, partnerships and support services. The latter would apply across the board. Food-feed crops would cover demand assessment, cropping systems, genetic enhancement, and nutrient management. Cultivated forages, trees, and grasslands would involve demand assessment, multipurpose uses, decision support tools, and forages. Rangelands research would cover drought relief, conflict resolution, local institutions, range degradation, health services, trade, and market information. The following criteria would be used to identify priorities for the Institute to conduct research on feed resources: poverty alleviation, ILRI's comparative advantage, international public goods, feasibility, geographic focus and targeted systems, and size of impacts on the poor and their systems.

Linkages to Development: It is important to develop direct and anecdotal information about fodder resources into hard data, with mapping of fodder resources, to ensure successful research-to-development linkages. The feed value of crop residues has been largely ignored in crop improvement. Consequently, new crop varieties and hybrids have been rejected by farmers because of insufficient crop residue quantity and quality.

Implementation: Different partners are needed to work on the potential feed resources described above. For example, research into rangelands as a source of fodder for livestock should focus on institutional and policy issues. Planting trees or establishing forage or grassland areas requires significant changes in the farming system. There must be a major shift in land and labor if these are to be used as a fodder source. Key partners include international and national development agencies working with local government, and agencies that have access to good quality germplasm.

Introduction

A strategy is outlined for ILRI to contribute to the alleviation of poverty in developing countries through research and research-related activities on feed resources and the improvement of livestock nutrition. We build on the efforts of the Institute to identify priority researchable issues in different production systems (ILRI, 1999a,b; see also Annex 1), within the context of the Institute's Strategy to 2010. Although much of the grain used in developing countries in industrial pig and poultry systems over the next few years will be imported from industrial countries, most of the rest of the feed, primarily in mixed crop-livestock and in grazing systems, will be produced on small-scale farms and in semi-arid and arid rangelands, respectively. It can be argued that these feed resources will be produced regardless of whether or not feeds-related research is conducted. So the obvious question is: Why is feed resources research required? We maintain that the research is not only needed, but it is a high priority for addressing poverty, because without appropriate technologies, a conducive policy environment, and effective institutions, the demands for more feed production (and the disposal of animal wastes) will impose a greater and severe stress on the already degraded natural resources of the poor. This will result in fewer opportunities to enhance the livelihoods of resource–poor livestock keepers and others who depend on livestock and livestock products. Research can provide the technologies, policies, and institutions required to stop this cycle of poverty and resource degradation.

First, we define the broad criteria by which ILRI identifies its priorities for feed resources research. Second, we discuss the key current research issues. And third, we suggest where ILRI should lead the research and where ILRI should be a partner in it.

Criteria for ILRI to identify priorities for research

We suggest that the following general criteria should be used to identify the priorities for ILRI to conduct research on feed resources:

Expected impacts on poverty alleviation: As described in the ILRI Medium Term Plan (ILRI, 2005), and in line with other international development initiatives, this is one of the most important criteria for evaluating the relevance of feed resources research at ILRI. The poverty impacts need to be considered widely as they will span beyond the producer focus, and should include impacts on poor consumers and on whole sectors (value added chains for example).

What is ILRI's comparative advantage?: Feed resources research has a wide range of actors, ranging from NARS to the private sector. It is essential that ILRI work on areas of a high comparative advantage to complement the work of others or where few partners are already engaged. The pro-poor focus helps in achieving this. ILRI should participate in projects with multiple roles: sometimes as a research leader or as a facilitator between stakeholders to ensure that the poor also benefit from the research.

Will the research produce an international public good?: The justification for ILRI's and the CGIAR's existence is largely based on the necessity to generate international public goods, by doing research that produces results of a generic character that can be applied across national boundaries. The nature of feed resources research makes it largely an international public good, whose outputs are not only applicable in large areas but also actively engages the rest of the CGIAR centers (food-feed crops research), partners, and others. The outputs and the research processes are generic, so the type of research that should be done should produce results that can generate lessons capable of being scaled out and up to other regions

Feasibility (costs, personnel, time for generation of useful knowledge): ILRI is a small institute that needs to be strategic in "picking the battles" that will yield the highest gains for the poor relative to the investments in research. Adequate partnerships are the key to ensuring that outputs are delivered.

Geographic focus and targeted systems: The poverty alleviation criteria are incomplete if information is lacking on the geographic focus and the types of systems where the research outputs can be applied to achieve the desired outcomes. This definition of the magnitude of the recommendation domains helps in identifying sites, partners, and others. It also enables ILRI to frame the research under a systems evolution framework, by looking ahead at how specific systems may change and how shifts in demand and supply of livestock products_will influence the relevance of particular research areas. In this way the research portfolio will remain dynamic as systems change.

Overall objectives of feed resources research

The **overall objective** of feed research at ILRI is to improve the livelihoods of the poor who are dependent on livestock, increase livestock productivity, and improve the sustainability of ecosystems affected by livestock through improved access to quality feeds. The three specific objectives are:

- To predict where feed-based interventions will be required, and where feed interventions will have significant effects on livelihoods by increasing livestock and overall farm productivity.
- To mitigate feed constraints under conditions of scarce natural resources, specifically land and water.
- Improve the efficiency of feed production and utilization to increase livestock productivity, and to reduce the adverse effects of livestock on the environment.

Key researchable issues to meet the objectives

Researchable issue I. *Predict where feed-based interventions will be required, and where feed interventions will have significant effects on livelihoods by increasing livestock and overall farm productivity*

The world's population is predicted to increase by 50% over the next 25 years. During this period, and if the livestock revolution fully materializes, there is likely to be a rapid increase in demand in developing countries for livestock products, driven by increasing urbanization and rising incomes (Delgado *et al*., 1999). As well, the impacts of climate change on smallholder crop and livestock production may be substantial. The result is that smallholder farming systems will inevitably change. The challenge is to ensure that the resource-poor, mixed crop-livestock, smallholder sector (and the increasing number of landless livestock keepers), which currently provides most of the milk and meat in the tropics, is able to take advantage of the opportunity to meet the increased demand for these products. To do so, the sector will need to intensify its efforts without compromising household food security, sustainable natural resource management, or rural livelihoods.

Inadequate feed resources are recognized as an important constraint to the productivity of mixed crop-livestock systems throughout the tropics. Resource-poor farmers have to make difficult choices between which nutrients are returned to the soil and which are fed to livestock. Changing production systems throughout the world and the increasing demands for livestock products, particularly in developing countries, are causing drastic changes in feed demands. To adapt to these changes and to be able to prioritize and target the research agenda on feed resources, the CGIAR system and its partners will require knowledge of the effects that these forces put on the on the demand for feed resources, from which ecosystems the supply is likely to come, and from which production and marketing systems.

Previous research by ILRI and its partners has defined potential feed and fodder resources for pastoral and agropastoral mixed crop livestock and industrial systems (Thornton *et al*., 2001). This research highlighted the important trends for feed resources derived from rangelands, crop residues, cultivated forages/trees, grains, and concentrate feeds. Unfortunately there is a lack of systematically collected quantitative data to reliably estimate and project the contributions of the various potential feed resources to actual and future feed budgets. It is also increasingly realized by national and international research and development managers that a more targeted approach to research on feed resources is required.

Research area 1: predict where feed interventions will be required, and where feed interventions will have significant effect on livestock productivity and poverty alleviation

An important international research challenge is the development of a conceptual framework, backed by a practical software-based tool, to predict feed shortages/demand using and synthesizing temporal and spatial information using livestock, population, cropping, biophysical, and economic/socioeconomic data. The conceptual framework will have a strong global dimension, while the testing and development of the practical tool will have a strong national and and district-level component. An important related issue is the development of reliable methods and tools for impact assessments to forecast the effects of feed-related interventions on the livelihoods of poor livestock keepers. There are real needs and opportunities for appropriate research to improve the livelihoods of poor crop-livestock farmers by addressing feed resource constraints. While much work has been done on feed resources, the basic problem remains: the insufficient availability of year-round livestock feeds within sustainable mixed crop-livestock systems. One reason for this is that, until now, research has tended to focus on just a small part of the total feed resource picture. The total picture is complex, involving biophysical, economic, sociocultural, institutional, and environmental factors, all of which need to be considered in relation to feed resource innovations. The conceptual framework and the impact assessment methods and tools are the mechanisms to facilitate a systematic, holistic assessment of the likely impact and consequences of feed resource innovations. To date, ex ante impact assessments have too often been focused solely on economics.

Current feed resource work at ILRI was preceded by ex-ante impact assessments that predicted cost-benefit ratios for research investments (Kristjansen and Zerbini, 1999; Kristjansen *et al*., 2002). Different impact models, however, can predict quite different impacts from the improvement of food-feed crops. There is also the growing realization that more field data on the adoption of feed technologies, and on the effects of adoption on livelihoods at the household level, are required to support and corroborate input assumptions into impact models.

Researchable issue II. *To mitigate feed constraints under conditions of scarce natural resources, specifically land and water*

The inability of producers to feed animals adequately throughout the year remains the major technical constraint in most livestock systems (Ayantunde *et al*., 2005). Meeting the future demand for meat and milk in a way that poor livestock keepers benefit more from their animal assets will require sustainable options to produce the feed required. Work at ILRI and elsewhere shows crop residues to be the single most important feed resource for livestock in smallholder crop-livestock production systems of Africa and Asia. Few country-level quantitative data sets exist.

Through coordinated central government and state efforts, India has attempted to systematically quantify fodder resources (NIANP, 2003). This survey showed that crop residues were the most important single fodder resource. Fodder from common property resources (CPR), forests, pastures and fallow lands, constituted less than 18%. Concentrates represented a very low proportion (< 4%) of the available feed resources, and there was no indication of any rapid increase in the use of concentrates (see Annex 2, calculated and summarized from NIANP, 2003). This situation is probably true for other areas where there are high numbers of poor livestock keepers, such as in West and East Africa (Thornton *et al*., 2001).

The nutritive quality of crop residues is often low and technologies for improving their quality by physical, chemical, or biological treatment have not been widely adopted The current research paradigm holds that the improvement of the nutritive quality of crop residues by plant breeding and selection is much more promising (Hall *et al*., 2004). Until recently, the feed value of crop residues was largely ignored and resulted in new varieties and hybrids rejected by farmers because of insufficient crop residue quantity and quality (Kelley *et al.,* 1996). Observations that prices for grain and crop resides are getting closer and are approaching 2:1 in sorghum (Ravi *et al*., 2004) corroborate the findings of Kelley *et al*. (1996).

The potential for breeding and selection of cultivars that provide superior grain and crop residue traits was discussed at a workshop at ILRI, and was considered promising (Lenne *et al.,* 2003) for two reasons: high demand for quality crop residues as fodder, and genotypic exploitable variation in crop residue fodder traits without detriment to grain yield. In addition, delivery pathways for improved food-feed crops are short, requiring only replacement of one seed with another without significant changes in the production system.

Next to crop residues, planted forages are generally the most important source of biomass for livestock feed (see Annex 2), especially in crop livestock systems in areas with limited land availability where grazing is limited and livestock are increasingly maintained in cut-and-carry systems. Currently about 5 million ha of forage legumes and more than 42 million ha of forage grasses are grown in the tropics, in a range of production systems from smallholder crop-livestock systems to more extensive grassland/grazing based systems (Shelton *et al*., 2005).

Research area 2: exploitation of genetic variability in crop residue quality in existing genotypes and further genetic enhancement in crop residue fodder quality

This research determines cultivar-dependent variation in the fodder/nutritive value of crop residues, and the relationships between crop residue fodder quality and other crop traits, notably grain and pod yields. Successful impacts on productivity enhancement and poverty alleviation of this research are dependent upon nutritionally significant cultivar-dependent variation in crop residue fodder value, and sufficient independence between crop residue traits and primary traits like grain and pod yield.

Previous, ongoing and planned research by ILRI and its partners covers several key crops (cowpea, sorghum, pearl millet, groundnut, maize, rice, pigeon pea, and cassava) in mixed crop/livestock systems. The expected outcome of this research is the inclusion of crop residue nutritive value as an additional selection trait and release criterion for new cultivars.

In essence this is an extension of previous research, which was largely concerned with exploitable variation in *existing* cultivars. In the light of increasing demand for fodder but decreasing land and water availability, crop residues will probably continue to play an important role in livestock feeding in the future. In fact, even in countries with largely industrialized agriculture such as the US, a renewed interest in crop residue as feed is emerging. It is therefore important to define opportunities and limitations for increasing crop residue nutritive quality above the respective crop-specific upper quality level that is currently available. This research can also use advances in the use of molecular genetic approaches.

Research in crop residues fodder traits will mainly impact on the nutrition of ruminants, but not exclusively. Research, for example, conducted by ILRI, CIP, and other partners to exploit food-feed variation in sweet potato for improving pig nutrition had a large positive impact in China (Pezo, 2004), and offers very promising results in Vietnam (Fuglie *et al*., 2005).

Achieving improvement in food-feed traits requires a change of mind-set in the international and national public and private programs on crop improvement. ILRI's primary partners and clients in this research will be the crop improvement centers of the CGIAR, in collaboration with other international and national crop research institutions. We suggest that ILRI be the lead institution, serving as a hub in these research efforts that advocates the food-feed crop paradigm, defines livestock nutritionally exploitable variation, and provides a platform that allows inclusion of crop reside quality traits as breeding and selection criteria into plant breeding. To identify the exploitable variation in nutritive value the analytical tool of choice is near infrared spectroscopy (NIRS), and the central platform through which NIRS equation can be accessed will be the Systemwide Livestock Program (SLP) of the CGIAR. Most CGIAR crop centers are already equipped with compatible NIRS instrumentation, and can therefore have easy access to NIRS equations for the crops of interest. In addition, key national institutions in East and Central Africa also have compatible NIRS instrumentation. Their exposure to the food-feed-crop concept and their access to NIRS equation was discussed at a recent workshop with participants from the US, India, Ethiopia, Tanzania, and Kenya. Follow-up implementation workshops are planned for 2006 in Ethiopia. In India several proposals are being prepared for submission to the National Agricultural Innovation Program 2006 that will strengthen Indian NARES capacity in food-feed-crop work.

Outputs and outcomes from research area 2 will yield important IPGs: a change in research paradigm in crop improvement to include multidimensional crop improvement, and tools, methods, and approaches to be used for multidimensional crop improvement.

Research area 3: use feed as entry point for overall productivity improvement in crop-livestock systems

Crop productivity in smallholder crop–livestock systems is generally low relative to the genetic potential of the crops. In most national crop improvement programs new cultivars fulfill the releasing criteria if they outperform grain/pod yields of available cultivars by 10%. This strategy can work for crops with available hybrid planting material and a competitive private seed industry that provides and promotes new cultivars. The strategy, however,often fails for crops where planting material consists of varieties that private seed companies have little interest in promoting. A 10% increase in grain/pod productivity seems to offer too little incentive and adoptive demand for such cultivars to be promoted, multiplied, and succeed. As recently shown with a dual-purpose groundnut cultivar in India, a concomitant increase of about 10% in pod yield, haulm yield, and haulm fodder quality (as reflected in higher milk yield) provided sufficient incentives for fast and large-scale adoption of the new cultivar (Pande *et al*., 2006). Release criteria for new cultivars intended for crop-livestock systems might therefore require revision. Research is required to synthesize the pertinent elements from research areas 1 and 2, to support the development of weighting criteria, and optimizing grain/pods and crop residue traits for the release of cultivars according to the production systems for which they are targeted.

In this process, ILRI will partner with many of the institutions collaborating in research area 1 and 2, but in a mainly advisory and backstopping capacity. The information generated will result in a better understanding of the criteria farmers use when adopting new cultivars, and will therefore increase the probability of adoption of new cultivars. In turn, adoption of improved cultivars will be the key element in increasing productivity in the mixed crop-livestock systems in West and East Africa and South Asia, which are also the key target areas for ILRI research because of their high numbers of poor livestock keepers (Thornton *et al*., 2001).

Research area 4: trade-off effects between use of crop residues as fodder and soil improvement in conservation agriculture

Resource-poor farmers constantly have to make difficult choices between which nutrients available as crop residues are returned to the soil and which are fed to livestock. All too often the poor choose short-term gains, which impact on their household security in the near future over options for long-term sustainability of their farming systems, such as prudent stewardship of soils and other natural resources. In most rainfed areas crop residues are completely removed from the fields and used to feed the livestock. Leaving crop residue on the field as mulch was only successful in better endowed irrigated areas, for example of the Indo-Gangetic Plain, and even there adoption of conservation agriculture practices may be mainly by wealthier farmers (Erenstein and Thorpe, personal communication). Research areas 1 to 3 will contribute to a better understanding of decisions pertaining to competitive usage of crop residues. For example, in cases of high demand for fodder and few alternative fodder resources, it is unlikely that crop residues will be used for soil improvement, and the pertinent information will be outputs of researchable issue 1.

Contrary to widespread belief most conventional crop improvement does not record straw or haulm yields, but only grain and pod yields. Breeding and selection of cultivars with good grain/pod and crop be used for soil improvement. Superior food-feed type cultivars identified from work under research area 2 should therefore increase the likelihood of implementation of aspects of conservation agriculture.

Research area 5: understand the conditions under which forage technologies are adopted

Forage technologies have had variable adoption in the livestock systems of developing countries (Shelton *et al*., 2005), and it has been shown that the successful integration of sown forages depends on there being a genuine need for improved feed by farmers. This is clearly demonstrated in the adoption of African forage grasses for improving grasslands in the extensive farming systems of Latin America in support of market-oriented beef production. By 1996, over 40 million ha were sown to *Brachiaria* pastures in Brazil (Miles *et al*., 1996). This adoption was supported by public private partnerships for forage seed production and driven by strong demand for livestock products in the region. Forage adoption has also been successful in some parts of Asia with adoption of *Stylosanthes* in both India (Ramesh *et al*., 2005) and Thailand (Phaikaew *et al*., 2004; Phaikaew and Hare, 2005). In sub-Saharan Africa forage adoption by farmers has been slow, due in part to much of the earlier work focusing exclusively on biophysical adaptation without adequate regard for socioeconomic (land and labor constraints) and policy issues, and without sufficient attention to how they fit into the farming systems.

Previous projects that have promoted technical interventions for livestock keepers have failed to achieve widespread sustainable impacts on livelihoods of the poor. This is attributed to poor delivery of technologies, inappropriate technologies and inadequate services for the poor, and inadequate local livestock-support organizations (Livestock in Development, 1999). Shelton *et al*. (2005) concluded that successful adoption of forage legumes was seen where the technologies were profitable, often with multiple benefits, and matched the production system niche and skills of farmers.

Participatory farmer-led research involving close interactive partnerships between a coalition of committed stakeholders over many years also supported adoption.

Low adoption of planted forages may be related to the lack of evidence of economic profitability, inadequate technical support (such as seed availability and a network), and more generally the lack of a network of actors to sustain the innovation process. In many countries, particularly in Africa, other problems such as land tenure and infrastructure need to be solved for the successful development and application of these technologies (‘t Mannetje, 1997). Studies by IARCs and their partners have shown that integrating planted forages into existing systems is dependent on ensuring good establishment, and that the forage produced is competitive with other farm enterprises in returns to investments in land and labor.

A priority research topic for forage development is to identify the drivers of forage adoption. Research is needed to better understand farmer demand for forages and their ability to adopt technologies to integrate forages into the system in a resource-constrained environment with shortages of labor, land, water and other inputs and increasing demand for human food. Lessons can be taken from successful and unsuccessful cases of forage adoption to understand better the constraints to increasing use of sown forages and the required market, socio-economic and policy environments required to promote uptake by poor smallholders to determine what are the drivers of adoption. The enabling environment for scaling-up available technologies is not well understood. The innovation systems approach can provide a useful framework for the analysis of the complex relationships and innovative processes that occur among the multiple actors, and the social and economic institutions involved in scaling up forage technologies, which determine whether the technological opportunities will be adopted.

Research area 6: use of forage resources as buffer, stabilizer and source of diversity in natural resource utilization

In addition to providing feeds, forages have a key role in maintaining the natural resource base and are an important land use strategy for marginal lands and steep slopes that are not suitable for crop production. They stabilize the soil, provide ground cover and wind-breaks to prevent soil erosion, and increase soil carbon content by having strong rooting and decomposition of leaf litter. Through microbial nitrogen fixation, they return nitrogen from the atmosphere to the soil. They also provide important environmental services such as carbon sequestration and enhancing the water productivity of the system. There has been much research aimed at capturing these benefits and there are now many alternative ways of introducing forages into the farming system (Peters and Lascano, 2003) that form the basis of livestock production systems as livelihood options for poor smallholders. There is, however, insufficient suitable productive germplasm identified for semiarid areas, especially in the tropical highlands where increasing population pressure and poverty have led to cultivation of marginal lands and overgrazing. The forage germplasm maintained in ILRI as a global public good is an essential resource for identification of more productive genotypes and maintenance of diversity in forage/pasture ecosystems. ILRI has established a platform of excellence in the conservation and use of forage germplasm in ILRI-Ethiopia and strengthened collaboration with CIAT in this area, as well as forage evaluation and to make full use of this key resource. Application of biotechnology in identifying traits of importance for use as feeds and environmental adaptation will further increase its use to maintain diversity and meet feed constraints in marginal environments.

Changes in land use patterns and systems intensification and market orientation, together with global climate change, are likely to have considerable impact on natural resource use in the short term. Studies are needed on how these changes influence cropping/land use decisions and livestock feeding practices, and therefore the demand for food-feed crops and planted forages, as well as the effect on the natural resource base. Gaps in research include studies to define more productive genotypes of forages in terms of biomass production, feed quality, and water productivity to meet the demands from smallholders for forages to use for ground cover in marginal areas in the drylands and tropical highlands. Impact assessment studies to determine the contribution of forages to system sustainability and rehabilitation, as well as livestock productivity, are needed to quantify the economic and environmental effects of planting forages and provide a basis for better informed decision-making by smallholder livestock farmers.

Research area 7: fodder from rangelands, common property resources and trees

These fodder resources often support livestock rearing by people with no land tenure rights. In general, availability of grazing land is decreasing due to expansion of cropping to meet demands for food, and urbanization and use of land for other activities such as industries (De Haan *et al*., 1997; Steinfeld *et al*., 1997). Reduction and fractionation of grazing lands do not necessarily mean a reduction in feed supply, but rather an increased grazing pressure and reduced access to feed resources during the cropping season. These trends are often associated with an increased risk of degradation of grazing resources and also with conflicts among different users. Public institution research into rangelands as a source of fodder for livestock focuses on institutional and policy issues. These encompass mechanisms to facilitate organization of communities to manage technical and economic resources, as well as interacting with state and national government agencies to lobby for issues such as land tenure, and usufruct rights for grazing and cut-and-carry from forest and other common property resource areas. Planting trees or establishing grassland areas requires significant changes in the farming system and tenure rights.

In this research ILRI should play mainly a facilitating role. Key partners would be national and international development agencies that work with networks of actors, and government agencies associated with policy issues. In this case, ILRI's role could be restricted to one of supporting institutional developments in association with other CGIAR centers (for example, IFPRI).

Researchable issue III. *To improve the efficiency of feed production and utilization to increase livestock productivity and to reduce the adverse effects of livestock on the environment*

Livestock clearly convey multiple benefits to society and particularly – the raison d' etre of ILRI - to the poor who rely on livestock for their livelihoods. Livestock, however, do contribute directly and indirectly to environmental problems, ranging from overexploitation of the natural resource base to production of greenhouse gases.

In most cases feed resources and feeding strategies exert a heavy influence on the degree and extent of negative environmental effects from livestock. For example fodder from crop residues will tax the natural resource base less than that sourced from intensively irrigated forage fields. Singh *et al.* (2004) showed that in Gujarat the intensively irrigated fodder plants resulted in the need for 3,400 liters of water to produce 1 liter of milk, resulting in a serious depletion of groundwater reservoirs. Efficient use of natural resources for fodder production should therefore be an important criteria for feed research at ILRI. Optimization of conversion of ingested fodder into useful products such as meat and milk is a further concept that reduces negative effects of livestock on the environment.

Research area 8: optimize feed conversion into meat and milk

Increased efficiency of conversion of feed carbon and nitrogen into meat and milk increases animal productivity while concomitantly reducing carbon and nitrogen emission into the environment. This concept is reasonably well understood (Leng, 1993; Beever, 1993) but application of the concept was hampered by lack of simple laboratory analytical techniques that can predict variations in the efficiencies of feeds and diets. The Cornell Net Carbohydrate and Protein System ultimately targets these efficiencies, but the system is analytically still quite cumbersome, and its application in feed research was constrained for this reason, particularly in developing countries. A simple *in vitro* technique was recently suggested and validated for a range of feeds that showed promise for application in routine feed analysis (Blümmel *et al*., 2001). Application of this technique to the prediction of methane produced by sheep fed crop residues and kept in respiration chambers showed two things: a) methane production was well-predicted by the *in vitro* technique; and, b) methane produced per kilogram of apparently digested crop residue varied from 35 to 61.8 liters (Blümmel *et al.,* 2005). These results suggest considerable scope in increasing efficiency of feed conversion into useful products, thereby reducing feed-derived emissions into the environment.

Keppler *et al*. (2006) presented data showing that plant metabolism could be directly responsible for up to 30% of the global methane budget, producing methane by an as yet unidentified biochemical pathway. Accepting these findings in the context of the unchallenged overall global methane balance (Keppler *et al*. 2006) leads to the conclusion that methane contribution from livestock was substantially overestimated. These findings call for a review of methane emissions from livestock. Feed intake and feed quality are the driving factors of methane production per unit livestock, and considerable uncertainties of both variables exist for many feeding systems/situations in developing countries. Filling these information gaps will have important implications for targeting the improvement of feed resources and for deriving more accurate estimates of the methane contribution from livestock.

ILRI will not lead research efforts into optimizing feed conversion into meat and milk. Recent experience suggests that ILRI can play an important role in advocating the concept, and in backstopping and capacity building for implementing technical approaches. In one instance a major global player in feed manufacturing (Cargill Animal Nutrition, USA) explored collaborative work with ILRI aimed at including the concept of optimizing feed conversion into meat and milk at the feed manufacturing level. Similarly, collaborative work was discussed with the National

Dairy Development Board in India, who also invest in feed manufacturing. Clearly both organizations have tremendous reach and multiplication possibilities that could result in significant impact.

Conclusions

As the only livestock research center in the CGIAR with many demands on it to be involved in a wide range of livestock research topics, ILRI must be careful to select those most appropriate to its mandate. For ILRI to engage in feeds research it must have a comparative advantage, being better suited than other institutions and players to take on the challenge and doing research that contributes to poverty alleviation in a way that produces international public goods. A strong targeting and impact assessment component is required to fulfill these conditions In the context of feed research for often rapidly changing systems, a feed resource framework is required to predict where feed interventions will be needed, what feed technology options realistically exists, and what impact can be expected from the adoption of feed interventions. ILRI's Themes 1 and 5 should promote and lead research to generate such a feed resource framework that would then be available to a wide range of international and national clients, for example from crop improvement institutions and other feed providers. The research should be executed in close collaboration with the Systemwide Livestock Program, the program that links cross-cutting crop livestock-related research issues within the CGIAR, and is an ideal platform for collaboration of a consortium of a wide range of partners.

ILRI is well placed to play a key role in developing approaches and technologies for mitigation of feed shortages. In this context, the following considerations are important:

- The major key feed resources that are common in target areas such as the mixed crop-livestock systems in West and East Africa and East Asia should be targeted.
- Production of feeds should not be accomplished by overexploitation of the natural resource base.
- Work on those feed resources should be partner-efficient, in that few well-defined partners can affect feed resources for the better through maximum leverage of synergies among partners.

Feed resources that currently answer these descriptions are crop residues/by-products and forages. Most partners in these areas are crop and/or natural resource management oriented, and ILRI should establish a research hub that relates to these partners providing livestock and forage nutritional expertise and leadership. ILRI has already established a platform with expertise and research facilities in the areas of livestock nutrition, feeds, and forage analysis and forage testing and use that can be used to help partners address issues of feed quality and shortages. One of the outcomes of this research is a change in crop improvement paradigms to provide cultivars that meet the need in mixed crop-livestock systems for crops that provide food and feed. Another outcome is to make better use of forage diversity to identify better adapted productive genotypes that meet farmer demands. These genotypes should be usable in low-fertility or degraded areas where cropping is not possible, to make land more productive and improve the sustainability of the production system. Initially ILRI needs to lead and drive these research efforts, promoting the concept, providing proof of the feasibility of the concept and generating appropriate tools and methodologies. Implementation of the appropriate interventions in crop improvement and cultivar release can then ultimately pass over to international and national crop improvement institutions, particularly the cultivar releasing agents.

Feeds play a crucial role in assuring benefits from livestock to the livestock keeper, but they are also a key variable in determining the degree of negative effect of livestock on the environment. Exploitation of the natural resource base to grow the feeds is clearly one mechanism by which environmentally negative effects can happen. Inefficient utilization of feeds by livestock is another. ILRI work on feed resources will address these issues by studying ways to mitigate feed shortages under conditions of limited resource input, particularly land and water. Efficiency of feed conversion in livestock into useful products such as meat and milk can be addressed by inclusion of efficiency criteria in genetic enhancement of crops and characterization of forages, and by improvement of feed formulation in manufacturing. Analytical tools to achieve this have been developed, and are available, and ILRI should promote the concept and means to use these tools through capacity building and technical backstopping.

There is considerable opportunity to meet the challenge of improving the livelihoods of smallholder farmers without causing irreparable environmental damage, by satisfying farmer demands, making, better use of food-feed crops and planted forages, and applying new approaches and tools in sustainable farming systems. This can best be achieved if ILRI works in close partnership with farmers, community groups, NGOs, NARES, the private sector, and donors to meet the challenges of improving livestock feeds.

Annex 1: Feed resources and indicative research areas

	Feed grains	Food-feed crops	Cultivated forages and trees and grasslands	Rangelands
Target systems	Poultry and pig systems	Mixed ruminant meat and dairy and pig systems	Smallholder dairy and dual purpose cattle-grassland systems (small ruminants?)	Pastoral and agropastoral meat and dairy systems
Regional relevance	Asia (China, Southeast Asia, South Asia), industrial systems in LAC, some areas of SSA and WANA	Mixed ruminant and dairy: S Asia, SE Asia, SSA, WANA, some areas of LAC Sweet potato-pig systems: East and SE Asia	Smallholder dairy: SSA, S Asia, SE Asia, some areas of LAC Dual purpose cattle-grasslands: LAC	SSA (Sahel, East and Southern Africa), WANA, East and Central Asia, NE Brazil
Indicative research areas	• International trade of grain and meat and impact on smallholders • Environmental impact of industrial pig and poultry systems and INRM • Improved crops for nutritional value • Feed industry development • Innovation networks, partnerships and support services for pig and poultry producers	• Demand assessment • Cropping systems for specific crop-livestock systems • Genetic enhancement of staple crops as feed • Nutrient management and trade-offs/competition between soil and livestock for nutrients • Innovation networks and partnerships for dissemination of food-feed crop technologies	• Demand assessment • Multipurpose use of forages for diverse environments and socio-economic niches • Information systems and GIS-based decision support tools • Forages in cropping and feeding systems • Forages in NRM strategies • innovation networks • Innovation networks and partnerships for dissemination of forage technologies	• Drought relief and early warning systems • Conflict resolution and herd mobility • Local institutions for communal use of resources • Options to prevent degradation of range • Supplementary feeding and health services • Domestic and trans-border trade • Market information systems for pastoral and agropastoral producers • Innovation networks, partnerships and support services for pastoral and agropastoral producers.

Annex 2: POTENTIAL AVAILABILITY OF DIFFERENT FEED RESOURCES IN INDIA (2003-04)

Source: NIANP, 2003

Feed Resource	**Availability (Million tons)**	**Percentage**
Greens		
1. From forest area	**89.37**	**10.0**
2. From fallow lands	**23.21**	**2.6**
3. From permanent pastures and grazing areas	**28.70**	**3.2**
4. From cultivable waste lands and miscellaneous tree crops	**17.51**	**2.0**
5. From cultivated fodder crops		
	303.26	**34.0**
Crop Residues		
1. Coarse straw	**154.83**	**17.4**
2. Fine straw		
3. Leguminous straw	**194.11**	**21.8**
	44.44	**5.0**
Total	**393.38 (44.2%)**	
Concentrates		
1. Oil Cakes	**15.76**	**1.8**
2. Brans	**13.29**	**1.5**
3. Grains for feeding livestock	**5.74**	**0.6**
4. Chunnis	**0.53**	**0.06**
Total	**35.32**	
Grand Total	**890.75**	

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