Global Agenda for Livestock Research

Proceedings of the Consultation for the South Asia Region

6–8 June 1995
ICRISAT Asia Center, Patancheru, India

edited by

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Preface

The International Livestock Research Institute (ILRI) is the newest centre of the Consultative Group on International Agricultural Research (CGIAR) having only come into being on the first of January 1995. The institutes long-term objectives are to conduct research on animal agriculture in developing regions to improve: (i) animal performance by overcoming identified constraints to animal productivity through technological research and conservation of genetic diversity amongst indigenous livestock populations; (ii) productivity of the major livestock and crop–livestock production systems typical of developing regions and to maintain their long-term productivity; (iii) the technical and economic performance of the livestock sector in these regions to ensure the appropriate translation of production system improvement into increased food security and economic welfare; and (iv) the development, transfer and use of technology by national programmes and client farmers in the agricultural systems of these regions.

In 1995, ILRI had three important tasks: (i) to develop a portfolio of research programmes to address the institutes objectives starting from the basis of the separate programmes in animal health and production previously conducted by the livestock centres of the CGIAR, (ii) to widen the former focus on sub-Saharan Africa to a truly global approach to livestock improvement, and (iii) to initiate a new system-wide initiative amongst the Centres of the CGIAR and their consortium partners to develop programmes of research for the improved provision and utilisation of feeds for tropical livestock globally. These challenges are set out in the papers by Drs Ryan and Dolan, and a report on the system-wide livestock initiative (SLI) by Dr Thomas.

As a critical part of the process of developing its global agenda for livestock research, ILRI is conducting a series of consultations with regional agricultural experts and senior representatives of national programmes for livestock research and development in the four developing country regions recognised by the CGIAR, namely Asia, Latin America and the Caribbean, North Africa and West Asia, and sub-Saharan Africa. Asia has been recognised as the initial focus for ILRl's global expansion in the Strategic Plan for the CGIAR's livestock research developed in 1994. The needs of the continent have been highlighted as being of prime importance because of the large and growing human population, the high number and relative proportion of poor people, the widespread integration of livestock into farming systems (of particular importance to the smallholders in the region) and the large numbers and diversity of livestock species.

In Asia, two major agro-ecological zones (or AEZs) are considered (an AEZ being a region sharing climatic and biophysical similarities within which there may be similar agricultural practices and concerns). The two AEZs are the humid and subhumid tropics—largely comprising the countries of the ASEAN (Association of South East Asian Nations) group, Indo-China and the Pacific—and the semi-arid tropics encompassing part or all of the countries of South Asia. In partnership with the International Rice Research Institute (IRRI) ILRI held a Consultation on the livestock research priorities for the humid and subhumid region of South-East Asia at a meeting hosted by IRRI in The Philippines in May 1995.

This Consultation, targeted at understanding and evaluating the livestock research requirements of the semi-arid tropics (SAT) of Asia, thus marks the second of the regional Consultations and following on from a global consultation held at ILRI's headquarters in Nairobi, Kenya, in January 1995. ILRI is very grateful that a second sister Centre of the CGIAR, ICRISAT (International Crops Research Institute for the Semi-Arid Tropics), has willingly hosted the present Consultation. As Dr Ryan, the ICRISAT Director General, points out in his introductory paper, this does not stem solely from the purpose of assisting ILRI hold the present Consultation. ICRISAT had recognised early the role played by livestock in smallholder agriculture in the SAT, and the present and future contribution ICRISAT's mandate crops can make to both human and livestock welfare in the ecoregion. ILRI's wish to develop knowledge of the region and appropriate programmes of research has therefore been well received by international and national bodies alike as a timely initiative.

We are grateful to the participating scientists from national programmes who developed truly representative papers for presentation to the meeting. We also acknowledge with thanks the participants (from regional donors, NGOs, national, regional and international bodies concerned with livestock improvement and ICRISAT staff) who joined in the lively discussions that animated the meeting. Not all invited speakers were able to attend and several participants contributed with informal rather than formal presentations. Nevertheless, the papers and priority setting discussions summarised in this proceedings highlight the similarities and contrasts represented by the range of agricultural settings found across a region as large as South Asia. We have sought to capture the important elements of all the contributions in this document which has added substantially to understanding the target production systems and researchable issues in livestock development in the SAT of Asia. We hope the document will be of use to all those interested in the improvement of livestock and agricultural development.

C. Devendra

P. Gardiner

Summary report on the priority livestock production systems and related research requirements for five countries of South Asia[1]

Frameworks for the identification of priority production systems in each participating country, and for the major research required for livestock or system improvement, were distributed to all participants. Participants from individual countries conferred on the submissions, and the priorities listed by the groups were discussed in the plenary session. The results of these deliberations are given in Table 1.

The major priorities for livestock improvement in the semi-arid tropics of Asia focus on:

- The provision of adequate or improved feed resources for livestock. This involves range management and/or the alternative use of fodder species in high altitude lands, and the improved use of forages and non-conventional feeds in mixed crop–livestock, single commodity dairy or fattening systems at lower altitudes.
- Mixed crop/ruminant livestock systems in dry rainfed areas are considered priorities for production systems improvement.
- Plantation/ruminant systems and small ruminant systems in Sri Lanka and Bangladesh have much in common with priority systems identified in South-East Asia. These systems should be considered with equivalent systems in other regions[2].
- Breed improvement for conventional livestock species (with a special focus on buffalo) and breeding/ conservation strategies for species typical of the region (such as yak, mithun and chauries) are required.
- Improved disease control (of both infectious and parasitic diseases, which differ in magnitude of effect by country) will be required to realise the productivity gains expected from better animal nutrition.
- The large numbers of subsistence or free ranging livestock in the region (many of which are important for poor landless people) suggest the need for research on policies and improved management of common lands to avoid land degradation and further loss of animal productivity with increasing human and animal populations.

Whilst this cross-breeding summary identifies the major opportunities for research, it cannot reflect the nuances in priorities in systems and livestock species that occur between countries subject to different climatic and socio-cultural influences. Readers are urged to consult the individual country papers for further details of the livestock situation and possibilities for research in the region at a less aggregated level.

1. Bangladesh, India, Nepal, Pakistan and Sri Lanka.

2. Devendra C. and Gardiner P. (eds). 1995. Global Agenda for Livestock Research. Proceedings of the Consultation for the South-East Asia Region, IRRI, Los Banos, The Philippines, 10–13 May 1995. ILRI (Int. Livestock Research Institute), Nairobi, Kenya. 280 pp.

Table 1. *Priority agro-ecological zone, production systems and researchable areas in the South Asian countries.*

Country	Priority AEZ	Priority production system	Researchable areas
Bangladesh	Rainfed humid lowlands	Smallholder mixed livestock production with cattle	Animal feeds and nutrition (including mitigation of flood damage)
			Breed development (of all livestock species)
			Disease control
	Semi-arid, rainfed or irrigated lowlands	Smallholder cattle/buffalo dairy production	Animal feeds and utilisation
			Breed development—with goat and poultry production targeted for opportunities for women
			Disease control
India	Semi-arid rainfed lowlands	Smallholder mixed farming systems with many livestock species including camels in dry areas	Feed resources
			Animal health (vaccines)
			Selective breed improvement (within and between breeds)
			Improvement of animal product quality (milk meat and wool)
	Irrigated lowlands	Smallholder mixed farming systems with buffalo as one key species	Feed resources
			Infectious and metabolic diseases
			Breed improvement
	Subhumid, rainfed lowlands	Smallholder mixed farming systems with multiple livestock species	Feed resources
			Animal disease vaccines
			Selection of breeding stock and genetic improvement
	Semi-arid highlands/uplands	Pastoral systems focusing on sheep and goats with other conventional and locally important indigenous species	Pasture management and additional feed resources
			Disease control and herd management
			Breed conservation and improvement
Nepal	Mountainous rainfed uplands	Subsistence smallholder herds of ruminants on high (>2400 m asl) altitude pasture	Range and migratory herd management
			Feed resources (pasture/fodder trees)
			Breed improvement (yak, chauries, goats and sheep) with wool as major output
	Mid-altitude lands (800–2400 m asl)	Mixed smallholder cereal/fodder trees/livestock for meat and milk production	Management of integrated systems
			Feed resources including forage trees
			Breed improvement (buffalo, and cattle for dairy)
			Disease control

	Humid lowlands	Mixed livestock/ crop/tree	Improve draft capacity of cattle systems
			Milk productivity from buffalo
			Utilisation of agro-industrial by-products
			Exploitation of village-level poultry production
Pakistan	High and medium altitude rainfed uplands (includes Barani and mountains)	Small ruminant fattening systems	Improving nutritive value of non-conventional feed resources
			Breed improvement (goats and sheep)
			Integrated ruminant fattening strategies
			Meat processing and marketing
		Smallholder dairying	Economic use of feed and fodder
			Small farmer co-operatives and marketing
			Disease control
	High and medium altitude semi-arid uplands	Small ruminant production	Migratory range management
			Improvement of range resources
			Breed improvement (sheep and goats)
		Draft/beef cattle production	Improved feed resources
			Feedlot fattening
			Camel production
	Semi-arid rainfed lowlands	Migratory small ruminant production	Migratory range management
			Improvement of range resources
			Breed improvement (sheep and goats)
		Semi-arid ruminant range systems	Improvement of range resources
			Breed improvement
			Anti-parasitic disease control
		Draft/beef cattle production	Improvement of use of crop residue
			Fattening systems
			Marketing
	Irrigated mid-altitude and lowlands	Smallholder mixed crop/livestock systems	Integrated livestock production strategies
			Economical livestock feeding
			Small farmers co-operatives and product handling
		Smallholder dairying	Economical use of fodder and feed
			Small farmers co-operatives
			Infectious disease control
		Livestock fattening systems	Nutritive value of non-conventional feeds
			Feedlot fattening
			Meat processing and marketing
			Economical rearing of buffalo calves

Sri Lanka	Integrated lowlands	Smallholder mixed cattle/buffalo/cereals/ draft with emphasis on milk offtake	Feeding systems for dual-purpose cattle
			Reproductive management
			Economics of production and marketing
		Poultry-intensive small scale with crops	System integration for smallholder income generation
			Environmental adaptation
			Health management
	Rainfed, semi-arid lowlands	Integrated cattle/ buffalo/crops systems for either (a) draft and meat from ruminants or (b) milk from ruminants	Utilisation of tree fodders
			Disease control
			Nutrient cycling
	Low- to mid-altitude rainfed lands	Coconut plantation systems integrated with cattle/buffalo/paddy rice for milk and draft from ruminants	System characterisation
			Introduction and utilisation of new fodders
			Patterns of collection and marketing of animal produce

Chair's welcoming remarks

J.G. Ryan

Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502 324, Andhra Pradesh, India

ICRISAT is happy to host this important meeting on behalf of the newest member of the Consultative Group on International Agricultural Research, the International Livestock Research Institute (ILRI). It is a meeting that involves 36 participants from nine LDCs [less developed countries], seven of them in South Asia, together with eight international donors and research agencies.

The overall aim is to assist ILRI define its research mandate. Until now, the International Livestock Centre for Africa (ILCA) and the International Laboratory for Research on Animal Diseases (ILRAD), its predecessors or antecedents, primarily focused on Africa. With its present global responsibilities ILRI wishes to build on extensive consultations held in 1993/94 to identify more precisely an appropriate research agenda in order to respond to the needs and priorities of national agricultural research systems (NARS) in ways that complement and reinforce them. Thus, consultation in South Asia is extremely important as livestock are very important in many farming systems.

We at ICRISAT have a special interest in livestock in South Asia as sources of draft power, organic matter, income, and livelihoods for the farmers and landless labourers of the semi-arid tropics (SAT). All of our crops, but particularly sorghum, millet, and groundnut, are also key resources for livestock, and we pay attention to their special value to livestock in our crop improvement programmes. Hence we look forward to participating in this Consultation, listening to our NARS and ILRI colleagues, and to learning from you how we, as primarily a crops research institute, can complement the emerging agenda of the national programmes, regional and international institutions in varied livestock research. We are all here to help to define the appropriate priorities and strategies for ILRI's programmes in South Asia.

Keynote address: ICRISAT's approach to developing priorities and structures for agricultural research in the semi-arid tropics of Asia

J.G. Ryan

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Summary

This introductory paper describes ICRISAT's current perspective on the conduct of its research agenda in collaboration with partners. The work is effected through 23 projects—16 single commodity projects, four integrated systems projects, and three crosscutting projects. They target specific agro-ecologies and priority outcomes within them. They represent within each project a continuum from the more strategic, basic, and applied research spectrum, through to the more applied, adaptive project, depending on the needs of the production systems, the comparative advantage of the place and the particular constraints that have been addressed during the framework of the project. We use production systems as an integrating or targeting device. These production systems are still being characterised more explicitly as part of the research projects themselves. We have explicit milestones identified. These are first described within the context of the projects and the subprojects within them, and are also used by scientists to prepare their annual workplans. We have cross-linkages among the projects, particularly via the subprojects of which a number are common to several projects. These subprojects also provide a crosscutting device for the exchange of knowledge, materials, methodologies, and technologies across the projects. And last, but by no means least, impact analysis is an integral part of the planning and the conduct of the research projects. We are thereby learning from successes and failures in translating research into technology options that make a difference in farmers' fields.

In this presentation I shall provide you with an outline of ICRISAT's research perspective in the semi-arid tropics (SAT). In particular I will highlight some of the changes that have occurred in the last two years or so in how we at ICRISAT define, organise, manage, and conduct our particular research in collaboration with our partners.

The significant change in orientation of our research and related activities across all of the ICRISAT locations was a primary emphasis in exploring the scientific synergies that are represented by the various locations. The way in which I would summarise the changes that we have implemented is represented by the acronym of ICRISAT which really stands for: Innovative, Collaborative, Responsive, Integrated, Strategic, Adaptable and Teamwork.

This signifies the background against which we moved towards these changes in organisation and management. The process began a number of years ago as we developed our Medium-term Plan (MTP) (Figure 1). These are the plans that the international centres submit to the Consultative Group on International Agricultural Research (CGIAR) which project their future work and provide justification for the resources that the individual scientists believe they need from the donor community. In our MTP we identified a total of 110 potential research themes. We reduced them to some 92 that represent the judgements of our national agricultural research systems (NARS) partners, and that show the primary constraints on the improvement of agricultural systems in crop production in the SAT and beyond, where our mandate crops play important roles.

Figure 1. The ICRISAT Medium-term Plan.

The practice that one integrates into making the choice is to look at particular problems that are significant constraints on the enhancement of productivity. One looks at past practices that could be important in enhancing productivity, and identifies those that are important in terms of their adoption potential—an important factor in terms of spillovers. The constraint themes were identified in collaboration with our partners in the national programmes. They were identified also to represent what we felt were the future comparative advantages for research by ourselves and partners. We then worked through all the themes from 1 to 92, using measures of efficiency (essentially a cost/benefit assessment of the value of success), concerns about equity—where the poorest of the poor are living, how would they potentially benefit from success—and showing the constraints that we record from success. We also looked at the internationality of the particular theme, and the contribution of each theme to the objectives and aims, considering the natural resource base. We made an estimate of the likely resources that would be required over a period of time to change the potential outcomes in an assessment of the likely values of success.

The Medium-term Plan was approved by the donors, and we began to implement it in 1994. Budget constraints intervened about that time, so that all of the planned activities from the MTP could not be implemented; indeed, some ongoing activities also had to be sacrificed. We then began to operationalise the MTP. We wanted to ensure that in translating constraints into operational projects these were focused on real needs, and that we achieved a high probability of success in the process. Our resources needed to be focused on those constraint themes to ensure efficiency, and to effectively deliver the outcomes. It was important that the themes integrated crop improvement activities with research on natural resources. We wanted to focus on sustained improvements in productivity, while conforming to the concerns about land degradation in our particular region. We therefore adopted a systems view. Another consideration was the need to provide a common focus in operationalising the MTP, that it should be effected in collaboration with national programmes.

One of the primary ingredients in translating the Medium-term Plan into operational reality was the decision to use the production systems concept as an integrating device, particularly with respect to crop improvement and resource management activities within ICRISAT. We had a lot of discussions on this issue within ICRISAT amongst the scientists, as to what that concept should represent according to the mandate of ICRISAT. What we concluded was that the concept of production systems would be primarily geographic in nature, be represented by the final characterisation of a set of physical environmental characteristics, and be a part of a characteristic suite of agricultural/farming systems. In defining production systems, we recognise that whatever sort of production system you define, there is going to be a great deal of heterogeneity.

The unique idea is that it would be a dynamic concept. Production systems are influenced not only by biological and climatic realities and trends, but also by socio-economic factors. This means that the boundaries will change over time, and at any point in time will obviously be blurred. The essential characteristics of the production system are defined by the distinctiveness of their physical resources and the overall stability of their characteristic farming systems, within which components involving technology options in various aspects of farming systems find a place.

The principle that was used to structure our research portfolio from the MTP was to target the priority needs and opportunities in designated farming systems within the SAT and beyond, recognising that a number of our crops, including chickpeas and groundnuts, are important and are grown in various agro-ecological zones beyond the SAT. In defining the production systems we clearly identified 29 target systems as being particularly relevant in collaboration with our national programme partners. We defined 12 systems in Asia, six in western and central Africa, six in southern and eastern Africa, and five in Latin America and the Caribbean region. These systems were characterised by geographic descriptives, physical environmental characterisation, elements of the major farming systems, and major constraints that operate within them. Further characterisation of those production systems is an ongoing research activity within the planned research portfolio, but we already have operational definitions and descriptions of the systems. To illustrate this point we have identified 12 systems in Asia. The first is defined as the 'Transition zone from arid rangeland to rainfed, short-season millet/pulse/livestock systems in the eastern margins of the Thar desert'. The second is 'Subtropical lowland rainy and post-rainy season, rainfed, mixed cropping of central and eastern parts of the Indo-Gangetic Plain'. The third is 'Subtropical lowland, rainy and post-rainy season, irrigated, wheat-based systems, again in the western parts of the Indo-Gangetic Plain' etc (see Figure 2 for further details).

Figure 2. Production systems relevant to ICRISAT's mandate.

Among the values of the production systems concept are that in structuring research it allows us to focus on longer term goals, provides a common focus for crop improvement and resource management research, and that it allows us to exploit synergisms within and without the research agenda of ICRISAT. It also facilitates the definition of researchable problems, and helps to define the priority outcomes that we expect from that research endeavour and, importantly, it facilitates the achievement of spillover effects across production systems and regions. As an international centre, one of our primary objectives is to try to maximise the spillover effects of what we do, so that we truly complement the activities of national and regional programmes. Another real value of the production systems concept is that in the area of research management the concept is a tangible reflection of land use, and the activities associated with the use of land; and it really helps recognition of the relevance of research for both donors and stakeholders. It provides a very useful way of ensuring the sustainability of what is done, particularly in the area of commodity improvement. In research management it allows us to disaggregate our work at various levels, depending on the need, and to reaggregate them or to divide them by agro-ecological zones for management and reporting, particularly to TAC, and to the donor community. To this end we have to define resources as best we can to be consistent in terms of aggregating up or disaggregating down. As I indicated earlier, we also believe the production systems concept provides a concrete framework for identifying collaborative opportunities with our NARS partners, and provides an integrated focus not only on research but, importantly, on technology and information exchange focused on those production systems.

So, we had a kind of a matrix that evolved as we identified those 29 production systems together with 92 constraint themes from the MTP. When we arrived at this point we realised that it was not feasible to set up project activities within the context of 92 themes. It was concluded that it was too complex and fragmented to go in that direction in terms of operationalising the MTP because we cannot work everywhere on everything at the same time. We therefore collapsed the 92 research themes into a smaller number of groups of related themes, or 'super themes'. The basic objective of that exercise was to achieve some economies of management and scale in the assembly of multidisciplinary teams, while focusing on themes of constraints. What we achieved was a recognition that there are only some production systems where certain constraints are a priority; in others these constraints would not be a component activity. This recognition was used to basically guide the location and targeting of research, and to facilitate spillover effects across regions. What that led to was then a decision to define projects that would focus initially on the production systems and the key commodities that characterise those production systems. This focus allows us to exploit synergies within an agricultural system, and to exploit the integrative power of the production system concept to focus on real problems in real production systems? and to provide a target for impact and spillover effects.

I think all of us in this field recognise that the basic supporters of agricultural research (i.e. the donors) are looking more and more for demonstrated examples of the impact of what we do. This is becoming a determining factor in the way in which we move to our final future organisational and management arrangements for research. However, the defined production systems are also commodity oriented to exploit the special strengths of ICRISAT in crop improvement and genetic resources, on which we have been working for some 23 years. We wanted to exploit these strategies in a way that recognises the central and complementary nature of crop improvement research to natural resource management. In this way we hope that the international programmes will be in a better position to package improved technology options for adoption in real farming systems.

Eventually, the outcome of these deliberations was to define three types of commodity system-based projects: Single Commodity Projects where crop improvement is targeted on the priority needs and opportunities for the mandate crops of ICRISAT—sorghum, pearl millet, finger millet, groundnut, pigeon pea, and chickpea. The projects are focused on target production systems internationally, so they are all globally defined. The second type of project that we identified is what we call Integrated Systems Projects that operate in a limited number of targeted production systems. Integrated Systems Projects are designed to achieve technology options for adoption by farmers, to enhance the welfare of those peoples who rely on those systems for their livelihoods. The third type of project is what we call Cross-Cutting Projects. They involve generic areas of research for the Institute that cut across, but also support, both the Commodity and

Integrated Systems Projects. Such projects are represented by socio-economics research on market and policy analysis, genetic resources research focused on conservation and management activities, and research-related activities on genetic resources issues and, importantly, by a cross-cutting theme on evaluation and impact assessment.

Table 1 illustrates briefly what these projects look like. There are 23 of them in all, and they are grouped into single commodity projects such as the three on pearl millet, where we associated agro-ecology and production systems. We have one project on finger millet, five on sorghum, three on groundnuts, three on chickpea, and one on pigeon pea. There are four integrated systems projects, and two economics and one genetic resources crosscutting projects.

As we move towards the project mode, we now recognise these 23 research projects as the basic operational and management units within the Institute. These projects are time-bound—they require a critical mass of multidisciplinary scientists to be involved in defining their likely impact, and the designated milestones that they expect to achieve (including the intermediate products on the way to final impact). These projects are larger than the projects we had before moving into this new mode. Resources are now assigned to projects that team leaders and team members can manage and be responsible for, and importantly, can be accountable for. There is, of course, provision for monitoring and evaluation in an annual process.

In moving ICRISAT to a project mode, we have primarily adopted a matrix form of organisation and management (Figure 3). The matrix mode that we have in place now was formally implemented in 1994, and the project mode began on 1 January 1995. It emphasises both shared responsibilities across locations amongst the scientists and those who support the scientists, and shared goals and outcomes. The matrix consists of regional programmes and the production systems within each geographic region on one axis, and global research divisions on the other axis. The axes of the matrix support the planning, delivery, and review of the 23 research projects described earlier.

The seven global Research Divisions include: Genetic Resources, Genetic Enhancement, Cellular and Molecular Biology, Crop Protection, Agronomy, Socio-economics and Policy, and Soils and Agroclimatology. Each has a Division Director, and these directors are also active members of project teams, conducting research within the project framework. On the other axis we have four Regional Programmes: Asia, Western and Central Africa, Southern and Eastern Africa, and Latin America and the Caribbean as illustrated in Figure 3.

Figure 3. ICRISAT's organisation and management structure.

In terms of achievement in translating the MTP into an operational mode emphasising projects, we believe we have achieved a balanced research agenda that allows expectations of efficiencies and synergies, is multidisciplinary, multilocational in nature, and that emphasises teamwork, devolution of responsibility, authority, and accountability amongst the scientific staff. It focuses on a rigorous research agenda that is linked to impact, is targeted on priority outcomes, and that is spelled out within the framework of projects, and endeavours to exploit the comparative advantages of ourselves with our partners in national programmes and other institutions. This provides an effective basis, we believe, for collaboration with our partners both in the NARS and in specialised institutions, and enables us to identify where special funding can be assembled in support of the areas that are on the agreed agenda of the CGIAR system.

Table 1. List of projects.

Project number	Designation	Commodity(s)	Agro-ecological focus
1	PM-1	Pearl millet	Arid to semi-arid tropical transition environments
2	PM-2	Pearl millet	Semi-arid tropical environments
3	PM-3	Pearl millet	Long-season semi-arid tropical environments
4	FM-1	Finger millet	Blast resistance/grain yield for eastern/southern Africa
5		Sorghum	Low rainfall areas
6		Sorghum	Medium rainfall areas
7		Sorghum	High rainfall areas
8		Sorghum	Post-rainy season systems
9		Sorghum	High elevation/low temperature areas
10	GN-1	Groundnut	Short duration rainfed environments
11	GN-2	Groundnut	Medium to long duration rainfed environments
12	GN-3	Groundnut	Irrigated post-rainy environments
13	CP-1	Chickpea	Moderately dry and cool environments
14	CP-2	Chickpea	Moderately dry and cold environments
15	CP-3	Chickpea	Dry and hot environments
16	PP	Pigeon pea	Short-duration production systems
17	ISP-1	Multi	Rainfed short season (< 100 days) millet/legume systems in desert margins
18	ISP-2	Multi	Short/intermediate season (110–125 days) rainfed millet/sorghum/legume production systems
19	ISP-3	Multi	Intermediate season (100–150 days) rainfed maize/sorghum/legume mixed cropping systems
20	ISP-4	Multi	Rice/wheat/legume production systems
21	Econ-l		Research evaluation and impact assessment
22	Econ-2		Market and policy analysis
23	GR		Assembly and management for conservation and utilisation

This reorganisation did not happen quickly. The planning for the MTP was started back in 1991 and was approved in late 1992 by the CGIAR. We started an internal organisation and management review in early 1993, the production system concept evolved during the course of 1993, with the major deliberations occurring in the middle of that year. The Governing Board approved the new organisation and management arrangements at the end of 1993, and we began implementation of the matrix approach late in 1993/early 1994. The concept of commodity system-based projects evolved early in 1994. There was an initial project-planning meeting in March 1994 for which most of the scientific staff were assembled. The Board approved the project portfolio outline that emerged from those planning discussions in April 1994. We had extensive training programmes for scientific and support staff during the course of 1994. These programmes involved such themes as team work, co-ordinating mechanisms, and conflict resolution—all the types of things that occur when one is endeavouring to enhance multidisciplinary interaction and cross-location interactions. Project planning continued throughout 1994, and consultations with national programmes are continuing, as they have throughout the process, particularly in 1994 when the projects began to unfold. On 1 January this year we moved to the project mode. The current and future activities associated with these changes—because project planning is a continuous process—does not begin and end at a point in time. As we are confronted by new challenges and opportunities that arise, we are willing to adapt the themes in a dynamic way; we do not plan to turn these on and off on any particular day of the year. Team building and management training will also be ongoing. Consultation with NARS is an ongoing process. Within the last two weeks there was a major consultation in southern and eastern Africa with our NARS colleagues. This was a very effective interaction to investigate how we can enhance the collaboration. The implementation of the portfolio will continue throughout 1995, and we have an annual project development cycle with provisions for review, modifications to the projects, and continuing collaboration with our NARS partners.

I think you can see from the projects that we now have, the ways in which we are using production systems as an integrating device that allows us to interact with the scientists in national programmes, in sister centres such as ILRI, and other institutions, in ways that achieve the sort of synergisms that we need. This is relevant not just amongst the projects that I have described, but amongst the needs of livestock producers and consumers and those working on the cropping systems of those production systems.

Introduction to the objectives of the meeting

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I wish to thank ICRISAT for hosting this Consultation, for its hospitality and for its support in the preparation for the Consultation. I also wish to thank Dr Jim Ryan for his welcome and introduction to the ICRISAT programme and the description of its recently completed priority-setting process. This consultation has been

supported in part by ACIAR (Australian Centre for International Agricultural Research) and we are grateful for their interest in the development of the Asian dimension of the International Livestock Research Institute's (ILRI's) programme. Finally I want to thank you, the participants, for coming to Hyderabad to assist ILRI in the process of identifying research opportunities that will contribute to addressing its new global mandate. It is my responsibility now to introduce you to ILRI and to the objectives of this Consultation.

ILRI has been established as a new livestock research institute within the Consultative Group on International Agricultural Research (CGIAR) incorporating two former institutes: the International Laboratory for Research on Animal Diseases (ILRAD) and the International Livestock Centre for Africa (ILCA). The new institute has a new mandate and a global responsibility. The development of its research programme will be determined by three major factors—CGIAR priorities, the established research strengths of ILRAD and ILRI, and a series of global consultations which will identify the key requirements to improve the contribution of livestock to sustainable agriculture in the different regions.

ILRI will have six programmes that will conduct research within an integrated framework:

- Biodiversity (conservation and characterisation)
- Production Systems Research
- Utilisation of Tropical Feed Resources
- Animal Health Improvement
- Livestock Policy Analysis
- Strengthening NARS.

The emphasis will be in crop–livestock systems guided by the CGIAR priorities:

- Increasing Productivity
- Protecting the Environment
- Saving Biodiversity
- Improving Policies
- Fortifying National Systems.

The consultations that we are organising involve senior livestock production and health officers from countries in each of the regions addressed by the CGIAR, and serve to identify the research priorities for these regions that would benefit from international research support and co-ordination. In addition, there is a CGIAR System-wide Livestock Initiative on feeds for which funds of up to US$ 4 million are available. These funds will be allocated on a competitive basis for research projects that link CG centres and NARS. Dr Derrick Thomas will describe this initiative in some detail later in the meeting.

A consultation has already been held in the Philippines (at IRRI, International Rice Research Institute) to determine priorities for international livestock research for the South-East Asian region. In the next few days we will be discussing priorities for the South Asia region and looking for priorities that the two Asian regions hold in common and which priorities are specific to the two major climatic zones. Two more consultations will be held, one in Costa Rica in October for Latin America and the Caribbean, and one that will be held in 1996 for West Asia and North Africa.

The CGIAR is attempting to consolidate its diverse research activities by encouraging links between research centres and collaboration through its system-wide initiatives, in feeds as I have already mentioned, but also in the areas of genetic resources (including forage), integrated pest management, and soil and water management. Other initiatives which address the specific agricultural problems of the major agro-ecological zones in tropical developing countries are also being mounted. The CG is also striving to strengthen national capacity. Thus, in keeping with this philosophy, the major thrust of ILRI' s future work will be in integrated crop–livestock research. Therefore, in your thinking about research priorities for ILRI, think not only of its established strengths but of what should be its new emphases, and think of them in a crop–livestock farming dimension.

We are consulting you to identify livestock research opportunities of an international and strategic nature. Projects that you are unable to undertake for reasons of lack of funding, qualified manpower, physical facilities or critical mass, and that will yield results of broad application. We should not be addressing work that is within the capacity of national systems, even if national systems are not doing this work. To undertake this strategic research we will require national] partners either throughout the life of a project, as in many aspects of farming systems research, or in validation, if new technical products, such as vaccines, are developed. We will not be able "to do everything for everyone" as Jim Ryan has said. We must be selective. We have no more resources than those of ILCA and ILRAD in the past, yet we are adopting a global mandate. Therefore, your help in identifying priorities for research whose solution will have broad applicability will be a worthy contribution to this Consultation.

Livestock research has been out of favour for many reasons including the adverse effects of meat and milk products on the health of man in the developed countries, perceptions that livestock do not contribute to the well-being of the very poor and a case that livestock are an important factor in land degradation. These reasons have contributed to placing livestock research very low among donor priorities and, in the recessionary times we have just been through, funding for livestock has been drastically cut: 40% within the CGIAR. These were also factors contributing to the CGIAR decision to reorganise its livestock research investment which has lead to the establishment of ILRI.

The weakness of many of the arguments against livestock have been exposed in more recent and thorough analyses that clearly establish the importance of meat and milk products in the proper nutrition of very large numbers of peoples and cultures in developing countries, the value of livestock in nutrient cycling and land restoration, and the absolute fallacy of some of the evidence of the role of livestock in desertification. It is important that we, the people directly involved in the development of livestock, crop-livestock and integrated farming systems, know what the real benefits of livestock are to the well-being of the poorest people. We must have these arguments available, and we must not be pushed aside by poorly substantiated and emotional criticisms. At ILRI we have assembled papers that contain quantified data and reasoned arguments, from both sides of this debate, and we will be pleased to make this information more widely available.

With adoption of its global mandate ILRI will, in conformity with its strategic plan, expand initially into Asia. This will be a gradual process, building on the outcome of these consultations, the system-wide livestock initiative and available support from donors. This does not mean that the sub-Saharan Africa region, which was the primary focus of ILRAD's and ILCA's research, will be forgotten. It is widely recognised that Africa will require assistance from the international research centres for some time to come and that ILRI's established research programmes can contribute to the improvement of the productivity of the Africans livestock industry at a strategic level. ILRI will continue to work on trypanosomiasis and tick-borne diseases. These two disease complexes are major constraints to Africa’s livestock industry but they are also global problems and therefore fit comfortably within ILRI's mandate. ILRI will continue to direct its accumulated knowledge and capacity to the development of improved control measures for these diseases but will look to where these capacities can be applied to other disease problems. This is one of the reasons for meeting with you in this Consultation.

We are also pleased to see FAO (Food and Agriculture Organization of the United Nations) represented at this Consultation. ILRI has had a long association with the FAO in the implementation of disease control and animal improvement. This will continue on a wider scale under its new mandate in the areas of genetics, production systems and policy research, and in impact assessment and decision support. These collaborations will be appropriate for the delivery of technologies to improve the role of livestock for agriculture and human well-being in developing regions of the world.

I look forward to the deliberations over the next three days.

The System-wide Livestock Initiative: Feed resource research and utilisation

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In the 1990s the CGIAR has embraced two new concepts for collaborative research to enhance the application of existing knowledge and research capacities of the CGIAR centres and their national programme partners to the agricultural problems of developing countries. These concepts are "ecoregionality" and "system-wide initiatives". Both stem from the desire to capitalise on the existing strengths in agricultural commodity research, farming systems approaches and technology application, as well as regional knowledge of the major agro-ecological zones (AEZs) resident both in the centres and in the wide group of national and international organisations in the agricultural development sphere. This approach leads to the formation of consortia of institutes, each with specific expertise and local knowledge to apply to the problem in question, and is designed to enhance co-operation and efficiency in research. Examples of ecoregional initiatives involving or convened by CGIAR centres are the African Highlands Initiative, Sustainable Mountain Agriculture (initially for the high Andes but expected to extend to the mountainous areas in other continents including Asia), the Desert Margins Initiative (which focuses on natural resource management issues in the arid and semi-arid tropics), Rice–wheat cropping systems (of importance to both major zones in Asia) and several others. These are encouraging centres, and a wider range of partners than before, to bring their specific expertise to bear in an integrated fashion on the agricultural improvement and sustainability issues of defined AEZs or ecoregions.

In a similar fashion to the ecoregional initiatives, in 1994 the Technical Advisory Committee (TAC) of the CGIAR recommended that three further subjects were of high importance to tropical agriculture and merited specific research initiatives drawing on the complementary expertise of CGIAR institutes: these were genetic resources, water and livestock. The new livestock institute, ILRI, was charged with convening the System-wide Livestock Initiative (or SLI). The specific objective set for the initiative was to define and support programmes of research to improve the provision and utilisation of feeds for tropical livestock. The rationale for this decision, based on human population demand for livestock and their products and the insufficiency of year-round feed supplies to provide productive livestock to meet this demand—a problem well known in this sub-continent—was set out in an ILRI document in 1995.[1] This focus on livestock feed improvement was reinforced by the participants from all regions who contributed to ILRI's first "global" consultation held in Nairobi in January 1995.

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1. Programme Plan and Funding Request for the System-wide Livestock Initiative. Feed Resources Research Production and Utilisation. ILRI, April 1995. 25 pp.

ILRI has convened an Inter-Centre Livestock Programme Group (IC-LPG) initially made up of senior representatives of CGIAR centres wishing to contribute to the initiative. As the SLI develops it is the intention to include representatives of other contributing institutes, including NARS, in the LPG. A call for concept notes on proposed research on the theme of feed resource improvement and utilisation went out. The full proposals came from ecoregional consortia and the SLI is supporting

regional meetings of consortium partners for the joint definition of objectives, distribution and sharing of research tasks on the basis of comparative advantage, and proposal development. All full proposals, suggested to define a three-year programme of research in the first instance, submitted to the LPG were subject to independent external review in August and September of 1995. A second meeting of the IC-LPG made recommendations on proposals to be supported by SLI funds (a total of US$ 4 million) with work on the priority research to be started in 1996.

It has been encouraging to note the enthusiasm and commitment of all concerned with the SLI process. It is hoped that strong programmes of research on this critically important topic for livestock improvement will emerge that are not only of value in specific regions, but will provide material, methodologies and results that are applicable across tropical developing regions.

Opportunities for collaboration in livestock research in Asia with ICRISAT

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Abstract

Since ICRISAT's formation in 1972, the Centre has focused on improving the production of its five mandate crops [sorghum (*Sorghum bicolor* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), groundnut (*Arachis hypogaea* (1.)), pigeonpea (*Cajanus cajan* (L.) Millspaugh) and chickpea (*Cicer arietinum* (L.)]. Of these five crops, sorghum, pearl millet, groundnut, and pigeonpea are used as dry or green fodder in most of the world' s semi-arid areas. Livestock (cattle and buffalo) numbers have steadily increased in Asia largely because of increasing demands from a growing human population. More than 70% of these large ruminants are owned by small-scale farmers who depend heavily on crop residues produced on their farms to feed these animals. These systems are under intense pressure and will need to significantly increase their production to meet future demands. ICRISAT's recent structural shift to a "project structure" with projects targeted to specific production systems and constraints in these systems will allow a greater focus on improving these crop/livestock systems. ICRISAT is committed to improving the production and sustainability of these systems and strongly feels its success in doing this will come through close collaboration with crop and livestock research and extension organisations in the region.

Background

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) does not have a mandate to conduct livestock research. However, livestock have a mandate to consume the crops within ICRISAT's mandate. This dichotomy can now be corrected through the establishment of mutually beneficial collaborative linkages with organisations that have expertise in livestock research. Of the five crops on which ICRISAT has a mandate to conduct research [sorghum (*Sorghum bicolor* (L.) Moench), pearl millet (*Pennisetum glaucum* (L.) R. Br.), groundnut (*Arachis hypogaea* (L.)), pigeonpea (*Cajanus cajan* (L.) Millspaugh), and chickpea (*Cicer arietinum* (L.))], the first three represent significant animal feed sources in the traditional systems where they are grown. In these same systems, livestock represent the major source of draft power, income, fuel, food, and fertiliser. These components are inseparable in their interdependencies; thus improving the productivity of these systems will be enhanced if all components are treated together.

At the time of ICRISAT's formation (1972) there was a strong need to improve productivity in its mandate crops in the face of a serious food security crisis. This necessitated a focus on increasing productivity in the crop components (grain vs fodder) most frequently used for human consumption. Today the situation has changed considerably, with human food being less of an issue and society's food preferences more of a driving force in determining priorities in crop improvement. These newly evolving production systems along with the more traditional systems offer significant opportunities to combine livestock and crops research agendas.

Realising these opportunities, ICRISAT has built into its recently reorganised structure a functional way in which collaborative crops/livestock research can be effectively conducted. Both the structure and the commitment are in place.

Crop research

Crop improvement at ICRISAT has many faces. Improving productivity through genetic improvement has been the backbone of our efforts. Considerable effort has gone into developing plant types that have higher grain yield potentials, resistance to pests and diseases, and enhanced tolerance to the stress-prone environments of the semi-arid tropics. Research partnerships with national agricultural research systems (NARS) have resulted in the development of improved varieties capable of significantly higher grain yields with multiple pest and disease resistance. These genetic materials have served ICRISAT and its stakeholders well. Problems of food shortages in the areas where we work have become part of the past, largely due to increased availability of human food.

Increased grain production has not always been followed by parallel increases in fodder production. In fact, increases in grain production have, in some cases, been achieved through partitioning more assimilates to grain while keeping total plant dry matter production constant. This strategy served the purpose of increasing the amount of grain available but did so with a proportional reduction in fodder production. Thus, the needs of a human population could be addressed but at a possible cost to the livestock population. ICRISAT was, and is, aware of these issues and is quickly moving in a direction that will result in crop improvement activities that are balanced to meet these changing demands.

We now know much more about changing demands than we did in 1972. In the case of sorghum and pearl millet, grain productivity remains a high priority in our crop improvement activities, although dual-purpose materials (i.e. raised for both grain and fodder) are a basic concern. Recent data (Kelley et al 1990; Kelley and Rao 1994) suggest that in some of the more traditional systems there is a need to be more aware of fodder production than we have been in the past. Price changes between sorghum grain and fodder over the last decade indicate an increased market demand for sorghum fodder. This is particularly true in areas where post-rainy season sorghum is grown and sorghum fodder is highly prized for its nutrient qualities. This increasing demand is driven by increases in total livestock numbers (Kelley and Rao 1994) and changes in livestock types. Traditional production systems relied on livestock primarily for draft power and income. Today these systems still depend on livestock to a large extent, as the primary draft source, although tractorisation is a significant factor. However, income generation has shifted from numbers *per se* to milk production. This shift is closely related to urbanisation and the requirements of a confinement dairy industry. The needs of this changing scenario will require a clear understanding of the livestock feed requirements before those requirements can be addressed through crop improvement. In addition to changing fodder requirements in sorghum, there is an indication that grain as a primary food source will be replaced with grain as a feed source (Kelley and Rao 1994). With increasing incomes there has been a shift away from course grains as human food to wheat and rice as staple starches. For sorghum, this could represent a shift to grain as a poultry feed. If this happens, there will be new and different requirements for grain quality. These requirements will be dictated by livestock needs which we need to understand.

Pearl millet represents an ICRISAT mandate crop that will continue to be closely linked to livestock systems for some time to come. This is largely because pearl millet is a staple crop in arid to semi-arid areas where few other crop species can survive and produce effectively. In these areas, pearl millet is grown as a dual-purpose crop. With its partners, ICRISAT has made marked progress in developing varieties that perform well and are accepted by farmers in the higher rainfall areas (300–500 mm) of the arid to semi-arid continuum. Progress has been slower in the drier areas where crop failure is a common occurrence and farmers are unwilling to invest in crop inputs. It is in these drier regions that livestock production becomes more important. Some of the same market trends cited for sorghum are true for pearl millet. In Rajasthan, India, severe droughts devastated livestock populations in the mid- to late 1970s. In response to this crisis, the Indian government embarked on a series of credit schemes to provide farmers with tractor power as a replacement for the draft animals lost in the drought. This scheme proved so successful that draft animals are now rarely used in this area. However, since this drought, livestock numbers have increased to the same levels they were before the drought (Kelley and Rao 1994). A major difference from the pre-drought years is that the mix of animals today consists largely of dairy animals. This change in livestock composition not only necessitates the need for a substantial fodder reserve, but requires an increase in fodder quality. To meet this demand for increased fodder quantity and quality, crop improvement activities in pearl millet will need to maintain grain production, yet remain fully aware of the potential in these systems for increased fodder quantity and quality. This can be done only through close collaboration with those involved in the development of livestock in these areas.

Groundnut is an ICRISAT mandate crop that is generally regarded as an oil crop in South Asia. While this is its primary role, there are large areas where its fodder is collected at harvest and used as a high quality feed source for cattle. ICRISAT has long realised that improving grain yield in groundnut would be enhanced through pest and disease resistance, since groundnut suffers from a range of pest and disease problems. Many of these pest and disease problems also affect the quantity and quality of fodder produced by the crop. In recent years, considerable progress has been made in developing genotypes that are resistant to specific pests and diseases, and it is now possible to address many of the farmers fodder concerns. Collaborative work in understanding the role of groundnut fodder in livestock production will be of special importance in the rainfed groundnut areas where animals are used for draft, and there is a shortage of fodder material. Currently the potential of groundnut as a fodder crop is not well appreciated by many farmers, scientists, and policy makers.

Resource management research

Research by ICRISAT and its partners to improve production through superior genotypes has been supported by a broad range of research activities targeted at improving resource management. The environments in which we work dictate a need to focus on drought. Crop/livestock systems dominate in these areas and their related production systems can be described as low-input low-output systems where the interrelationships between crop and livestock production within these systems are quite basic.

From a crop research institute point of view, livestock can be regarded as consumers of plant products and a recycling facility in fertility management. Most of the livestock-related work of ICRISAT has been conducted in the field of soil fertility. Much of this work has been explanatory and preliminary in nature and needs to be expanded. An improved understanding of the role of livestock in these systems, e.g. the nature of the relationship between livestock numbers and mix and crop production, is required. The extent to which crop selection and preferences by farmers is dependent on livestock numbers is not known. Information exists on the role of livestock in nutrient cycling but this is largely descriptive in nature and little has been done to develop a knowledge base on integrated nutrient management systems where both crop and livestock changes are incorporated. We recognise the need to develop such systems, but know this can only be done with full collaboration from organisations conversant in livestock research. There is a need to develop such partnerships in research.

Livestock in Asia

In the semi-arid tropics and subtropics of Asia, crop and livestock production have always been closely associated in mixed farming systems. Seventy per cent of large ruminants (cattle and buffaloes) are owned by small-scale farmers who share their activities between crop production and livestock. The cattle (343,093,000 head) and buffalo (132,349,000 head) in these systems depend on natural pastures, wastelands, and crop residues for their survival. The estimated area under permanent pasture is 425 million hectares, of which 400 million hectares are located in China. These permanent pastures provide a major part of the roughage intake for two to six months of the year. Taking a conservative annual estimate of about 0.8 t dry-matter yield/ha, these pastures should produce approximately 340 t dry-matter annually. This amount represents roughly 25% of annual requirements (1372 t/year) for 457,442,000 large ruminants, assuming that they require 3 t of dry matter per animal each year. The additional food resources needed to maintain these animals must come from wasteland, forest land, straw, stubble, special fodder crops, and crop by-products.

Fibrous crop residues (stover) are the basal feeds for most village animals and many urban dairy animals. Based on 1993 estimates, the production of stover from pearl millet, sorghum, rice, and wheat is about 626,962,000 t/year. These residues are the main source of feed for large ruminants in this region. There is still a substantial gap between supply and requirements, even though legume residues and some by-products are used.

Rice and wheat straws are available in larger amounts than those of sorghum, pearl millet, or groundnut, but they are not considered to be of sufficient quality to maintain animals without considerable supplementation. A strong preference for sorghum, groundnut, and pearl millet fodders has driven prices upwards to a point where, in some areas, returns to the farmers from stover are equal to or greater than those from grain. Increased production and use of these resources could contribute to the maintenance of larger animal numbers. Significant improvements in fodder/forage quantity and quality are necessary if the increasing demands for milk, meat, and other animal products are to be met. To meet these demands ICRISAT realises an integrative approach to research and development will be required.

ICRISAT structure and commitment

In 1990 ICRISAT completed its Medium-term Plan (MTP). This document represents a quantitative approach to addressing production constraints across the areas of ICRISAT's mission and mandate. To implement this plan, ICRISAT has recently undergone a series of structural changes. Central to these changes has been the identification of the priority needs and opportunities in target production systems that will serve as a focus for research projects. Production systems were initially delineated by cropping systems that were dominated by ICRISAT mandate crops. Following from this, more detailed descriptions were developed for these production systems, including information on secondary crops and livestock. Projects were subsequently developed to address primary constraints in specific production systems. Projects fell into three categories: 1. Single commodity projects, 2. Integrated systems projects, and 3. Crosscutting projects (i.e. impact analysis). In all cases these projects are closely cross-linked with other appropriate projects within the Institute, and with our collaborating partners (see Ryan, this proceedings).

Single commodity projects represent a focus on genetic enhancement and are committed to improving production in specific target production systems. For sorghum, pearl millet, and groundnut, improving productivity will necessitate increasing fodder quantity and quality. A close interface with livestock research experts is required in order to achieve our need to understand quality determinants, and the associated plant characters that will need to be enhanced. In many cases further expansion of these crops will depend more on livestock requirements than on human needs. Thus, a comprehensive understanding of the current and future livestock needs is necessary, and we feel this will require close collaboration between scientists of ICRISAT and institutions with expertise in animal production.

Integrated systems projects are unique in that they contain a broad range of disciplines and undertake research more in a "systems" mode. Because of this, they look at all components of the production system and are committed to improving whole-system productivity which in most cases involves improved livestock production. Some work has been initiated in these projects to define the role of livestock in target production systems. There is a significant amount of soil fertility work planned in these projects, and this work will need to take into account livestock/crop interactions. Livestock are an integral part of that resource base and it is crucial to understand this component as much as any other component. While striving to improve both grain and fodder quantity and quality, it is equally important to use livestock to recycle these feeds and return maximum fertility to the soil. Better livestock management will lead to higher production and more opportunities for farmers. Providing farmers with choices that include livestock management strategies that will also enhance crop production must be a primary objective in collaboration in livestock research for development.

ICRISAT has a substantial commitment to this type of collaborative work. All of our commodity projects involved in the improvement of sorghum, pearl millet and groundnut are committed to improving fodder quantity and quality. Soil fertility and issues related to livestock feed are integral parts of all integrated system projects. Funding for these activities is identified in project documents and will be available, providing the appropriate expertise is available. We want this work to move forward and will do our best to ensure its success. Building effective partnerships in research to achieve these goals is essential.

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FAO's programme for the conservation of domestic animal diversity in Asia

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Abstract

FAO (Food and Agriculture Organization of the United Nations) has a long history of involvement in the conservation (or the best use and long-term maintenance) of animal genetic resources and now has a Special Action Programme for this purpose. The programme for the management of global resources is being developed and includes a comprehensive domestic animal diversity information system (DADIS) which includes the global breed databank. The programme will be based regionally linked both to a small central unit in FAO headquarters and to each country through national focal points (co-ordinators). The FAO regional project for Asia and the Pacific is the first in the world and is acting as a pilot scheme. It is supported by a trust fund provided by Japan and covers 12 countries. It has a budget of US$ 1.8 million and will operate for four years (from December 1993). The objectives can be summarised as improving the breed data and developing improvement schemes especially for indigenous breeds, training personnel, the formation of an Asian Network for Domestic Animal Diversity (ANDAD) and publication of information. The overall result will be in the form of a national policy document for animal genetic resources for each country and the identification of priority areas for project development. Research and development issues include: the maintenance of breeds until objective data in genetic distancing and contributions to species diversity are identified; breed characterisation and the study of genotype/environment interactions involving indigenous and exotic breeds; urgent research on tolerance of or resistance to specific disease conditions claimed for certain breeds because of its potential global importance; applied animal breeding and the need to develop *in situ* improvement schemes based on actual infrastructural conditions.

Introduction

The FAO (Food and Agriculture Organization of the United Nations) has been concerned with the use and maintenance of animal genetic resources for most of its history but, since the early 1980s, together with UNEP (United Nations Environment Programme), has taken a more active role. There has been a series of publications on various aspects of the subject covering, for example, conservation, management, databanks, cryogenic storage, *in situ* schemes, molecular engineering, the breeds of China, the breeds of the USSR and many other topics. In the last six years, the FAO ruling bodies (Council and Conference) have debated the subject on several occasions and there is now a Special Action Programme.

In 1992, an Expert Consultation on the Management of Global Animal Genetic Resources was held. This made some far-reaching recommendations on the institutional aspects as well as on the more practical points of definition of degree of risk, lists of priority breeds and actions. These recommendations, including the responsibility for global management, were accepted by the FAO and have resulted in the development of a global strategy. The plan is aimed at establishing a sound structure for the conservation of global resources— where conservation is defined as the best use of resources in the short term and their maintenance to meet the long-term needs (see Annex 1). The key features of the programme include:

- Umbrella projects for the major regions of the world in order to involve and assist governments in designing and implementing a national policy, co-ordinating arrangements within each country and a small global focus in FAO headquarters in Rome
- Rapid development of the Global Databank on Animal Genetic Resources building on the initial global survey in 1991/92 and the publication of the World Watch List for DAD (Domestic Animal Diversity) (the first edition was published in 1993) and further development to form a global information service—DADIS (Domestic Animal Diversity Information Service)
- Continuous monitoring of populations to ensure that the degree of risk is known to governments and others
- Fostering the development of *in situ* and *ex situ* strategies
- Development of a global scheme for the establishment of the amount of diversity and the contribution of breeds to that diversity within the major livestock species.

The overall structure is summarised in Figures 1 and 2.

Figure 1. Global operational structure.

Figure 2. Participating country structure.

Obviously, the overall objectives of the programme coincide with the major aspects of the Biodiversity Convention agreed in 1992 and now ratified by a large number of countries. This gives a much broader scope than the consideration of food production and has, in general, led to emphasis on species other than those usually considered domesticated. However, FAO will limit its main activities to the 14 or 15 species making the major contribution to food and agriculture.

At the same time as these various developments were taking place, the Japanese government proposed a Trust fund project on "The Conservation of Animal Genetic Resources in Asia and the Pacific" with FAO as the executing agency. This project, initially for four years, covers 12 countries—Bhutan, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Thailand and Vietnam—and has a total budget of US$ 1,800,000. The project started in December 1993.

The objectives include:

- The identification, characterisation and conservation of animal genetic resources so as to maintain biological diversity for sustainable agriculture.

1. The enhancement of productivity *in situ* of those indigenous breeds at risk and their simultaneous preservation.

- The training of lead persons in the techniques relevant to breed surveys, characterisation, *in situ* and *ex situ* conservation of live populations and cryogenic storage, and data handling as well as strategic livestock development planning, breed improvement systems/methods and cost-effective dissemination.

- The publication of all information collected or produced related to animal genetic resources.
- The establishment of the Asian Network for Domestic Animal Diversity.

The initial activities are concerned with attempting to fill the gaps and update the information held in the Global Databank. The data for the region will be updated at regional level and then entered into the global system (and hence the regional system) only after checking in Rome—the central focal point.

The improvement of the basic data is crucial to the second major activity which, if one summarises the various items of the stated objectives, is to establish a national policy and work plan for the conservation of animal genetic resources. Such a policy and work plan should also become the plan required from a country as part of Agenda 21—the action plan following the Biodiversity Convention.

From the work plans, a series of project proposals will be developed, some of which should be immediately operational within the country. Others will need external funding or loans and funding agencies/governments will be approached as appropriate. These proposals will be limited to the essential and pressing activities.

Each country has a National Co-ordinator (NC) for the project—the breed surveys, policy discussions, and drafting the project proposal outlines and costings will all need inputs from many different sources within a country. This role is similar to that proposed by Barker (1992) who referred to the role as a National Animal Genetic Resources Officer. The NC is located at a specific institution which will be the national focal point and at which the network node for the country will be based, i.e. the Co-ordinating Institute.

While nothing in the project will itself provide answers to the genetic problems of sustainable improvement, utilisation of hybrid vigour, maintenance of diversity etc, it will provide a small amount of funds to cover the immediate operating costs of the NC and the training workshops. More importantly, it is considered that the availability of advice, of direct assistance and the catalytic effect of a regional focal point with its continued interaction—coupled to regular visits—will provide the necessary impetus to achieve national policy documentation and a work plan.

With 12 countries, it is impracticable to attempt to deal with all at once so three groups have been formed, each of four countries. Each group of four will be given priority attention for one year thus covering three years after the initial six month start-up. This will leave six months at the end of the four-year project for assessment and actions to try to ensure continuation of activities in a sustainable manner.

The changing problem

Much of the material in this section has been taken from Steane et al (1994).

As population pressures increase and urbanisation expands so the pressure on animal production mounts —primarily to produce more and, secondly, from less land. More efficient use of all the resources (land, water, feed and genetic) will be required if Asia is to feed its population in 25 years time. However, different countries will have different pressures and priorities and these will affect their ability to adopt both short and longer-term policies which will ensure sustainable livestock production.

In identifying some of the changes with major implications for genetic resources, there are several countries which are of major significance: China, India and Pakistan, respectively, have 270, 190 and 90 known breeds listed in the World Watch List (WWL). The next most numerous is Australia with 44 breeds, but with no indigenous breeds of domesticated livestock. However, this does not mean that these three countries contribute most to genetic diversity; many Chinese breeds have already been grouped together by Chinese experts (Loftus and Scherf 1993). The various contributions to genetic diversity are not known and will not be known for some years ahead. A global programme for establishing the genetic relationships among breeds of each species has been proposed (FAO 1993) and this, once achieved, will provide much better objective measures of the contribution to overall diversity within species.

China has, to date, probably one of the world's most enviable records in terms of its care and maintenance of its domestic animal diversity. Jiang Zhihua (1992) indicates some 12.5% are at risk—a proportion well below that in most parts of the world. Many years ago, China established nucleus breeding units for the vast majority of its breeds and these have ensured the survival of several which, as pure breeds, are no longer attractive economically. While the breeds of China have been reported following a massive survey effort in the early 1980s, the detailed information is, so far, in Chinese only and therefore full information is not easily available although some has been published by FAO (Cheng Peilieu 1984). The ability of the Meishan pig is well known; that of another Taihu breed, the Erhualian, less so. The Min pig's ability to cope with large variation in temperature (-30 to 30°C), its good prolificacy and lower fat level than the Taihu pig's is not widely known and nor is the ability of Hu sheep to breed seasonally as well as be highly prolific. Jiang Zhihua (1992) points out that in the last 40 years, 27 breeds have been exported— several to make most useful contributions in production environments elsewhere in the world.

However, the particular circumstances which now exist in China (with 20% of the global human population) have brought matters to a crucial point in the history of genetic resources in that country. Several years of high economic growth (average 12%) have led to a shortage of operational funds, and rapid privatisation is intensifying competition and emphasising short-term policies aimed initially at business survival. This has brought China to a crisis point in the context of the maintenance of biodiversity since state farms, now required to produce profitably, are no longer willing to be the custodians of pure breeding of indigenous populations. The previous excellent policy appears to have brought the world's largest national resource (in terms of the number of breeds) to the edge of a precipice. The national policy requires urgent consideration, redirection and assistance if the world is not to lose a significant portion of its domestic animal diversity.

India has a very different culture, religious and wealth status and structure. India has for a long time developed a policy for its animal genetic resources, being one of the first countries to establish a specific institute. Nevertheless, India still appears to have a number of breeds at serious risk—the WWL lists seven, whereas Jiang Zhihua (1992) quotes two different authors listing 16 and 20, respectively, for the same species. A small but very positive start has been made with the Animal Genetic Resources Institute carrying out some characterisation work and operating a cryogenic store. However, with the large number of breeds available, resources are severely restricted and seriously deficient. Nevertheless, Nivsankar and Malik (1992) outline a programme for laying down semen from 10–15 cattle breeds and efforts for *ex situ* conservation which could be made for some breeds of buffalo, camel, cattle, equines, goats and poultry. *In situ* conservation is carried out for the more important dairy cattle breeds by each being kept on 8–10 farms providing a population of 1500–2000 breeding females per breed.

Of the developed countries within the region, Australia has the most breeds recorded but takes no formal action in the context of the maintenance of these. The "current market" appears to be the sole criterion with the clearly implied policy of reliance on other countries to maintain the genetic diversity which might be needed by Australia in the longer term. There is an NGO—the Australian Rare Breeds Trust—which was formed some three years ago and has involvement with 40–50 breeds (Barker, personal communication).

With high feed costs and the pressure of free trade agreements, animal production itself is under question in Japan. The country has some 21 breeds listed in WWL of which 12 are in the high risk categories (Critical: Endangered). The government initiated a genebank project in 1985; banks are located at several of the major institutions. By 1992, the project had collected a large number of resources: 15 cattle breeds, I buffalo, 8 horse, 28 pig, 4 sheep, and 4 goat breeds together with 96 poultry, 5 rabbit, 34 laboratory animal breeds, 2 bee and 477 silkworm varieties.

The region is one in which, because livestock production is so important, there has been much use of exotic breeds, sometimes referred to as "improved" breeds. While the description is valid, it would be more helpful if the environmental aspects, management inputs and precise breeding objectives for such "improvement" were clearly identified to would-be users. There are good biological reasons why a Holstein-Friesian can neither produce high output and regular calving nor live long on a diet of highly fibrous grasses and waste products; the same reasons are behind the small local breed being what it is. However, it is important that the useful genes from such exotics are exploited whenever and wherever they are shown to improve the efficiency of resource use. The crucial element is to ensure it is in a sustainable, systematic manner. There are several countries which have successfully used "exotic" crossing and reaped the benefits of the F_1 only to find real problems in deciding how best to maintain the initial gains. This is particularly true for the uniparous species—the logistics of maintaining sustainable crossbreeding structures is virtually impracticable even in countries with excellent infrastructure and well-developed economies.

The Philippines has developed a cross-breeding programme for the Carabao (swamp buffalo) but now is having to tackle the problem of different objectives (milk, meat and draft power) and the level of infertility which comes when crossing animals with different numbers of chromosomes. Nepal too faces the backcrossing problem—which way will provide the best use of resources and improve efficiency? How much exotic contribution will provide the optimum system of production in the local environment? Bangladesh, having tried a range of dairy breeds and crosses, has now concluded that with an environment renowned for heat and ticks, combinations not exceeding 50% Holstein in urban conditions and 25% in rural areas can most effectively provide the industry with its needs. With a central scheme coupled with a basic structure of artificial insemination this can be successfully achieved. Laos has done very little crossing so far but, like many other countries, has not been doing any real selection of its local breeds. It now needs to develop its livestock production but has elected to do this mainly by selecting and using its indigenous populations. However, at normal rates of within breed genetic change a 10% improvement from genetic selection may take some time to achieve for the farmers. With co-operation from local farmers and an effective central nucleus, this could be increased considerably in the early years. Nevertheless, methods still have to be developed to exploit all genetic aspects for improved efficiency in a sustainable manner. This question has basically been neglected by most of those involved in modern improvement programmes.

Discussion

In a situation where populations have not always been identified, the initial problems concern the number of breeds and degree of risk. The philosophy adopted is to identify as populations, groups which normally are inter-se mating and have been doing so for five generations. While selection is unlikely to have caused major differences, drift and any bottleneck effects could do so. Given that microsatellite analysis will take some years to achieve, it is important to keep these populations/strains until it can be shown that they are not sufficiently different to be of use in a diversity sense.

One of the dilemmas in a situation where many breeds are at risk, is the basis for decisions on investment in a breed. Some have traits which clearly could be useful in their own right (e.g. prolificacy in Erhualian pigs and aseasonal breeding of the Hu sheep) whereas others do not. Genetic distancing offers an objective criterion for diversity but does not indicate value for specific genes. Other criteria such as social and religious practices, banking etc are rarely considered and remain unquantified.

Breed characterisation, in all its aspects, will be a major task especially in this region which has already experienced many problems associated with "exotic" breed use. In this context, there must be evidence of genotype/environment interaction but for many species such evidence will not be easy to justify in terms of the costs involved to do the trial. However, with some species this would be relatively cheap and easy to do—poultry and pigs probably provide the most useful investment.

There are many "old wives' tales" of breed resistance to, and tolerance of specific/generalised conditions. However, there is usually some justification in the claim although it may well be that the explanation is very different (is resistance an indication that the pathogen is more specific than realised and is not actually attacking the "resistant" strain?). Having recently had first hand discussions in which the villagers clearly did not appreciate that foot-and-mouth disease could affect pigs, it is clear that better studies and information are needed urgently.

The efforts of applied animal breeders globally have understandably been directed at systems in which data is easily attainable and both infrastructure and finance are available. Serious efforts are needed to study systems which can optimise and sustain genetic gain in the developing country environment without the tacit assumption of all other resources being readily available, i.e. the development of breeding schemes *in situ* is needed.

While the project is a useful, positive start, it is only a basis for further action. Much more needs to be done both within the project countries and within the region as a whole. The changing human population and related agricultural situations have brought the problem to a head with a distinct and immediate threat to a large number of breeds about which little is really known. Without good knowledge, proper and sensible decisions about the maintenance of domestic animal diversity become a matter of chance. Global resources are too valuable to be a matter of chance—the cost, in terms of human survival, is too great.

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Annex 1

Use of terms (Hammond 1994)

Clear terminology is necessary to advance understanding, facilitate education and training, communicate successfully with the wider public and realise a common purpose in application. Terms must accommodate all practical situations—in our case all genetic resources and diversity associated with each species, both resources currently in use and those not in use, the common and the rare, the long developed and the new, the commercial lines and the research stocks. The conservation literature includes a number of terms that are not well understood in the domestic animal context; and the following simple working definitions are proposed.

Animal genetic resources: The genetically unique breed populations formed throughout all domestication processes within each animal species used for the production of food and agriculture, together with their immediate wild relatives (here "breed" is accepted as a cultural rather than a technical term, and also includes strains and research lines).

Domestic animal diversity: The genetic variation or genetic diversity existing among the species, breeds and individuals, for all animal species which have been domesticated and their immediate wild relatives.

Conservation (of domestic animal diversity): The sum total of all operations involved in the management of animal genetic resources, such that these resources are best used and developed to meet intermediate and short-term requirements for food and agriculture, and the diversity they harbour remains available to meet possible longer-term needs.

Conservation (in general): The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustainable utilisation, restoration and enhancement of the natural environment (IUCN-UNEP-WWF and FAO-UNESCO 1980).

***In-situ* conservation:** Primarily the active breeding of animal populations for food production and agriculture, such that diversity is both best utilised in the short term and maintained for the longer term. Operations pertaining to in-situ conservation include performance recording schemes, and development (breeding) programmes. In-situ conservation also includes ecosystem management and use for the sustainable production of food and agriculture. For wild relatives in-situ conservation—generally called in-situ preservation—is the maintenance of live populations of animals in their adaptive environment or as close to it as is practically possible.

***Ex-situ* conservation:** In the context of conservation of domestic animal diversity, ex-situ conservation means storage. It involves the preservation as animals of a sample of a breed in a situation removed from its normal production environment or habitat, and for the collection and cryopreservation of resources in the form of living semen, ova, embryos or tissues, which can be to regenerate animals.

While other methods of genetic manipulation, such as the use of various recombinant DNA techniques, may represent useful means of studying or improving breeds, these methods do not constitute ex-situ conservation, and may not serve conservation objectives. At present the technical capacity to regenerate whole organisms from isolated DNA does not exist.

Priorities for feed resource utilisation in the semi-arid tropics

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Abstract

Strategies that are currently used for the promotion of efficient utilisation of available feed resources for livestock production are discussed with reference to current availability and projected energy requirements for ruminants by the year 2000. Potentially important nutritional strategies that are being pursued include urea–ammonia treatment of straws, use of urea–molasses block licks, tree forage supplementation, utilisation of agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR) and development of crop-residue-based, complete feeds. The importance of on-farm verification of on-station tested feeds is highlighted. Research priorities for improved feed resource utilisation encompass integration of ruminants into cropping systems, development of agroforestry systems and more intense use of AIBP and NCFR.

Introduction

In all countries of South Asia, an inquiry into the strategies for feed resource development and utilisation is imperative at this time in view of inadequate feed supplies, continuing low productivity from animals, and the need to maximise returns. This problem is acute in India because of the intense pressure on land and its availability which is progressively declining. There are large animal populations, whose density and distribution are spread across a variety of agroclimatic conditions, which range from highlands, semi-arid and arid regions in the north and north-west to subhumid situations in central and south India. When considering the productivity of livestock under different conditions, it is essential to recognise that, while environmental and management conditions are variable, the general principles of feeding and nutrition are unchanged. Differences in productivity are dictated mainly by the prevailing standards of how the animals are managed and the problem is exacerbated especially in the semi-arid tropics because of hot environments, variable supplies of feed and their quality, and generally inferior animals.

It is particularly important therefore in any situation, where the primary objective is the search for efficiency in the use of animal and feed resources, that there be clear objectives of production. This necessitates the maintenance of appropriate species or breeds while taking full advantage of the totality of the available feed resources. These two prerequisites are fundamental to all efforts that are aimed at increasing the current level of productivity of livestock (Devendra 1991).

The animal resources

The relative sizes of large (cattle and buffaloes) and small (goats and sheep) ruminant populations and annual growth rates over the period 1970–88 are given in Table 1. The number of goats grew at a faster rate (3.5%) than sheep (2.0%) and small ruminants accounted for 38% of the total ruminant population. India's buffalo and cattle populations constitute 50% and 20% of the world population, respectively.

Ruminants are mostly owned by small farmers, peasants and landless labourers. In contrast, poultry constitutes an advanced animal industry in India because of the availability of germplasm and successful transfer of proven technology in poultry production.

The landholdings of selected households are classified into five categories (Table 2), treating one hectare of irrigated land as equivalent to two hectares of unirrigated land (ISPA 1994).

Table 1. *Ruminant resources in India.*

	Population (10^6)				Growth rate/annum
Species	1970	1980	1988	2000*	1970–88 (%)
Cattle	178.6	180.0	194.4	218.9	0.5
Buffaloes	57.9	62.0	69.8	100.2	1.7
Goats	64.6	81.5	105.0	149.1	3.5
Sheep	38.0	41.3	51.7	64.1	2.0

* Projected estimates based on current trends.

Source: Directorate of Economics and Statistics, Ministry of Food, Agriculture and Irrigation, GOI, New Delhi.

Table 2. *Milk contribution from landholdings of selected households*.

Categories	Landholding	Milk contribution (ha)	(%)
Landless	0	–	–
Marginal farmers	<1	51.9	27.74
Small farmers	1–<2	30.0	31.86
Medium farmers	2–<4	16.0	24.46
Large farmers	4+	2.1	15.94

Feed resources and nutrition—the overriding constraint

In India, chronic annual feed shortages for animals and undernutrition are common. The major factors in low productivity from animals are the quantity and quality of feed available. There has been a decline in the area of forage production. The area under agriculture increased by about 20% between 1951 and 1981, while the cattle population increased twofold and the small ruminant population increased by 70%. It is estimated that by the year 2000, India would require 830 million tonnes of dry fodder and 990 million tonnes of green fodder. According to optimistic estimates, the total potential dry and green fodder in the country today are 450 and 250 million tonnes, respectively.

Table 3 presents the feed energy available in 1970 and also projections for the year 2000. Arable land includes land under annual crops, fallow and arable idle land, temperate meadows for hay, silage or pasture, and range lands. Non-agricultural land refers to forests and other lands.

Table 3. *Feed energy resources available to ruminants in India*.

	Year		
	1970	1980	2000*
Land and type of feed	(Metabolisable energy (10^9 MJ))		
Permanent pastures and meadow	62.8	100.5	130.1
Non-agricultural land forage	63.8	49.7	41.8
Arable land			
Forage	1736.4	1825.0	1822.8
Crop residue	1129.7	1330.8	1464.4
Grain	12.6	30.1	62.8
Oil seeds	20.9	20.9	20.9
Agro-industrial by-products	125.5	213.4	272.0
Total	3150.7	3570.4	3874.8

* Estimated values.

Source: Adapted from Byerly et al (1978).

Feed energy is projected to increase by about 25% from 1970. The growth in feed energy availability of less than 1% annually is unlikely to be sustained because of decreasing land availability. The bulk of increased supply is expected to come from permanent pastures, crop residues and agro-industrial by-products.

Current and projected energy requirements

An attempt has been made to indicate the extent of total metabolisable energy (ME) requirement by ruminants (large and small) and the availability of energy between 1970 and 2000 (Table 4). For calculating these requirements, the following data were used as suggested by Devendra (1991).

- Buffaloes: The daily ME requirements per head is 523 MJ/$W^{0.75}$ kg. For an average live weight of 400 kg, the daily and annual requirements are 56.1 MJ and 20476.5 MT of ME, respectively.
- Cattle: The daily requirement per head is 494 MJ/$W^{0.75}$ kg. For an average live weight of 300 kg the daily and annual requirements of 42.7 MJ and 15577.0 MJ of ME, respectively.

- Goats and sheep: The daily ME requirement per head is 424.2 kJ/$W^{0.75}$ kg. For an average live weight of 30 kg that is assumed for both species, the daily and annual requirements are 6.5 MJ and 2379.8 MJ of ME, respectively.
- In addition, a 20% increment has been included in all cases to allow for extensive grazing systems as well as the requirements of production (meat, milk and fibre). The calculated requirements are therefore approximate, but they do give an indication of the magnitude of the needs.

Table 4. *Current and projected metabolisable energy (ME) requirements and availability.*

	ME requirements (10^9 MJ)	
Species	1970	2000
Goats and sheep	0.67	1.39
Cattle and buffaloes	3973.9	5341.2
Total ruminants	3974.57	5342.59
Requirement as % of availability	-26.2	-34.4

Source: Devendra (1991).

The annual requirements were multiplied by the respective populations to provide an estimate of total requirements for ruminants for the individual years.

ME requirements of ruminants are in excess of availability, current as well as projected, by between 26 and 34%. The deficits are underestimated as they do not include the energy requirements of non-ruminants and other herbivores like camels, donkeys, mules and asses. The calculations are similar to those projected by Reddy (1987).

Constraints to feed resource utilisation

The agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR) are presently underutilised. There are several reasons for this state of affairs and some of them are as follows:

- production is scattered and in some cases the quantity produced is too low, especially for processing
- high cost of collection, transportation, storage and processing
- presence of deleterious substances, HCN or prussic acid, tannins and other anti-nutritional factors. The cost of detoxification and processing may exceed the economic value relative to conventional raw material
- lack of managerial and technical skills to utilise the feeds *in situ*.

Research towards more efficient utilisation of NCFR will have the advantages of increasing the availability of much needed feed stuffs that can alleviate the imbalance between total animal resources and feed supplies.

Strategies to overcome constraints

Feed resource production and availability

Agroforestry systems

The concept of integrating farming and forestry originates from the realisation that trees play a vital role in safe guarding the long-range interests of agriculture, including animal husbandry. Such integration, known as agroforestry, makes agricultural economy more viable. It involves more or less intimate and interacting associations of agricultural crops, horticultural crops and woody perennials on the same unit of land. This form of land use has two main objectives:

- productivity involving a multiplicity of outputs
- sustainability, which implies the conservation or even improvement of soils, broadening future land-use options.

Agro-forestry embraces many production systems (Singh 1990). These are:

- agrosilviculture crops, including tree and shrub crops
- silvipastoral (pasture animals and forage trees)
- agrosilvipastoral systems (crops, pasture animals and trees)
- hortiforage food system (fruits, forage and food crops).

Agrosilvipasture system

In the age-old "taungya" plantations, forest labourers grew agricultural crops with forest tree crops to meet their daily food requirements. This approach was aimed at obtaining food, fodder and fuel from the same unit of land. Under rainfed situations this can be achieved in a production system including the crop–grass–tree combination. Production could be increased threefold if legumes were introduced into the system (Table 5).

Table 5. *Production potential and energetics of restructured forage production systems.*

Subecosystem	Maximum harvest (g/m)	Annual energetics (kcal/m)
Local situation	240	1100.0
Heteropogon contortus + *Faveolatus*		
Reconstructed adaptable ecosystem		
Cenchrus ciliaris + *Chrysopogon* + *Leucaena leucocephala* + cowpea	670	3697.5
C. ciliaris + *Chrysopogon* + *Albizia lebbek* + wild pigeonpea	790	3357.5
Schima nervosum + *C. ciliaris* + *A. lebbek*	735	3123.8
C. ciliaris + *A. procera* + *Phaseolus* spp	760	3230.0
C. ciliaris + *Prosopis julifora* + *Dolichos lablab*	710	3017.5
A. lebbek + *Heteropogon contortus*	410	1742.5

Source: Deb Roy et al (1978).

The silvipastoral system yields seven times as much food/fodder and fuel as the traditional land-use system, with year-round forage availability; forage that is nutritious and high in protein (Singh 1988) (Table 6). Promising shrubs and tree species were tested on marginal and sub-marginal land sites with recommended plant densities for fodder and feed. Albizia and *Acacia* species gave high firewood production while *Leucaena* and *Sesbania* produced the highest forage yields per unit of land.

Table 6. *Production potential of some fodder trees in the Bundelkhand region of India.*

Species	Age (years)	Trees/ha	Leaf fodder production (kg/tree)	Firewood (kg/tree)
Acacia tortilis	7	440	3.2	51.6
Albizia amara	7	440	13.5	86.6
Albizia lebbek	6	440	5.3	155.0
Albizia procera	6	440	11.3	85.5
Leucaena leucocephala	3	5000	0.8	5.5
Hawaiian giant	1.5	5000	1.5	4.2
Sesbania grandiflora	3.5	5000	0.9	16.1
Sesbania sesban	3.5	5000	0.3	12.1

Source: Singh (1988).

Forages from shrubs and trees are a particularly neglected, inadequately understood aspect of the feeding systems of ruminants in India. There is little doubt that tree fodders have a potentially important role in improving the efficiency of the prevailing feeding systems and increasing meat and milk production in ruminants. Demonstration of these benefits, including economic advantages justifies expanded use of tree forages. Increased attention must be given to include potentially important trees into native pastures, alley farming and agroforestry systems. The value of tree fodders is greatest in extensive systems in the semi-arid tropics because of feed shortages. Research and development programmes, currently inadequate, need to address their utilisation more widely and vigorously. These programmes also need to pursue quantitative aspects of true forage production, biomass structure, palatability, nutritional value, comparative use by individual animal species, detoxification of anti-nutritional factors (if any) and extent of degradation of dietary protein in the reticulo-rumen.

Optimum feed utilisation

Urea–ammonia treatment

Rice and wheat straws are the main by-products from cereal cultivation and these supply the basic diet for the ruminants. They provide bulk and energy for maintenance needs, but not for production. The justification for increased importance on the value of urea treatment is increased digestibility and higher intake.

Extensive research results are available on urea treatment of straw to improve the quality of this most abundantly available crop residue in the region. For implementation of this technology for average livestock raisers—who are mostly small farmers—the following conditions should be satisfied:

- the method must be practically feasible at farm level
- it should not cost more than what the small farmer can afford for feed
- should be safe for use at village level.

A typical treatment method involves the use of 4% aqueous urea solution allowing 7–14 days of reaction in a closed system such as in pits or polythene bags. Alternatively, the straw can also be sprayed with urea solution just before feeding.

Table 7 clearly demonstrates the benefits due to the urea treatment. Feeding rice straw in the wet form significantly increased (P<0.05) intake compared to when the straw was dry; the presence of a higher content of non-protein nitrogen may have stimulated the increased intake. Differences in digestibility of dry matter (DM), organic matter (OM) and neutral-detergent fibre (NDF) were also found between the wet and dry forms of straw.

Table 7. *Effects of urea treatment of rice straw on the voluntary intake and digestibility in cattle.*

	Voluntary intake (as % of)			Digestibility (%)		
Treatments	kg/day	LW/day	$LW^{0.75}$	DM	OM	NDF
T1, 3% of UTS, wet	2.6	2.6	81	47.2	53.0	57.0
T2, 3% of UTS, dry	1.7	1.7	53	52.6	57.7	61.6
T3, 3% of UTS, wet+salt	2.7	2.6	83	49.5	57.5	62.1
T4, 3% of UTS, dry+salt	1.7	1.8	53	54.5	62.6	63.2
TS, 5% of UTS, wet	2.7	2.6	82	55.3	64.0	66.3
T6, 5% of UTS, dry	2.2	2.2	70	54.0	61.0	64.1
T7, 5% of UTS, dry+salt	2.4	2.5	78	48.9	56.6	62.1
T8, 5% of UTS, dry+salt	2.0	2.0	63	55.2	62.5	67.6
Significance						
Urea concentration	NS	NS	*	*	*	*
Wet/dry form	*	*	*	*	*	NS
Salt addition	NS	NS	NS	NS	NS	NS

UTS = urea-treated straw; DM = dry matter; OM = organic matter; NDF = neutral-detergent fibre; I/W = intake/live weight; NS = not significant; * = P<0.05.

Source: Wanapat (1987).

The use of urea-treated straw for dairy animals has been successful due to immediate visible impact (more milk production). The application of this technology to feeds for draft animals tends to be less popular (ISPA 1990**).**

Any practical treatment of straw to increase the nutritional quality must take into consideration prevalent animal husbandry practices related to harvesting, transportation, storage and feeding of straws.

Urea–molasses blocks

As an alternative to the urea treatment of straw, supplementation with urea–molasses block licks has given promising results when cattle are fed on crop resides (Kunju 1986). In addition to soluble nitrogen, these blocks supply soluble carbohydrates and minerals for rumen microflora to flourish and convert fibrous residue to microbial protein and volatile fatty acids (VFA). Large-scale application of urea–molasses blocks distributed through dairy co-operatives has been undertaken in India, initiated by the National Dairy Development Board (NDDB), Anand. The ingredient composition of the block is as follows:

Urea–molasses block

Ingredient composition		Chemical composition	
Ingredient	%	Principle	%
Molasses	45	Soluble nitrogen	7
Urea	15	Ether extract	0.5
Mineral mix	15	Crude fibre	1.5
Salt	8	Ash	2.5
Calcite powder	4	Calcium	6
Bentonite	3	Phosphorus	2
Cottonseed meal	10	Natural protein	4
		Moisture	5–10

A block of 3 kg will last for 7–10 days/animal on straw-based ration. The impact from the use of urea–molasses blocks, particularly for low productive dairy cattle owned by small farmers, is tremendous resulting in better utilisation of straw with more milk production at lower cost (Table 8).

In view of the high demand, the NDDB has commissioned two production plants at Mehsana and Bangalore to meet the growing demand from southern states of Karnataka, Andhra Pradesh, Tamil Nadu, Kerala and Orissa. There are plans to establish another five plants.

The major benefits from use of urea–molasses blocks are:

- activation of rumen fermentation
- increase in VFA production
- provision of essential minerals and vitamins
- easy handling and transport
- prevention of urea toxicity
- mass production on a commercial scale
- economical.

Table 8. *Response to feeding urea–molasses block licks in villages in Kaira Milk Producing Union L td, Anand, India.*

Village	Average milk sold (kg/day/animal)		Fat (g/day)	
	Before (no block)	With block	Before (no block)	With block
Alwa	4.8	5.9	330	450
Punadhara	4.0	4.8	270	340
Fulgenamuwada	2.4	3.5	160	280
Hirapura	4.2	5.2	350	480
Banroli	3.6	4.2	270	380
Dehgam	4.3	4.7	310	350

Source: Kunju (1986).

Tree forages as strategic supplements

An alternative resource that serves as a potential form of fermentable nitrogen is proteinaceous forages (Table 9). Tree forages have enormous potential for application with ruminants, especially in situations where animals are abundant and varied (Devendra 1989). Legume tree leaves which are now used as sources of supplements include *Leucaena*, *Gliricidia* and *Sesbania*. As a priority, the legume should have a high protein content to supply both fermentable and by-pass protein. If they contain other critical nutrients, the rumen ecosystem is activated resulting in increased microbial growth and rate of fermentation (Preston and Leng 1987).

Table 9. *Important proteinaceous forages.*

Common name	Crude protein (%)
Acacia	22.2–24.7
Banana	17.1–18.3
Cassava	21.7–26.6
Erythrina	28–29.2
Gliricidia	20.2–24.6
Leucaena	22–25.2
Mulberry	16.5–17.9
Pigeon pea	20–25.6
Sesbania	22.6–24.7

Source: Devendra (1989).

Supplementation with tree leaves, such as, *Leucaena*, *Gliricidia* and *Sesbania* to a basal diet of N.B. 21 grass at a 40:60 ratio on a dry-matter basis significantly increased the retention of nitrogen and calcium in native lambs (Rao et al 1993). The nitrogen of foliage from *Leucaena* and *Gliricidia* has been reported to ferment at a slower rate than the dry matter, indicating the possibility of some dietary nitrogen escaping rumen fermentation on such a feeding regimen.

Table 10 demonstrates the potential value and use of forage supplements by individual ruminants. There was a consistent increase in live weight or milk production and in many instances the beneficial response (meat/milk) was associated with a reduced cost of production.

Table 10. *Economic benefits of forage supplementation in livestock.*

Feeding regimen	Forage supplement	Species	Results	Reference
Wheat straw	*Leucaena*	Buffaloes	Liveweight gain	Akbar and Gupta (1985)
Oat silage + concentrates	*Leucaena*	Buffaloes	Reduced cost/kg milk	Dharmaraj et al (1985)
Concentrates	*Prosopis cineraria*	Cattle	Reduced cost/kg milk	Talpada and Shukla (1988)
Browse	*Prosopis cineraria*	Goats	Liveweight gain	Parthasarathy (1986)
Browse	*Zizyphus nummularia*	Sheep	Liveweight gain	Bhatia and Ratan (1981)

There are many advantages concerning the use of forages (Devendra 1989). They include *inter alia*:

- availability in the farms
- accessibility
- provision of variety in the diet
- source of dietary N, energy, minerals and vitamins
- reduction in the requirement of purchased concentrates
- reduced cost of feeding
- laxative influence.

Utilisation of AIBP and NCFR

In an effort to narrow the gap between availability and requirement of feed resources, the Indian Council of Agricultural Research (ICAR), as early as 1967, initiated the All Indian Coordinated Research Projects (AICRP) in different regions of the country. The projects focused on the utilisation of agro-industrial by-products and industrial waste material for evolving economic rations for livestock. Several agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR) have been assessed for their approximate composition, potential toxic factors, nutritive value and per cent incorporation in ruminant and poultry rations. The Compound Feed Manufacturers' Association (CLFMA) is presently using these resources to formulate economic rations for the poultry industry, which is in the hands of affluent businessmen. AIBP includes crop residues and by-products produced from food processing. NCFR includes new sources of feeds, single cell proteins, poor quality cellulosic roughages, stubbles, haulms, vines, slaughter house by-products (feather meal/meat and bone meal), by-products from processing sugar, citrus fruits etc.

Table 11 illustrates the availability, protein, energy and toxic factors of AIBP and NCFR in India. Several feeds contain toxic substances like haemagglutinins, cyanogens etc. A potentially important by-product from animals of value as a feed is poultry excreta. (Devendra 1991). Poultry excreta consist of dry excreta and the feathers and broken eggs that drop beneath the poultry cages. About 1.2 million tonnes are available annually (Reddy 1991) and can be used as a component of dairy cattle rations. Presently, poultry excreta are being used as fertiliser for crop cultivation.

Table 11. *Availability and nutritive value of agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR).*

Name	Availability (10^5 t)	DN (% DM basis)	TDN (% DM basis)	Deleterious factor
Ambadi cake (*Hibiscus cannabinus*)	0.3	18.7	63.8	Nil
Babul	0.5	5.7	62.5	Tannins (5%)
Cassava starch waste	0.4	1.8	64.0	Nil
Castor bean meal (*Ricinus communis*)	0.6	22.5	64.0	Ricin (0.22%)
Cocoa pods (*Theobroma cacao*)	0.3	6.6	63.5	Nil
Coconut pith	2.0	0.0	62.7	Lignin (35–40%)
Karanj cake (*Pongamia*)	1.3	25.5	62.0	Karanjine (10–15 mg/ 100 g)
Kokan cake (*Garcinia indica*)	0.2	9.3	80.0	Nil
Kosum cake (*Scaleichrva alcosa*)	0.3	14.7	79.6	HCN (2–4 mg/100 g)
Mango seed kernels (*Manjifera indica*)	10.0	6.1	70.0	Tannins (5–6%)
Mahua cake (Madhuca cake)	3.0	9.3	49.8	Mowrin
Niger seed cake (*Guizotia abyssinica*)	1.0	32.7	49.4	Nil
Prosopis juliflora pods	1.0	7.0	75.0	Tannins (0.7–1.5%)
Rubber seed cake	1.5	18.6	66.0	HCN (9 mg/100 g)
Salseed meal (*Shorea robusta*)	0.7	0.1	57.8	Tannin (8–10%)
Sugar-cane bagasse	20.0	1.1	49.2	Lignin (8–10%)
Sunflower straw	2.0	2.3	45.6	Nil
Sunflower heads	2.0	–	–	–

Source: AICRP (1985).

Research priorities for feed resource utilisation

On-farm application of feed information

New and improved technology is of little use in increasing livestock production, unless it is used by small farmers. The technology must reach all categories of farmers, especially those operating at subsistence levels. One aspect of research that merits very high priority is the application of feed information and the accumulated knowledge on feeding and nutrition. This aspect is neglected in the research planning process and needs to be considerably improved. On-farm animal research is probably the only accurate assessment of whether new technology packages are acceptable, both economically and socially, to the farmers as they take into account all the interacting components unique to farming systems (Devendra 1987).

It is essential that all the components of on-farm studies are considered and discussed at the initiation of the project. The discussions should involve the project leader, scientists from various disciplines and extension personnel. A decision to start such a project should be based on a preliminary survey of potential values and success, and concurrent discussions that enable logical follow through of this potential in which large-scale utilisation can be demonstrated for economic benefits (Amir and Knipscheer 1989). Such planning demands:

- more effort and organisation
- clear responsibilities at all levels of implementation
- collective participation
- commitment of the various persons in the project.

More intense use of AIBP and NCFR

In view of the priority on the development of ruminants, expanding the use of AIBP and NCFR will necessarily have to focus more on these species, including their individual characteristics in the quest to increase productivity from them.

One of the biggest drawbacks of the research on AIBP and NCFR in India was that the on-farm component was completely neglected by the planners and thus the study was limited to the evaluation of chemical composition, nutritive value, estimation of toxic principles and the percentage incorporation in ruminant rations. Since AIBP and NCFR have potential nutritive value at on-station level, the next step is to implement large-scale application of the results on-farm. Recently attempts were made to translate on-station technology to on-farm stations in the state of Andhra Pradesh (Raghavan et al 1991). This has created awareness among farmers and a drift from the conventional type of rearing small ruminants to semi-intensive systems for fat lamb/kid production for early marketing. Such trials have been far too few in the past and wider use of these resources in the future will be significantly affected by on-farm work. Thus there is an urgent need for widespread evaluation of these feed resources through on-farm testing and demonstrations.

Priorities for using AIBP and NCFR in India according to their potential value and importance, especially to individual species of animals is detailed in Table 12. The broad type of feeds, their essential characteristics and the main species which currently use them are described.

Integrated ruminant–tree crop systems

India has a long history of shortages of animal feeds and fodders. The problem has been complicated by low productivity from animals, ruthless exploitation of available grazing resources, preference of farmers for growing non-forage crops and increasing livestock populations. To overcome this shortage, growing food and fodder crops on the same unit of land and integrating trees and grasses with crop farming on marginal and sub-marginal land deserves high priority.

Table 12. *Priorities for utilisation by animals of agro-industrial by-products (AIBP) and non-conventional feed resources (NCFR) in India.*

Feed source	Characteristics	Species
Energy and protein (e.g. rice, bran, coconut, poultry litter)	High energy, high protein	Poultry, ducks, pigs, lactating and growing ruminants
Good quality crop residues (e.g. cassava leaves)	High energy, high protein	Poultry, ducks, lactating ruminants and as supplements to ruminants
Medium quality crop residues (e.g. sweet potatoes, vines)	Medium protein	Pigs, ruminants, camels and donkeys
Low quality crop residues (e.g. cereal, straws and bagasse)	Low protein, very fibrous, low energy	Ruminants, camels and donkeys

Source: Devendra (1991).

The integration of small ruminants with tree cropping, especially in south India where there is intensive tree-crop production is imperative. Mukundan and Balakrishnan (1986) estimated that there were about 1.7 million hectares of land under cashew, coconut, jack fruit, mango, rubber and areca nut in Tamil Nadu, Kerala and Karnataka. Oil palm was introduced into Andhra Pradesh in the early 1990s and the area under oil palm cultivation is projected to be increased to 0.04 million hectares in the near future. Little or no research has gone into investigating the integration of small ruminants into these tree-cropping systems, and considerable increased productivity from the land can be achieved by the combined approach. In palm oil and rubber plantations, the common legume covers used in Thailand are *Calopogonium* sp, *Centrosema pubescens* and *Pueraria phaseoloides*. Similar legumes, conducive to these areas if established will provide increased feed supplies, enable a higher carrying capacity and also improve the soil fertility (Chee Yan Kuan and Devendra 1981).

Processing and complete feeds

Associated with the more intensive use of AIBP and NCFR is the development of complete rations for ruminants. The main principle in this system is that all the feed ingredients inclusive of roughages are processed (chaffing, grinding and pelleting) and mixed into a uniform blend that discourages selection (Reddy 1987). These complete rations provide adequate and balanced nutrients in an optimum ratio of roughage to concentrates. More than 60 complete diets have been formulated and processed at a pilot plant at Andhra Pradesh Agricultural University, Hyderabad, during the past decade using locally available AIBP, NCFR and forest grasses. The ingredient composition, and nutritive values and chemical composition of complete rations used for dairy animals are given in Tables 13 and 14, respectively. These complete diets have been successfully tested in several experiments on growing crossbred calves (Table 15), milch buffaloes and cattle (Table 16).

Table 13. *Ingredient composition (%) of complete diets.*

	Name of the crop residue				
Ingredients	Dry forest grass	Sorghum straw	Wheat straw	Cotton straw	Sunflower straw
Dry forest grass	47.5				
Sorghum straw		46.0			
Wheat straw			50.0		
Cotton straw				45 0	
Sunflower straw					35.0
Tapioca chips		20.0			
Groundnut cake	10.0	10.0	10.0	10.0	
Maize ground	10.0				
Cage layer droppings (dried)		10.0	15.0		
Cottonseed cake					25.0
Molasses	10.0	12.0	13.0	15.0	8.5
De-oiled rice bran			100		
Wheat bran	20.0			10.0	10.0
Rice polishings				17.0	10.0
Urea		0.5	0.5	1.5	
Mineral mixture	1.8	1.0	1.0	1.0	1.0
Common salt	0.8	0.5	0.5	0.5	0.5
Nutritive value					
DCP (%)	7.7	7.0	7.3	9.5	5.3
TDN (%)	63.1	56.4	51.8	48.6	56.2

Source: Reddy (1989).

The cost economics of processing diets have been assessed on a pilot plant basis (Reddy 1989) taking into consideration fixed charges (depreciation on building and machinery, interest on block investment and maintenance) and direct charges (cost of power, labour, operators etc), and the average values are detailed in Table 17. Processing costs are dictated by the level and physical nature (brittle or elastic) of the crop residues. The cost of rations was calculated taking into consideration the existing market rates of different ingredients used in the formulae. The total cost of the complete rations depends on the type of processing (chaffing, mash and pellets), type of roughage and percentage of concentrates in the rations. Pelleting of mash increases processing costs by 57 to 130%.

Table 14. *Chemical composition and nutritive value of 67 complete diets.*

Item	Percentage
Roughage component	20.0–70.0
Approximate composition	
Crude protein	9.2–16.0
Crude fibre	14.2–29.9
Ether extract	0.9–6.8
Nitrogen-free extract	33.0–60.0
Total ash	9.7–20.9
Acid-insoluble ash	1.9–7.9
Calcium	0.7–3.2
Phosphorus	0.2–0.9
Nutritive value	
DCP	4.5–10.6
TDN	41.2–64.4

Source: Reddy (1991).

Table 15. *Effect of feeding complete diets on growth in crossbred calves.*

Feeding regime	Average daily gain (g)	Dry-matter intake (kg)	Cost of feeding/ day (Rs)
Control ration	371	11.54	5.65
68% mixed forest grass (mash)	513	9.55	5.02
68% mixed forest grass (pellets)	609	8.17	4.75
45% cotton straw (mash)	796	7.4	5.1
45% cotton straw (pellets)	878	6.8	5.3
50% wheat straw (mash)	460	10.16	5.92
50% wheat straw + 15% berseem	462	11.28	6.78

Source: Reddy (1991).

These studies indicate that fibrous crop residues can successfully be used as the sole source of roughage in complete feeds for optimum growth and milk production. Complete feeds have a particular relevance and considerable future potential when viewed in the context of a shift towards more intensive systems of production. The latter is distinctly likely given the diminishing availability of land and the need to have more intensive feeding systems and efficient feed resource use.

Table 16. *Effect of feeding complete diets on milk production.*

Species and feeding regime	DMI/100 kg LW (kg)	Milk yield kg/day	Milk fat (%)	FCN (%)	SNF (%)	DMI/kg milk
Murrah buffaloes						
Conventional ration	2.94	5.51	6.18	7.22	9.91	1.89
47.5% dry mixed grass (mash)	4.00	6.38	5.85	8.04	10.09	2.23
47.5% dry mixed grass (pellets)	3.95	6.55	6.00	8.48	10.03	21.40
Crossbred cows						
Conventional ration	3.34	8.09	4.65	8.86	9.37	1.43
47.5% dry mixed grass (mash)	4.26	8.69	4.55	9.34	9.44	1.70
47.5% dry mixed grass (pellets)	4.59	8.80	4.39	9.26	9.34	1.82
45% cotton straw (pellets)	3.43	7.25	4.12	7.36	9.35	1.70

Source: Reddy (1989).

Table 17. Processing costs of complete feeds.

Item	Mash	Pellets
Number of complete diets	27	24
Roughage component	46–68	20–70
Rate of feed production (q/hr)	3–8	3–9
Processing cost/q (Rs)	7–10	9–22
Total cost of feed /q (Rs)	45–108	47–109

Rs = rupees.

Source: Reddy (1989).

Recommendations

Numerous opportunities exist for utilisation of the research available which deals with urea-treated cereal straws, tree fodder supplementation, AIBP and NCFR. On-farm animal research is the only accurate assessment of whether or not new technology packages are acceptable both economically and socially to the farmers. This is because on-farm animal research takes into account all the interacting parameters unique to different farming systems.

- There is a need for large-scale, widely replicated on-farm research and development programmes.
- Multidisciplinary approaches and strong institutional linkages are necessary to ensure that constraints are addressed thoroughly and there is efficient technology transfer.
- A systemic model needs to be developed integrating fodder trees, crops and ruminants specific to different agroclimatic regions. The benefits of integration

need to be measured in terms of crop–animal productivity complete with economic analysis. The current paucity of information on economic assessment needs to be fortified with more information that can demonstrate viable benefits.

- Research on management and use of shrubs and tree fodders is limited, although their potential is increasingly being recognised. Priority must be given to more important shrubs and trees appropriate to individual environments and of benefit to ruminants with reference to rate of productivity, biomass structure, palatability and nutritional value, and targeted to individual animal species.
- Priority must be given to introduce potentially important shrubs and trees into native pastures, alley farming, and agroforestry systems.

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Availability and requirement of different sources of livestock feed in India with special reference to sorghum and millet straw

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Abstract

There is a continuing debate on the feed availability and requirements for livestock in the semi-arid tropics but few hard conclusions can be drawn due to the capacity of data and suitable methodology. The paper attempts to quantify feed availability and bovine requirements. Although this assessment does not indicate the magnitude of the problem of feed resources, it helps in understanding to what extent the situation has improved or deteriorated over time. At the national level the availability of crop residues from fine cereals, concentrates and bran has increased during the last 20 years. However, the availability of coarse cereal straws, which form the bulk of the feeds, has declined due to a decrease in the land area planted with these crops in favour of oilseeds etc. This has put pressure on straw prices as reflected in an increasing straw/grain price ratio. At the more regional level, a mixed picture emerges with feed resources per bovine increasing and/or decreasing over time. In India, crop residues will continue to be a major source of feed in the near future.

Introduction

Livestock contribute to human welfare by providing food, draft power, transport, and manure. Their importance in Indian agriculture has long been recognised. Indeed, mixed crop–livestock enterprises dominate farming systems everywhere in India. In these farms, the relationship between crops and livestock is both complementary and competitive. Livestock provide draft and manure; by-products from crop land are converted into meat and milk products. In many regions, livestock and livestock products are the most important source of cash income for farmers. But they are competitive in the sense that food crops compete for land suitable for cultivating and harvesting forages (e.g. forage cropland, fallows, forests and wasteland).

This study is presently examining the extent to which livestock feed, and particularly bovine feed (i.e. green forage crops, grasses, crop residues and concentrates), have increased, or perhaps decreased, in availability over time in response to a growing demand for them.

Demand for feed

Rising incomes

There are several factors associated with the rising demand for livestock feed, but the driving force behind all these is the changing economic structure. Rising incomes over the last two decades have resulted in a marked increase in the demand for milk. As incomes rise, per capita demand for cereal food grain—

especially coarse cereals—declines. At the same time demand for other food items such as vegetables, fruits, milk and meat rises. These commodities have economic characteristics which are reflected in consumers decisions conditioned by change in prices and expenditure (proxy for income). Responses are measured in the form of elasticities, i.e. the percentage change in quantities demanded given a 1% change in income or price. Milk and milk products have one of the highest expenditure elasticities in India. Radhakrishna and Ravi (1990) estimated that a 1% rise in disposable income is accompanied by a 1.10% (rural group average) and 0.92% (urban group average) increase in consumption of milk and milk products. In contrast, the demand for superior cereals (rice and wheat) will increase by 0.5% (rural group average) and 0.3% (urban group average). Their study projects the per capita demand for milk to increase at 2.3% per annum until the year 2010, higher than for any other food group. This is the driving force behind the increase in the demand for livestock feed, derived through a preferred food group.

Milk production

Milk production in India went up from 19 million tons in 1966 to more than 51 million tons in 1989, a 2.5-fold increase. Per capita milk production also increased from 39 kg/annum in 1966 to 65 kg/annum in 1989. This reflects a similar trend occurring in the major regions (Table 1). The Northern region has the highest per capita production of milk (103 kg/annum) while the Eastern region has the lowest (34 kg/annum).

Table 1. *Distribution of milk production in different regions of India, 1966 and 1989.*

	Milk production (000 tons)			Per capita production (kg/annum)	
State	1966	1989	Compound growth rate (%)	1966	1989
Eastern region	2709	6877	4.1	21.81	34.23
Northern region	9327	21,485	3.7	74.44	103.05
Southern region	2899	10,331	5.7	23.74	54.35
Western region	3815	11,146	4.8	36.15	63.80
All India	19,342	51,448	4.3	39.22	63.77

Source: Government of India, Bulletin on food statistics, various years.

The increase in milk production was not simply the result of increased numbers of milch animals, though this was considered a contributing factor (see next section). Milk production per animal nearly doubled during the same period. Higher milch animal productivity is attributed to several factors including a shift in the she-buffalo/cow ratio, improved breeds of cows, and better veterinary services. In general, female buffaloes and crossbred cows are better converters of energy and protein from feed into milk (Nair 1985).

What role has increased feed requirements per milch animal played in nearly doubling productivity? It seems such a "white revolution" could not have been possible without significant increases in total feed availability. In the following sections of this paper we address the issue of feed availability versus requirement in India, and shed some light on the importance of different sources of feed and their contribution to increased milk production. Before examining the livestock feed issue, however, we look at trends in the bovine population and their distribution across major regions.

Bovine population

A direct consequence of the increase in demand for milk has been the increasing number of livestock in India. The livestock which depend most on cultivated forage crops, crop residues and grazing land are the bovines: the cattle (bullocks and cows) and buffaloes. During the period between the 1966 and 1987 Indian livestock census their numbers rose from 229 to 273 million, a 19% increase. The increase, however, has not been uniform for the different bovines. Since 1966 the bullock population has remained relatively stagnant at about 100 million (Figure 1). Traditionally in India, bullocks are used for draft power and transport. With improvements in infrastructure, more and better roads in the rural areas and greater availability of other forms of conveyance, and with the increasing use of tractors, growth in demand for bullocks has been almost negligible. Indeed, in some states such as Rajasthan, where tractor numbers have increased from 3900 in 1966 to 91,200 in 1987, numbers of bullocks have declined significantly. A similar story holds for Punjab and Haryana. While the bullock population has remained stagnant at the All-India level, it has grown by 1% in the eastern region (Table 2). Interestingly the growth in tractor numbers has been the lowest in this region. In the northern and southern regions the growth rates are negative though not significant.

Figure 1. All-India bovine population.

Table 2. *Annual compound growth rates (%) of draft and milch animals in different regions of India: 1966–87.*

	All-India	Eastern India	Northern India	Southern India	Western India
Draft					
Bullocks	0.1	1.1	-0.6	-0.6	0.4
Male buffaloes	0.7	0.6	2.0	-1.8	1.0
Milch					
Cows	1.0	2.1	0.2	0.5	0.8
Buffaloes	2.0	1.5	2.5	2.0	1.8

Source: Government of India, Livestock census (1966; 1987).

The major change in the number of bovines has occurred within the female population. As the demand for milk has risen steadily during the last two decades, numbers of milch animals have risen too. At the all-India level the number of cows increased from 80 to 100 million (1% per annum) and the number of female buffaloes from 40 to 60 million (2% per annum). As the rates of growth have varied across different regions of India the distribution of bovines across these regions has changed over time as well. In 1966 the cow population in India was more or less uniformly distributed across the four regions (Table 3). By 1987, there was a positive shift in the proportion of cows in the eastern region. For female buffaloes, the proportions did not change markedly; they have always been relatively more important in the northern region. The northern region (Haryana, Punjab, Uttar Pradesh, and Rajasthan) accounts for almost half (46%) of the total population of female buffaloes. Those four states also account for 42% of India's milk production.

Table 3. *Distribution (share) of draft and milch animals in different regions of India, 1966 and 1987.*

	All India ('000 nos)		Regions (per cent to All-India)							
			Eastern		Northern		Southern		Western	
	1966	1987	1966	1987	1966	1987	1966	1987	1966	1987
Draft										
Bullocks	96,660	96,681	26	31	26	2	19	16	26	27
Male buffaloes	79,471	97,388	25	32	24	20	22	20	26	25
Milch										
Cows	14,606	16,770	20	20	30	40	28	17	20	22
Buffaloes	38,340	59,632	9	8	42	46	23	22	23	22

Note: Eastern region: Assam, Bihar, Orissa, and West Bengal

Western region: Gujarat, Madhya Pradesh, and Maharashtra.

Northern region: Haryana, Rajasthan, Punjab, and Uttar Pradesh.

Southern region: Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.

Source: Government of India, Livestock Census of India (1966; 1987).

Some trends appear to be emerging. First, the percentage of milch animals in the total bovine population is increasing. This can be seen by looking at the growth in the ratio of female to male bovines over time. At the all-India level, the ratio has gone up from 1.05 to 1.34. In the northern and southern regions the ratio is much higher. Second, the relative importance of female buffaloes in milk production is increasing. The ratio of female buffaloes to cows increased from 0.48 to 0.61 between 1966 and 1987 at the all-India level. Once again, this ratio is considerably higher in the northern region, indicating a strong preference for female buffaloes there (Table 4). A third trend relates to the urban versus rural milch animal population. Although urban milch animals constitute a small proportion of the total, their numbers have increased more rapidly. In the northern region, for example, numbers of cows and female buffaloes in the urban areas increased by 55 and 135%, respectively, since 1966, compared with only 2 and 65% increases for the rural areas. Urbanisation effects, with its associated increased demand for milk, account for this phenomenon.

Feed availability vs requirements

No readily available sample survey data exist to examine changes in bovine feed consumption over time. Various studies, however, using secondary data have attempted to estimate feed availability and feed requirements at a point in time. Almost all these studies have reached a similar conclusion: there exists a huge deficit between feed availability and feed requirement for livestock in India. Those findings, however, must be viewed with some degree of circumspection.

Table 4. *Change in composition of bovine population in India, 1966 and 1987.*

	Female/male bovine ratio		Female buffalo/cow ratio	
Region	1966	1987	1966	1987
Eastern region	0.85	1.03	0.18	0.16
Northern region	1.17	1.62	0.84	1.36
Southern region	1.14	1.70	0.51	0.70
Western region	1.05	1.34	0.48	0.61
All-India	1.05	1.34	0.48	0.61

Note: Eastern region: Assam, Bihar, Orissa, and West Bengal

Northern region: Haryana, Madhya Pradesh, Punjab, and Uttar Pradesh.

Southern region: Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu.

Western region: Gujarat, Madhya Pradesh, and Maharashtra.

Source: Government of India, Livestock Census of India (1966; 1987).

It is somewhat problematic trying to even roughly quantify feed requirements and availability. One major problem is the lack of standard feeding rate requirements acceptable to all. Standard feeding rates used by the National Dairy Research Institute differ from those used by National Commission on Agriculture, which differ from others using, for example, an economic standard feeding rate. Furthermore, different standards of feed should be based on age, size, and type of animal and on work capacity/milk productivity performance. Without more detailed information about the demographic structure of the bovine population, it is extremely difficult to work out national feed requirements. Some avoid the problem by adopting simple formulas, e.g. calculating dry feed requirement as roughly to 2–3% of body weight. This method, highly questionable at best, cannot dismiss the problem that the weights of the livestock are simply not available from the population data.

Calculating feed availability can be almost as problematic, and estimates in general, vary widely. A variety of forage crops are cultivated in India and while area data are sometimes available, production data are not. The same is true for wild or natural grasses growing on grazing lands, permanent pastures, and fallow lands. While these certainly contribute to the livestock feed supply no reliable production figures are available.

Despite such obstacles, periodic attempts have been made to estimate feed availability and requirements for livestock in India. (Livestock include sheep and goats, which are not considered in our own subsequent analysis; sheep and goats do not compete with bovines for concentrates and crop residues, and usually not for forage except for green grasses from grazing or fallow lands). The Committee on Fodder and Grasses (1987) in their report came up with an all-India deficit of nearly 600 million tons for green forage and 400 million tons for dry fodder (e.g. straw/crop residues). Mudgal and Pradhan (1988) estimated smaller, but still significant, deficits in green forage (47 million tons), dry fodder (45 million tons), and concentrates (9 million tons). More recently Singh and Majumdar (l992), drawing on a 1991 report of the NMWD (1991), worked out the supply and demand of livestock feed based on a regional analysis. Out of 55 regions in India only 12 had net surplus in feed production. Notwithstanding the assumptions in each of these studies, heroic at best, it appears likely that there is a shortfall in livestock feed supply in India. And while none offer any hard evidence for this shortfall growing over time, many speculate that it has. Indeed, most expect the situation to deteriorate further. Hazra and Rekib (1991) estimate the projected demand for livestock feed in the year 2000 to be about 950 million tons of dry fodder and 1135 million tons of green forage against a present availability of 450 and 320 million tons, respectively.

Feed balance sheet: All-India

While there probably is a gap between requirements and availability of feed for cattle and buffaloes in India, we question whether in fact the situation has worsened (and will continue to worsen) over time. Our working hypothesis is that there is not sufficient evidence to indicate there has been a deterioration in bovine feed availability overall, even if certain components of the system have deteriorated, e.g. grazing lands. Casual observation suggests that it would have been highly unlikely to have achieved the dramatic increases in milk production and milch animal productivity during the last two decades without an improvement in overall feed availability per animal.

To examine this issue, we approach the problem a little differently from the studies mentioned above have. We take stock of the feed availability situation in the mid-1960s and compare it to the situation in 1986–88. This is done on a per animal basis, giving us something comparable to a bovine feed balance sheet. This, in turn, indicates how far and to what extent the feed resources have kept pace with the bovine population.

Bovine feed resources in India can be divided into six major groups: (1) cultivated forage crops, (2) green grass from permanent pastures, cultivated waste land and fallow land, (3) cereal crop residues (straw), (4) bran/husks from cereals and pulses, (5) concentrates (oilcake etc), and (6) cereal grains. Since production data are virtually impossible to estimate for (1) and (2) we examine changes in feed resources from these sources in terms of area only. To estimate the changes over time in (3), (4), and (5), production figures are calculated after using standard conversion rates. For (6) data on cereal grain used for feed are obtained from USDA (1989). The advantage of this approach is that it shows the relative importance of different sources of feed and the net changes of each over time.

Using data from the Directorate of Economics and Statistics, Figure 2a shows the changes that have occurred in area under total forage crops, permanent pastures, cultivable wasteland, and fallow land between the years 1967–69 and 1986–88. Area figures are given on a per 1000 bovine basis and so reflect supply changes relative to changes in demand. Kelley and Rao (1994a) found that while total forage area remained stagnant at the all-India level irrigated forage area increased by 2% between 1966 and 1988. To account for this, an adjusted forage area variable has been created to account for superior quality and productive capacity of irrigated forage land. It was assumed that 1 ha of irrigated forage is equivalent to about 3 ha of dryland forage. Thus, while total (unadjusted) forage area declined from about 26 to 21 ha per 1000 bovines, adjusted forage area declined by a mere 2 ha, from about 37 to 35 ha per 1000 bovines. A larger than three-is-to-one conversion factor would suggest that forage availability has not declined at all, or perhaps even increased. Before more definitive statements can be made, more data are needed to establish a proper conversion factor.

Figure 2a. Change in area/1000 bovines, all-India, 1967–69 to 1986–88.

Fallow land, contrary to widespread belief, has actually increased in acreage in India during this 20-year period. On a per 1000 bovine basis, the area has remained almost constant at 95 ha. It is the area under cultivable wastelands and permanent pastures that has registered the biggest reductions in area over time. Here the evidence is more convincing that we have indeed seen a decline in the availability of green grasses from those feed sources. Area per 1000 bovines under cultivable wastelands declined from 70 to 55 ha and for permanent pastures from 58 to 42 ha. There is also good evidence to suggest that the quality of grasses from these sources has deteriorated due to overexploitation of those resources and poor management (Jodha 1986).

In Figure 2b, the changes in total crop residue (i.e. straw or stover) production from the major cereal crops, are shown, again on a per 1000 bovine basis. Though production figures for straw are not given in the statistics, they can be derived using standard grain to straw ratios. Total straw/stover production from the major cereal crops increased from 921 to 1040 tons per 1000 bovines. Straw/stover constitutes an important source of feed for bovines and is generally available throughout the year. The increase in straw production is due to significant increases in the production of wheat (more than doubled per 1000 bovines) and paddy in India during this period. In contrast, sorghum stover and pearl millet straw production declined significantly. Falling acreage and increased use of high yielding varieties (HYVs) with a higher harvest index are largely responsible for this drop. Despite their smaller contribution at the all-India level, sorghum and pearl millet straw are important in specific regions. Furthermore, sorghum stover is generally considered the most preferred of the major cereal straws for milch animals. Maize stover production per bovine has remained relatively constant.

Figure 2b. Change in straw production/1000 bovines, all-India, 1967–69 to 1986–88.

In Figure 3 the changes in bran/husk, oilcakes production and cereal grains used for feed are shown. Standard conversion rates are used to arrive at production of bran/husks and oilcakes. Bran/husks production per 1000 female bovines has increased from 50 to 65 tons and oil cakes from 50 to 60 tons (since almost all this is fed to milch animals, we have considered female bovines only). Cereal grain fed to bovines still constitute a very small proportion of total feeds consumed, however, its share has increased from a low of 2.5 tons/1000 female bovines to 9 tons.

Figure 3. Change in bran, oil cakes production and cereal grain use/1000 female bovines, all-India, 1967–69 to 1986–88.

While no other reliable sources on cereal grain feed use are readily available, a few sources do mention importance of grain feed use in India. The National Commission on Agriculture assumes that about 2% of the total coarse grain production in India is used for cattle feed. They do not say whether or how much this has increased over time. Elsewhere, Ranjan (1992) reports that sorghum and maize constitute about 8 to 12% of the raw material used in compound cattle feeds. We know that compound feeds are becoming increasingly important. A study by Yamadgai (1991) indicates that the production of compound feeds in India has increased from 0.15 million tons in 1964 to 4 million tons in 1990. An IFPRI study (Sarma 1986) showed that use of cereals as feed in India will grow at 3.4% between 1980 and 2000 which is higher than the growth of food use of cereals.

From the calculations above, it would not seem justifiable to conclude that a deterioration in bovine feed supply has occurred at the all-India level. Given the greater relative importance of crop residues in the diets of draft and milch animals, it does not appear likely that reductions in area under permanent pastures and wasteland were significant enough to offset the increases in straw/stover production and growth in the use of bran/husks, oilcake, and cereal grains. Of course, this may not hold for specific regions/states in India. In some states of India deficits are quite likely, in others surpluses.

Feed balance sheet in two states

Two states, Haryana and Maharashtra were selected for illustrative purposes. Haryana is one of the leading milk producing states; Maharashtra is second only to Madhya Pradesh in numbers of bullocks. In Haryana, cultivated forage crops and crop residues from wheat, paddy, and sorghum straw are important sources of feed, as are bran/husks and oilcakes. (Data on cereal grain used for feed at the state-level are not readily available). Although the area under total forage crops per bovine has declined, adjusted forage area actually rose. This reflects the high proportion (over 80%) of irrigated to total forage area there. In contrast, area under permanent pastures, cultivable wasteland, and fallow lands per bovine has declined (Figure 4a). The most dramatic increase has been in the production of wheat and paddy straw which more than doubled per bovine during the 20-year period (Figure 4b). Haryana sometimes exports its surplus wheat and paddy straw to neighbouring states like Rajasthan.

Figure 4a. Change in area/1000 bovines, 1967–69 to 1986–88.

Figure 4b. Change in straw, bran and oil cakes production/1000 bovines, 1967–69 to 1986–88.

In Maharashtra, cereal crop residues, mainly sorghum stover, are by far the most important source of feed, but grasses from permanent pastures and fallow land also contribute to the feed supply. In contrast to Haryana, area under cultivated forage crops in Maharashtra declined, as did area under permanent pastures and fallow lands. Of greater importance, however, was that sorghum, pearl millet, and paddy straw per bovine declined. Wheat straw increased somewhat but not enough to offset the decline in the other cereals. Bran/husks and oilcake production increased marginally. This would suggest that the bovine feed supply situation in

Maharashtra has probably worsened over time. Imports from other states can help meet the demand but the scope here is limited. The difference in adjusted forage crop area per 1000 bovines for Haryana and Maharashtra is large (220 ha vs 40 ha, respectively), as is the difference between production of straw/stover per 1000 bovines. This alone probably cannot account for the big difference in per capita milk production in Haryana and Maharashtra (196 vs 47 litres/person per annum) but it surely explains some of it.

One can argue that such regional deficits could be made up by transporting straw from surplus areas to deficit areas as is done for wheat straw from Haryana and Punjab to Rajasthan. This is possible when states are neighbouring and the distances not too far. However, it is not economically feasible to transport straw from Haryana to Maharashtra as straw is a bulky commodity and difficult to transport. With improvements in processing, e.g. cutting or compressing into bales, it may become more attractive to bring in straw from greater distances, if the price is right.

Sorghum and pearl millet straw

The steady decline in area under sorghum and pearl millet in the major growing states with a resulting shortfall in production of stover/straw has had an impact on milk producers. These crops are grown in the drier regions of the semi-arid tropics of India. Here, alternative sources of feed are hard to come by particularly in dry years. In these regions farmers expect dry or drought conditions to prevail in 3 to 5 years out of 10 (Kelley and Rao 1994b; Kelley et al 1996). A recent study by Phansalkar (1992) in a few selected districts in India shows that changes in cropping pattern (particularly shifts from cereal crops like sorghum, pearl millet and paddy to oilseeds crops, chillies, plantation crops and orchids) has led to a shortage of cereal straw. This has resulted in sharp increases in the straw prices raising cost of production, particularly for small-milk producers having to purchase in straw.[1]

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1. Most farmers produce forages and use cereal straw for their own livestock with little surplus left for marketing. Nevertheless, small and landless farmers buy straw and stover from large farmers informally within the village and these transactions are not recorded. Also, dairy producers in urban areas depend on crop residues supplied via "unregulated" fodder (i.e. straw and stover) markets. Fodder, unlike grain, is not a notified commodity and not under government control. Records on fodder deliveries and prices are usually not kept. Unlike grain markets, fodder markets are thinner, and not as integrated spatially or temporally. The bulky nature of the commodity with its high transportation and storage costs accounts for this fact. Thus, a major problem in studying relative changes in dry fodder value over time is to identify data sources. Two fairly reliable sources have been the state marketing co-operatives (Maharashtra) and the cost of cultivation schemes.

Data from wholesale fodder (straw and stover) markets in Solapur, Maharashtra show that sorghum straw prices rose from Rs 12 per quintal in 1970 to Rs 120 per quintal in 1993, a tenfold increase. In contrast, grain prices rose from Rs 100 to Rs

450 per quintal, a fourfold increase. Thus, the sorghum grain/straw price ratio declined from 6/1 to 3/1 by 1993 (Figure 5). Similar trends were found for both rainy and post-rainy season sorghum in other major sorghum growing districts in Maharashtra. For pearl millet similar trends were found in the grain/straw price ratio in Rajasthan. Thus for example in Nagaur and Jaipur districts, straw prices increased from Rs 15 to Rs 50 per quintal from 1971 to 1989, while grain prices doubled from Rs 100 to Rs 200 per quintal. This is reflected in a falling grain/straw price ratio from around 8 to less than 4 (Figure 6).

Figure 5. Annual sorghum grain/straw price ratios at Solapur, 1971–93.

Figure 6. Annual pearl millet grain/straw price ratios in selected districts of Rajasthan, 1970–89.

Sorghum and pearl millet straw continue to be an important feed source as reflected in their economic value. While straw production of sorghum and pearl millet per bovine animal has declined during the last two decades, it still represents a significant input in many of the mixed crop–livestock production systems in India. The value attached to sorghum and pearl millet straw by milk producers in rural and urban areas has helped slow the trend of falling sorghum and millet acreage in India. These otherwise low-valued coarse grain crops would be even less competitive without the significant economic contribution made by the straw production component.

Summary and implications

The two-and-a-half fold jump in milk production since 1970 was almost certainly achieved by, amongst other factors, an increase in production and utilisation of crop residues and concentrates, and, particularly in the northern states, increases in the production of forage. The available data does not lend itself to a robust examination of changes in bovine feed availability over time in India. However, the simple approach used here looking at changes in the availability of each of the major feed sources over time per bovine animal does not support the hypothesis that the gap between availability and requirement is widening over time. Indeed, the opposite appears to be true, except in the case of some specific states, e.g. Maharashtra.

While the overall availability of cereal crop residues has increased, the availability of sorghum and pearl millet straw has declined over time. These straws still represent a significant input in many of the mixed crop–livestock systems as reflected in their increasing economic value over time. While some of the reduction in straw has been compensated for by an increase in the production and utilisation of oilcakes and feed grain, crop residues from sorghum and millets will continue to constitute a major feed source for bovines in India for some more time to come.

The implication of this is that straw yield and straw quality of sorghum and pearl millet play a key role in cultivar adoption decisions of farmers particularly in more marginal environments where these crops are grown. This raises a strategic question for the sorghum and pearl millet improvement scientists in India: how much effort should be given to improving stover/straw quantity and quality in dual-purpose cultivars vis-à-vis efforts at improving the (single-purpose) grain and forage types. Presently, straw from dual-purpose types contributes significantly more in the diets of milch and draft animals in India than grain (as concentrates) and forage (as green fodder) types do. An effective strategy that breeders should adopt for increasing adoption of these crops beyond those regions presently covered is to give increased emphasis to straw yield and quality of these crops. This is all the more pertinent in view of the changing relative importance of straw over time, a trend that is likely to continue into the future. This will undoubtedly change in the future as the steadily growing demand for milk is partially met through expansion of irrigated forage area (particularly in the north), increases in forage productivity, and an increasing share of cereal grain production (including sorghum) for feed use.

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Livestock research priorities in Bangladesh

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Abstract

Seventeen researchable areas are identified and a number of research elements are mentioned under these areas from which the research projects will be developed according to the needs of the country. From these researchable areas, a unified research programme needs to be developed according to priority. A holistic approach including breeding, feeding, disease control and management should be developed for the country. It is suggested that ILRI may set up one subcentre in Asia according to the population density of livestock. Small ruminants should be given priority to develop meat production in the country.

Introduction

Livestock represent an important component of traditional farming systems. The majority of the ruminants in Asia are owned by smallholders (1–5 animals). The improvement of livestock and poultry from the level of a scavenger system to a commercial scale is constrained by inadequate resources. Therefore, a strategy is to be formulated to develop an appropriate low-input technology commensurate with the economic efficiency of the farmers. Resource limitations therefore demand that a long-term research priority be formulated to achieve a targeted level of protein self-sufficiency.

Table 1 presents the extent of livestock resources in Bangladesh in comparison to some countries in Asia.

Table 1. *Statistics on livestock populations.*

	Cattle (10^6)	Buffalo (10^6)	Sheep (10^6)	Goats (10^6)	% distribution
Bangladesh	23.2	1.9	1.1	10.8	2.6
Pakistan	16.5	13.4	25.8	30.8	2.7
India	200.0	75.0	54.6	102.9	19.0
China	66.9	20.0	94.2	61.9	7.1
Asia/Pacific	395.5	133.5	457.7	244.9	40.7
Other countries	876.3	81.9	688.0	247.3	59.3
World	1271.8	138.9	1145.7	492.2	100.0

Source: FAO (1986).

Economic analysis of production performance

In Bangladesh high livestock density is reflected in 145 large ruminants/km^2 compared with 90/km^2 in India.

The low level of livestock production is invariably related to the socio-economic conditions of the farmers. The farm size, family size, literacy rate, labour supply etc are closely related to livestock raising. Also, religious taboos and orthodox convictions very often influence livestock production.

The improvement of livestock has received limited attention. This is related to ignorance of the livestock sector, and is associated with (i) lack of recognition of the contribution of livestock to the national economy, (ii) lack of recognition of the importance of livestock from a macro-economic perspective, (iii) lack of effective demand for livestock products in the rural areas, and (iv) the absence of a constant pressure group against deprivation.

Livestock contribute 6.5% of the GDP in Bangladesh. This estimate excludes the value addition from draft power and dung. A recent report claims that the contribution of livestock sector to GDP is actually about 15%.

Livestock are important from a macro-economic perspective. For instance, crop production may be increased significantly with the adequate supply of draft animal power. Similarly, the increase of milk and meat production can improve the balance of payment position by reducing imports of powdered milk. It could also contribute to the success of the national health programme by improving the nutritional status of the people.

There is a lack of effective demand for livestock products in the rural areas. Poor farmers buy tobacco or cigarettes instead of milk, because they have the impression that milk is not part of a poor man's diet.

The absence of a constant pressure group for the development of appropriate policy is another reason why the livestock sector is neglected. In Bangladesh, livestock are integrated into farming systems. Here, crop production dominates the farm activities. Very few farmers depend solely on livestock rearing. Thus, there is no pressure group to act against deprivation of the livestock sector from its due share in national development plans. As a result, this sector receives less priority in development efforts of the government.

A clear understanding of the linkages and interdependencies is necessary for prioritising development programmes for livestock. The most critical areas to improve production rate of livestock are:

- improved nutrition
- disease and parasite control
- improved animal genotypes to take advantage of the improved management
- improved animal growth leading to larger animals with greater draft capabilities
- improved implements for draft animals, reducing the number of animals required
- reduction in the number of the unproductive animals
- keeping proper livestock statistics.

Researchable areas

There are a number of researchable areas in livestock production in Bangladesh. These are briefly discussed.

Animal feeds and nutrition

Poor nutrition as a consequence of inadequate feeds and fodders seriously limits the productivity of livestock and poultry. It is unlikely that any significant proportion of land will be available for growing fodder crops, because of the emphasis on the production of food grains and other crops intended for human consumption. The challenge therefore lies in developing innovative practices of fodder production. These practices include intercropping of legume species, accommodating quick-growing fodder crops that enrich soil fertility during the turn-around time between two major crops, using current fallow and cultivable waste lands for raising fodder, growing dual-purpose crops like maize, and using road sides, hills, forests, community lands and homesteads for growing fodder trees and forages.

Other opportunities include maximising the use of crop residues, agro-industrial and marine by-products that are available but not widely used as feed (e.g. shrimp meal, bone meal, blood meal, wheat straw and pulses). Some non-conventional items such as water hyacinth, algae, azolla and duck weed, sweet potato and potato discards, canning industry waste, leather shavings etc as feed supplements, and frogs as a source of protein may also be explored for farm-level use. Toxic compounds and anti-nutrients are frequently found in the non-conventional feed resources. Techniques should be developed for detoxification of such feed resources.

Substantial gains in the utilisation of feed can come from improving the use of non-protein nitrogen (urea–ammonia) for conversion by ruminants into protein.

Improvement of animal health

Disease is one of the major constraints to livestock productivity. The provision of an efficient animal health service will require pursuance of a two-pronged strategy: (a) development of a disease-reporting system and (b) a disease-control programme.

The disease-reporting system contains information on the incidence of disease mortalities, the geographical distribution, seasonality and dynamics of the situation including the epidemiological interaction of hosts, agents and the environment. These will be the basis for decisions on where, when and how to launch attacks on disease outbreaks. A disease-reporting system should begin with computerisation. These data should be statistically analysed for trends of incidence of specific diseases by species, age, breed, season, year and location. Once the disease-reporting systems develop, the disease-control programme will entail two approaches: strategic planning, and delivery systems for treatment and vaccination.

Strategic planning for control of different economically important diseases encompasses (a) short-term planning (5 years) to reduce the incidence and economic losses, (ii) medium-term planning (5–10 years) to bring down the incidence of disease to negligible levels and to start its eradication from parts of the country, and (iii) long-term planning (10 years) to eradicate the disease from the country.

The delivery system calls for vaccination programmes, sanitation, quarantine, test and slaughter, treatment, and extension programmes for farmers. It will be backed by support systems consisting of diagnostic and vaccine laboratories and research units.

Research in animal health should also include fundamental studies on the biological factors relating to host resistance and parasitic infection.

Breed development and genetic upgrading

Bangladesh has a cross-breeding policy involving local and Holstein-Friesian (50:50) and/or Shahiwal-local cross (50:50). The breeding policy is carried out through artificial insemination to produce crossbreds in different locations. In the absence of progeny testing and appropriate follow up, potentially high yielding F_2 progeny have started showing declining milk yields. Frozen semen has recently been introduced to increase efficiency, and rapid upgrading of local stock through MOET (multiple ovulation and embryo transfer). Other approaches in breed improvement include the open nucleus breeding system (ONBS), using modern reproduction biotechnology to conserve gene pools of relatively uniform types of cattle in some milk pocket areas. Special cattle/buffalo breeding farms will be required to propagate pure breed exotic dairy cattle and dairy buffaloes to supply germplasm for breed improvement programmes.

Goats and sheep provide a wide range of products—meat, milk, wool and skin—and contribute to the security of the livelihoods of small farmers. The potential for goat development is enormous in Bangladesh. The goat may be a dominant component of the complex agricultural system of Bangladesh in the future. Research should be directed to conserve the genetic parity of the Black Bengal goat and analytical studies of hybrids should be undertaken to further improve production potential of meat, milk and skin. Application of embryo-transfer techniques for goats should receive priority attention.

Research on draft animal power

The demand for draft power has increased considerably with the expansion of high yielding technology and intensification of cropping with a shorter turn-around time between crops. Livestock are already providing the majority of non-human farm power and this is expected to continue. Therefore, improvement of quality of draft power should be emphasised through better nutritional management of the animals and veterinary coverage. Appropriate low-cost technologies for the preparation of balanced feeds (straw treatment and urea–molasses blocks) should be developed, and also increasing the use of single-animal plough systems coupled with efficient harnessing techniques to increase the efficiency of energy conversion.

Dairy research and development

Recently in Bangladesh, livestock development policy is aimed at encouraging establishment of small and marginal farms for milk production through subsidies that also create rural employment. The research areas that deserve attention are developing improved technology for making different types of dairy products and their preservation, quality control procedures and standards, and establishing a sound marketing system of dairy products and by-products.

Poultry research

Regional genetic pools should be developed according to the environment and conserved from where the quality genetic material can be distributed to develop improved breeds.

Abundant fresh water resources in rural areas have considerable potential for rearing ducks, and Bangladesh has a comparative advantage over other countries in duck production. The technology applied by farmers is still primitive and inefficient. Strong research efforts, particularly in breeding and disease control will be required to increase the productivity of poultry farming. More research should be made to promote duck-cum-fish farming in the country.

Utilisation of animal by-products

Animal by-products, such as hides and skin, wool, bones, various glands and organs are considered as important items for industrial use. Due to the absence of scientific and modern slaughterhouses, animal by-products are handled in unhygienic and wasteful ways. This results in inferior by-products and pollution of the environment. Proper collection, processing and use of animal by-products would be a viable proposition for generating income of the farmers. Research should include the production of quality leather, use of bones and leather shavings for animal feed, fertiliser, glues, feather and hairs for various industrial uses and handicraft purposes, wool for garments, blankets, carpets and glands for medicine etc.

Frontier research

Application of innovative techniques is key to achieving rapid improvement in livestock productivity. Twinning in dairy and beef cattle should be a promising technology. Other technologies include hormone treatment for super ovulation, controlled breeding, non-surgical recovery of fertilised eggs and non-surgical embryo transfer to females of low breeding value.

Non-surgical embryo collection is now aided by extremely sensitive micro-techniques for embryosexing, freezing and implanting. These can revolutionise genetic improvement and productivity of dairy and beef cattle. Manipulation of rumen microflora in the ration of dairy and beef could greatly increase utilisation efficiency of nutrients.

Above all, animal disease control, improved production and utilisation feeds and genetic improvement are equally important. There will be little value with improved utilisation of feeds without timely inputs of disease control, genetic improvement and increased reproductive efficiency, and vice versa.

Researchable issues

The specific researchable issues in Bangladesh are discussed below.

Animal nutrition

Utilisation of agro-industrial by-products

1. Developing techniques for improving straw utilisation by small and large ruminants through pre-treatment, supplementation with urea–molasses, protein concentrate, rumen microflora and grasses.
2. Developing techniques for using sugar industry by-products, e.g. molasses and bagasse as animal feeds.
3. Techniques for processing leather industry by-products, e.g. offal, trimmings and shavings as animal protein supplement for ruminants and poultry.
4. Developing techniques for using energy rich by-products from the canning industry (e.g. banana, citrus fruits, pineapple, sugar-cane etc).

Utilisation of non-conventional feed resources

1. Developing information on chemical composition, nutritive value, toxic factors and value of non-conventional feed resources in feeding systems.
2. Utilisation of aquatic weeds, e.g. water hyacinth, algae, duckweeds, azolla etc as feed for ruminants and poultry.
3. Utilisation of tree leaves and seeds for ruminants and poultry.

Development of feeds and feeding standards

1. Prepare inventory of feed resources, identify seasonal availability, nutritive value and economic benefits of different feeds and fodder under various crop production systems.
2. Determine available metabolisable energy and microbial protein production under different straw based rations for ruminants.
3. Determine nutrient requirements for different productive purposes in different groups of livestock.
4. Develop rations for beef fattening, dairy cattle and breeding bulls.
5. Identify the mineral deficiencies in cattle, sheep and goats and solve their problem.

Technology for increased fodder production

1. Develop sustainable forage production in the existing cropping pattern.
2. Develop SALT (Sloping Agro-forestry Livestock Technology) modules in the hilly areas.
3. Develop saline-tolerant fodder in coastal areas.
4. Introduce fodder trees and fodder shrubs in various agricultural systems.
5. Develop sustainable low-cost fodder farming for livestock.

Infectious disease control

1. Developing an effective system for reporting infectious diseases of livestock and poultry and develop corresponding databases.

2. Developing forecasting models for control of infectious diseases of livestock and poultry based on epidemiology–economic studies.
3. Devising genetic and molecular tools for quick effective and efficient laboratory diagnosis of infectious diseases.
4. Developing knowledge of the immunological characteristics of infectious organisms for devising new and/or more potent vaccines.
5. Evaluating new drugs with longer prophylactic value (pharmacokinetics/dynamics) against different infectious diseases.
6. Designing effective vaccination programmes against the economically important infectious diseases of livestock and poultry.
7. Developing a surveillance system to identify zoonoses (disease transmissible from animal to man) that may affect the community.
8. Establishing the distinctive clinic–pathological features and pathogenesis of infectious diseases of livestock and poultry.

Non-infectious disease control

1. Investigating the ecology of parasites and their host/parasite relationship and determining methods/models for strategic and tactical control of parasite disease.
2. Studying the bionomics of vectors and intermediate hosts of etiological agents of livestock and poultry diseases.
3. Conducting studies on the physiology, genetics and resistance to anthelmintics of endo- and ectoparasites.
4. Identifying toxic herbs, shrubs and plants and insecticides/pesticides and finding effective antidotes (to pesticide and plant-toxin poisoning of livestock).
5. Developing knowledge of nutritional deficiency and metabolic diseases of livestock and poultry under existing management and feeding practices.
6. Developing reproductive health management systems with artificial insemination activities.
7. Developing methods for assessing the social and economic implications of zoonoses and developing food hygiene programmes.
8. Investigating the effect of the environment on animals and using the information obtained to protect human and animal health.
9. Developing, adopting and evaluating various surgical procedures in the treatment of various conditions, including teratology.
10. Investigating the relationship between various hormone profiles and reproductive performance and diseases of large and small ruminants.

Animal breeding

1. Characterising, conserving and improving different dairy type indigenous cattle and buffalo through selective breeding (using open nucleus breeding systems with multiple ovulation and embryo-transfer techniques).

2. Evaluating the performance and adaptability of exotic breeds of cattle and their crosses in comparison with that of the native breeds.
3. Developing high-yielding varieties (HYVs) of livestock adapted to the local environmental condition.
4. Determining the desirable economic traits, reproductive and productive efficiency of indigenous breeds using Black Bengal goats in Bangladesh.
5. Investigating, collecting, conserving and enhancing the germplasm of indigenous breeds of goats and sheep.
6. Developing disease-resistant breeds of cattle.
7. Introducing non-conventional meat sources like rabbit, hare, cattle breeds like Gayal (*Bos frontalis*) etc.

Dairy research and development

1. Developing strategic supplementation for milk-producing cows under smallholder conditions.
2. Developing calf feeding and starter programmes for dairy calves and replacement stock programming.
3. Developing a dairy training and research institute.

Poultry research

Breeding

1. Identifying, evaluating, conserving and improving native chicken varieties according to the environmental conditions.
2. Introducing superior germplasm for establishing suitable grade of some particular breeds/strains for immediate development of rural poultry.
3. Selecting, improving and introducing non-conventional meat and egg sources (like guinea fowl, quail etc).

Nutrition

1. Developing feed information systems (FIS) including data on availability, chemical composition, nutritive value and toxic factors.
2. Developing the cheapest ration from available resources for different classes of poultry.
3. Establishing the nutrient requirements of different kinds of poultry under different geographical condition.
4. Developing a feed quality control system.

Housing and management of livestock and poultry

1. Developing models for livestock production systems commensurate with the existing topography and farming systems.
2. Designing low-cost housing systems and management practices for poultry and goats, especially under existing farming systems.

3. Developing sound ecological and demographic bases for the management of wildlife (including jungle fowl etc) and the conservation of endangered species in the forests of Bangladesh.
4. Developing strategies for the management of crisis with animal feed, health and diseases during post-disaster periods.

Production technology and extension

1. Identifying and packaging the existing potential technologies for rapid transfer to the farmers.
2. Acquiring and adopting exotic livestock production technologies of potential benefit to developing countries in South Asia.
3. Conducting research on "indigenous technology" particularly on the use of indigenous dairy products like ghee and sweet meat at farmer level and inclusion of indigenous material in the processing of milk.
4. Developing effective modules for strengthening extension, research and education among the developing countries with a view to minimise the time in acquisition and dissemination of knowledge about improved techniques/technologies.

Draft animal power

1. Improve the quality of draft power through appropriate feed and nutritional management of existing draft animals.
2. Identify limiting factors of power output of draft animals.
3. Explore the possibilities of adopting single-animal ploughing.
4. Study economics of the solution to draft power shortages and their consequences.

Socio-economic research in livestock

1. Studies related to employment creation, income generation and women's participation in the livestock sector.
2. Studies on the marketing structure, organisation and mechanism of different species of livestock and poultry, their products and by-products.
3. Cost and returns from feeds and fodder production.
4. Impact of lending policies on distribution, utilisation, repayment and management of livestock credit.
5. Studies on the effect of contemporary tax structure, government subsidies and pricing policies on livestock development.
6. Economics of milk, meat and egg production under different conditions of farming.

Processing and preservation of livestock and poultry products

1. Assessment of the losses of poultry and livestock products due to spoilage.

2. Developing and propagating sanitised meat processing technology and slaughterhouse and domestic waste disposal.
3. Developing short- and long-term processing and preservation technology for milk and meat products in rural areas (pasteurisation, refrigeration, curd, cheese, sweet meat, ghee etc).
4. Developing handling, packaging, longer shelf life and safe storage technology etc for meat, dairy and egg products.
5. Standardising quality control measures, including microbial standards and sanitary conditions for meat, milk, poultry and their products.
6. Developing hides and skins improvement schemes for continuous guidance to the producers, processors and exporters.

On-farm livestock research

1. Evaluating the role and relative economic importance of livestock including poultry in the various cropping systems.
2. Identifying the problems, restraints and limiting factors in increasing animal output within farmers' resource capabilities.
3. Studies on impact analysis of mature technologies at on-farm levels.

Developing an accurate data base for more effective planning and execution of livestock programme both at the macro and micro (farm) levels.

Frontier research in livestock

1. Apply genetic engineering techniques in bacterial, viral and parasitic vaccine production.
2. Apply proliferation technologies (embryo transfer, frozen fertilised egg, cleavage technology, external fertilisation, sex checking of sperm etc).
3. Produce growth hormones by gene manipulation.
4. Manipulate rumen microflora to increase digestibility in ruminants.
5. Study the strategic supplement of crop residues for reduction of methane production.
6. Utilise hybrids/hybrid vigour for increased milk, meat and egg production.

Conclusions and recommendations

The livestock farmers of South Asian countries are poor and are not organised. ILRI (International Livestock Research Institute) may help to improve the efficiency of these farmers by collaborative arrangements with farming communities and providing an international approach to the improvement of livestock. The following areas are recommended:

- The implication of achieving self-sufficiency in protein production is to be realised in its appropriate context.
- Achievable targets for livestock production based on resources are to be set and adhered to according to regional needs.

- The factors associated with increased productivity must be assembled together and a holistic or a total livestock development plan is to be undertaken.
- A total development plan means a total plan to improve the rural forces associated with livestock production, marketing and consumption.
- Rural livestock planning is to be done at the rural level where rural people are to participate to implement it.
- Research for improvement of livestock through genetics and breeding, feed and nutrition and disease control are to be target oriented.
- Basic research should also be given due consideration.
- Strengthen linkages among research, extension and education.

Research priorities for improving animal agriculture by agro-ecological zone in India

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Abstract

The Planning Commission in India originally identified 15 resource development regions for the purpose of integrating planning in these regions with state and national plans, to spur agricultural development on a regional basis. Major emphasis was placed on agro-techno-climatic considerations. Their classification was primarily for development purposes. Within the Indian Council of Agricultural Research (ICAR), the use of agroclimatic zones for implementing agricultural research projects gained momentum with the National Agricultural Research Project (NARP) in 1979. The objective is to upgrade research efforts in each agroclimatic zone, using a zonal research station as the focal point for research within a zone to generate relevant research for specific agro-ecological conditions. Emphasis is on analysis of agro-ecological conditions and the cropping patterns to develop a balanced and coherent research programme directed at the major problems limiting agricultural growth in the zone. Under NARP, India was divided into 12 agroclimatic zones plus three zones for islands. These correspond to the 15 regions of the Planning Commission. In addition, studies have been conducted along transects in states for animal production purposes.

Introduction

Livestock farming in India is primarily a small-scale unorganised rural activity, and is an integral part of diversified agriculture. Cattle, buffaloes, sheep, goats, horses, camels. pigs, poultry, yak, mithun etc are maintained for various purposes, namely to provide food, draft, fuel, fibre, animal products, security etc. It is only poultry farming, and to some extent dairy farming, which recently have been developed on a commercial basis into large units involving high-producing genotypes, adequate housing, feed and health cover.

Resources

According to the 1987 census, there were 196 million cattle, 77 million buffaloes, 99 million goats, 45 million sheep, 1.83 million horses, mules and donkeys, 1 million camels, 10.8 million pigs and 258 million poultry. There is a large genetic diversity reflected by the presence of many breeds: 26 breeds of cattle, 8 of buffalo, 40 of sheep, 20 of goats and 4 of camel, excluding several breeds of horses, pigs and poultry. The country has some of the world's best dairy breeds, draft cattle, carpet wool sheep and the most prolific goats.

It is now an established fact that the contribution of livestock has assumed appreciable dimensions in the agricultural economy of the country. According to provisional estimates of the Normal Accounts Division of the Central Statistical Organisation (CSO), the gross value of output from the livestock sector at current prices was about Rs. 588 billion[1] (1992–93) (Rs. 35 ≈ US$ 1) which is about 26%

of the value of total agricultural output. This excludes the contribution of animal draft power.

The contribution of livestock as a source of power has, however, not been fully realised. The 84 million draft animals contribute 30,000 MW energy equivalent annually, giving on electricity saving worth Rs. 100,000 million. During 1972–88, the livestock sector generated nearly 4.2% of rural employment annually.

Some of the factors responsible for the low productivity of livestock in this country are low genetic potential, substandard and imbalanced feeding and poor health management.

National agricultural research systems (NARS) capacity

Agricultural research is mainly being conducted through a well-structured system. The Indian Council of Agricultural Research (ICAR) is responsible for research, education and testing of technology transfer in the country through a large number of institutes and state agricultural universities (SAUs). This infrastructure and the role played by it has been recognised and appreciated internationally. Besides SAUs, there is a network of 85 institutes/national research centres/project directorates and more than 75 all India co-ordinated research projects/network projects. In animal sciences and fisheries, there are 24 institutes and 12 network projects.

In animal sciences the research projects are mainly directed towards: (1) evolving high yielding strains of livestock including poultry, (2) evaluating the utilisation of conventional and non-conventional feed resources with emphasis on developing new feed resources and feeding systems, (3) studying the problems of reproduction and adaptation, (4) developing effective immuno-prophylactic and laboratory diagnostic methods and (5) improving techniques for processing milk, meat and animal fibre.

Some of the major achievements in animal production include the development of (1) high yielding strains of cattle such as Karan Swiss, Karan-Fries and Frieswal, (2) sheep strains such as Avikalin, Avivastra and fine wool and mutton synthetics, (3) improved germplasm of indigenous breeds of buffaloes and identification of outstanding bulls using farmer' s animals, (4) technology for improvement of nutritive value of existing feeds and nutritive requirements of livestock species, (5) behavioural studies on dairy animals with regard to the climate, reproduction, growth and hormonal aspects, (6) standardisation of the technique of embryo transfer and associated technologies for producing better livestock, (7) improved vaccines and diagnostics against rinderpest, foot and mouth disease, rabies, sheep pox, lungworm disease, canine distemper, theileriosis, clostridial disease, Marek's disease and gumboro disease, and (8) methods for conversion of dairy wastes into whey drinks and for standardisation of buffalo milk to simulate human milk and infant foods.

Priorities for research and development

In accordance with the dietary allowances recommended by the Indian Council for Medical Research, 200 g of milk and 15 g of meat (for non-vegetarians only on an average) per person per day, the total requirement of milk and meat is 79.5 million tonnes and 5.4 million tonnes per year, respectively, to meet the requirements of the human population of 990 million. The present production of livestock products in the country is 60.8 million tonnes of milk, 3.37 million tonnes of meat and 24 400 million eggs which reveals that there is a wide gap between actual production and requirement (1993–94 anticipated achievements).

To achieve the estimated production targets, the major approaches are to: (1) develop a more effective understanding of the available genetic resources and ensure their conservation and management, (2) determine the available feed resources and their utilisation, identify non-conventional feeds, improve the nutrition of the existing resources through mechanical/chemical/microbial treatments, (3) develop systems for disease surveillance, monitoring, forecasting and more effective diagnostic prophylactic measures against important animal diseases, (4) develop methods for efficient handling, processing and storage of livestock products so as to reduce losses, add value, increase shelf-life and reduce bulk. These technologies should be very efficient on a small-scale in rural areas, and (5) utilise modern biotechnologies for genetic resource conservation, genetic improvement, maximising utilisation of available feed resources, improved reproduction and development of more effective diagnostic and prophylactic measures.

Researchable areas and issues

Animal breeding

Research emphasis needs to be on genetic studies of crossbred and indigenous cattle with a view to developing selection criteria, determine genetic and phenotypic trends and generate superior crossbred germplasm for milk production. Similar studies need to be made on draft, dual purpose and milch breeds of indigenous cattle and buffaloes. To achieve appropriate intensity and accuracy of selections and generate large enough pools of superior germplasm, linkages need to be developed with the existing central and state organised farms.

Animal health

In addition to most important diseases, e.g. foot-and-mouth disease, rinderpest, reproductive disorders, haemoprotistan diseases, enteropathogenic bacterial and viral infections and mycotoxicosis, studies are also required on non-infectious disorders. The studies should include metabolic and nutritional abnormalities and other limiting factors in high-producing animals. Research on development of a system for animal disease monitoring, surveillance and forecasting will be given priority.

Animal nutrition and physiology

For smallholder systems, the fundamental challenge is to develop animals that can grow, reproduce, and lactate and produce at satisfactory levels on diets based on crop residues and by-products. To study these mechanisms and find solutions the National Institute of Animal Nutrition and Physiology is being established by ICAR.

Dairy technology

There has been little emphasis on indigenous dairy products and other intermediary products that can be developed in rural areas for reducing the bulk, increasing the shelf life and adding value. More modern technologies such as those for raw milk preservation, ultra heat treatment and membrane technology require research.

Meat production

In optimising production of meat from buffaloes, sheep, goats, pigs, rabbits and poultry, there is need to carry out research on improving quality and increasing quantity in addition to devising measures for consumer safety.

Egg production

Emphasis needs to be given to breeding research for developing breeding techniques and producing strain crosses of layers.

Fibre production

Sheep, goats and rabbits are important sources of fibre. As India has a number of good carpet wool-producing breeds, it is envisaged that genetic studies on the performance of these breeds (involving farmers' flocks) will be undertaken.

Animal draft

Animals commonly used for draft are cattle, buffaloes, equines, camels and yaks. It is proposed to undertake genetic studies on purebred performance of important breeds of cattle and buffaloes for draft so that proper selection criteria for improving draft capacity can be evolved.

Animal biotechnology

Research on embryo transfer and associated biotechnologies as a mechanism for enhancing genetic progress through selection and micro-injection of extraneous genes into fertilised embryos for developing transgenic animals would be strengthened. Research in these areas will involve developing techniques for cryopreservation, sexing, cloning, genetic engineering and studies on embryo–environmental interaction.

Biotechnology related to DNA recombinant techniques, and monoclonal antibodies (hybridomas) have emerged as an important area of application in animal health research, particularly in respect of developing suitable diagnostics and prophylactics. Application of molecular biology, immunology and other related areas to the problem of animal health needs serious attention.

Biotechnologies related to enhancing reproduction especially in the area of immuno-reproduction, development of simple methods for oestrus detection and early pregnancy diagnosis, use of growth-promoting factors, manipulation of the rumen environment for maximising the utilisation of low quality roughages and crop residues will be developed and extensively utilised in livestock improvement.

Agro-ecological zoning

An agro-ecological region is defined as an area of the earth's surface characterised by distinct ecological responses to macroclimates as expressed by soil, vegetation, fauna and aquatic systems. The agro-ecological zone or region is the land unit carved out of the agroclimatic region when superimposed on land forms and on the kinds of soils and soil conditions that act as modifiers to climate and length of growing period. An agroclimatic zone refers to a land unit in terms of its major climates and suitability for a certain range of crops and cultivars. The soils and climatic conditions of a region largely determine the suitability of different crops and livestock and their yield potential. Intensive efforts have therefore been made by research workers to map agro-ecological regions to identify suitable crops and livestock and to develop optimum cropping patterns for increasing agricultural and livestock production and develop optimum feeding regimes for livestock.

The concept of dividing the world into various zones has a rich and varied history. Of particular interest is the FAO's Agro-Ecological Zones Project that set out criteria based on plant growth days, soil types, rainfall and temperature regimes. As individual countries and divisions within a country adapted these concepts, more specific criteria could be used. To try to generate more specific situations, and as part of the learning exercise, transects may be drawn through the zones.

In India, since the inception of formal planning in 1951, a number of attempts have been made to categorise the country into different agro-ecological regions and zones. Many different approaches were made to classify the land area into climatic regions. Carter (1954) divided India into six climatic regions ranging from arid to peri-humid based on the Thornthwaite criteria for climatic classification. Singh (1974) classified the country according to parameters like that of cattle, buffalo, draft animals, milk cows and milk buffalo per 100 ha of cropped land. He also classified the country in terms of percentage of total crop area planted to fodder crops over the period 1961–66 as well as cropping zones. Krishnan (1988) delineated 40 climatic zones based on major soil types and moisture index. Muthariah (1988) classified the country on the basis of livestock density using the 1977 livestock census as well as per capita milk production for 1985–86.

The Planning Commission, as a result of their mid-term appraisal of planning targets of the Seventh Five-Year Plan (1985–90), divided the country into 15 broad agroclimatic zones based on physiography and climate. This classification is based on physical conditions such as topography, soil type, geographical formation, rainfall, cropping patterns and development of irrigation. Since these zones were too broad to serve the purpose of planning, project teams were formed for each agroclimatic zone and subzones under the National Agricultural Research Project (NARP) of the Indian Council of Agricultural Research (ICAR). This process identified 15 agroclimatic zones, which were further sub-divided into 120 micro-agroclimatic subzones after taking into account the rainfall patterns, temperatures, soil types and existing cropping patterns of each state as a unit.

The major limitation of these approaches has been non-uniform application of criteria used, and the use of states as a unit for subdivisions. This resulted in the creation of many subzones with similar agroclimatic characteristics but occurring in different states. These approaches also did not give adequate consideration to soils. It was therefore necessary to generate an agro-ecological region map of the country giving due importance to soil environments. The National Bureau of Soil Survey and Land Use Planning of ICAR was then engaged to bring out an agro-ecological map of the country through several approximations, using physiography, soils, bio-climatic types and growing period. During 1989, the Bureau produced a 54-zone map that was circulated for comments. The most significant comment was that it had too many delineations which may be difficult to accept as far as the planning process at the national level is concerned. Furthermore, the delineated boundaries cut across district and state boundaries that may pose difficulties for developmental work at district/state level. These comments necessitated generalisation of the criteria used (physiography, soils, bio-climate and growing period) and a generalised map with 22 delineations was prepared.

The Director General of ICAR formed a top-level committee to look into the validity of the map, examine the criteria used to meet the needs of the country. The committee recommended the preparation of two maps: one showing zonal delineations based on the detailed criteria and another regional map for broad planning at the national level. The maps were modified and two agro-ecological maps with 54 and 21 delineations, respectively, were then prepared. These maps were presented and discussed at the International Seminar on Sustainable Land Use Systems. These maps and the write up were finally discussed by the committee and the agro-ecological region map with 21 delineations was approved. It was hoped that the maps would serve India's needs in generating agro-technologies and transferring these to other comparable areas. They are expected to help plan land use on a more sound and sustainable basis.

Sastry (1993) made an attempt to collect secondary data and information on various aspects of animal husbandry from different sources and classified these data on an agroclimatic and regional basis. The agroclimatic regions considered were the 15 described by the Planning Commission. These 15 regions were regrouped into five regions: Himalayan regions (1 and 2); Gangetic Plain Region (3 to 6); Plateau and Hill regions (7 to 10); Coastal regions (11 and 12); and the Island Region (13,14 and 15). He made the following general conclusions:

- The numbers of various species of livestock are increasing in the country in general with higher growth rates being recorded for buffaloes, goats and pigs and lower marginal rates for cattle and sheep.
- Although there appears to be too many livestock relative to land, feed, and fodder resources, livestock products are still in short supply.
- The demand for animals and their economic value for farmers are the same as in the past. However, the efficiency of animal production has declined over the years. The most important reason for this is the depletion of traditional livestock feed resources, especially the common land resources in villages.
- The entire milieu of a region (climate, terrain, soil, ecology, people, and through them, crop production) determine which species mix of animals are to be reared there.
- The need for draft bullocks continues to be a prime moving force behind cattle rearing, and tractorisation has not yet caused any great reduction in bullock numbers.
- Shortage of feeds, especially grazing lands, is going to persist for a long time to come.

With regard to regional dairy production, Sastry (1993) also concluded that:

- Cattle were important in all the agroclimatic regions, predominantly as work animals. Cattle as dairy animals (crossbreds) are prevalent in the West Coast

Plains and the Ghats region and in Western Plateau and Hills, Southern Plateau and Hills, East Coast Plains and Hills in the two Himalayan regions.

- Milk production and marketing is most developed in those parts of north-western, western and southern India where agriculture is better developed. The importance of buffaloes as dairy animals diminishes as one moves eastward and southwards.
- Excluding the two Himalayan regions, all the other regions have severe feed constraints, especially grazing lands.

It may be concluded that India has diverse land use patterns, cropping systems and livestock keeping. Various attempts have been made to classify the country into different agroclimatic regions. However, the suitability of macro-regions from a farming systems perspective, particularly livestock and crop farming, needs to be reconsidered. Parameters like livestock density, productivity of dairy cattle and buffaloes, sheep, goats, and pigs, feeds and fodder availability, milk availability, resource infrastructure, marketing etc need to be reconsidered. In addition, socio-economic parameters like family size, social status, income, literacy rates, customs and traditions also need to be included when classifying the country into different regions or recommendation domains, though the problems of this technique should not be underestimated.

Agro-ecological zoning and transects

In the Indo-Dutch Project entitled Bioconversion of Crop Residues (BIOCON) studies along transects were conducted in the states of Haryana, Karnataka, West Bengal, and Gujarat (Singh and Schiere 1994). Thirteen factors, derived from constraints analysis, were studied along the transects:

1. A partial listing of constraints on the production and utilisation of straws and fodder crops by different categories of farmers
2. Different systems of harvesting, threshing, handling, and storage
3. Extent of loss of straws for purposes other than livestock feeding
4. Alternative use of straws for purposes other than livestock feeding
5. Productivity of different crops and livestock
6. Labour costs and availability
7. Marketing facilities available at different points
8. Status of adoption of improved techniques
9. Type and quantity of straws available by season
10. Dominant caste groupings
11. General socio-economic and gender status of families
12. Other supporting services for animal production (artificial insemination centres, animal health centres, village co-operative societies, milk collection centres etc)
13. Availability of communal and other grazing lands.

The above issues were considered important for assessing the types of recommendation domains that could be developed from the transect studies. In addition, it was presumed that most of these factors could be analysed and discussed based on the types of secondary data used to carry out the transect description.

For the sake of illustration only a short description of the transect study of Haryana state is given. Along the north–south transect, there were predominantly small and marginal size farms. The scarcity of green fodder increases towards the south because the area of irrigated land is less and most of the green fodder is grown during the monsoon (*kharif*) season under rainfed conditions. In the south, available straws are wheat, gram, and barley in the winter (*rabi*) season, and *jowar* and *bajra* in the summer (*kharif*). In the north, wheat and rice straws are readily available. Basmati rice straw is preferred although its quantity is much smaller. Wheat straw is the preferred dry fodder in all areas of Haryana. Loss of straws during harvest and storage is highest in the central and northern parts of the state. Alternative uses for straw are limited to small quantities of rice straw used for paper and packaging materials, although this is only marginally profitable given the high cost of collection and transport and low price paid. There is little competition between the use as animal feeds and alternative uses. Wheat productivity is highest in the south of the state. Milk yield of cows is highest in the south, probably in response to the market opportunities in the Delhi milkshed. The same trend is evident for buffaloes. Marketing facilities in the form of organised co-operatives are best in the north near Ambala city whereas in the south, a strong milk vendor marketing system exists around Delhi.

In the general area of adoption of improved technologies such as crossbred cows, modern varieties, fertilisers and pesticide use and mechanisation, acceptance is more prevalent in the north where farmers are more progressive and have more capital. Regarding socio-economic status, the north is more prosperous than the south. The transect format is difficult to use to ascertain other socio-economic factors such as social status, level of infrastructure and social services. No definite pattern on use and availability of communal grazing lands was found. In general, Haryana has adequate dry fodder resources but technical and economic problems prevent better utilisation of these feeds. Wheat straw is widely used for dairy animals but labour constraints are leading to more combine harvesting resulting in high field losses of straw. Storage of bulky straw is also a problem. Baling machines would reduce storage volumes, lower the cost of shipping wheat straw and reduce storage losses if bales could be covered. Studies on why this technology has not been adopted would be useful.

In these studies, the concept of agro-economic zoning to generate recommendation domains was discussed in detail. The concept was generally found to be relevant. The wealth of information generated would be useful in identifying general problems and development needs for researchers, extensionists and policy makers. Specific needs of the livestock subsector can then be addressed through a more detailed study relating to soil, water, and topographical features, feed resources, animal breeds, marketing facilities etc.

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Research priorities for animal agriculture by agro-ecological zone in Nepal

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Abstract

Livestock are an integral part of farming systems in Nepal. They provide high quality food like milk, meat, eggs, and draft power and dung for crop production. Livestock and poultry are also the major sources of cash income of farming families. Most of the livestock and poultry breeds are indigenous types and are characterised by low productivity. Due to the rapid deterioration of the forests in recent years, feed and fodder shortages are an acute problem. There are several constraints to livestock production. In the past, several exotic breeds of animals and several exotic species of grasses and legumes have been introduced in the country. Despite all these efforts, livestock and poultry production are not well developed. There is an urgent need for research in livestock production to identify suitable breeds, improved management systems and suitable technologies to produce feeds and fodder that can fit into the farming systems. The mid-hills have the highest concentrations of livestock and human populations. This agro-ecological zone requires the highest priority in livestock research. The major research areas are smallholder dairy production, integration of food and forage crop, sheep and goat production and draft power. In the high mountain areas, pasture and yak production need to be studied and in the Tarai, crop–livestock production systems should have priority.

Introduction

Nepal is a small land-locked country, situated along the southern slopes of the central Himalayan region. It has an area of 147,181 km^2. The human population is 19.2 million.

The economy of Nepal is based on agriculture, and the human population is dependent on this sector. Nepal is confronted with increasing population growth (2.1% per annum) in the face of limited cultivatable]e land. Forestland and grazing lands are forced into agriculture cultivation to meet the food deficit. Nepal's growth lies in increasing agricultural productivity but not at the expense of increasing land degradation. Development of technology for increasing agricultural productivity is one of the basic approaches of Nepal's eighth five-year plan. Agricultural research is therefore important to generate sustainable production systems for self-sufficiency in agricultural production.

Physiographic regions

Nepal is divided broadly into three physiographic regions (Table 1).

Table 1. *Percentage of major land use by physiographic region.*

Regions	Cultivated land	Grazing land	Forest land	Other land	Total
Tarai	40.0	2.0	44.0	14.0	100
Hills	19.0	9.0	52.0	20.0	100
Mountains	4.0	22.0	29.0	45.0	100
Nepal	19.0	11.9	42.2	28.1	100

Source: Agriculture Perspective Plan, Land Resource Mapping Project (Economic Report).

Tarai

The Tarai is in the south, running from the east to the west of the country and is a part of the Gangetic plain. It covers 23.1% (3408 thousand hectares) of the total land area of the country and has 46.6% of the total human population (LRMP, Economic Report). The altitude ranges between 76 to 280 m above sea level (asl). It has a humid, subtropical climate with an average rainfall of 1600 mm per year. Temperature ranges between 25 to 32°C in summer and 8–24°C in winter. It is very hot and humid in summer and has mild, cold winters. It has alluvial soil. More than 60% of the cereal grains are produced from this region.

Mid-hills

The Mid-hills are situated to the north of the Tarai. The altitude ranges between 800 and 2400 m asl. It covers 41.7% (6153 thousand hectares) of the total land area of the country. It forms the central and largest area of the three ecological zones. The terrain is made up of high ridges, much older and harder rocks and steep-walled valleys embracing numerous streams. Two important valleys, Kathmandu and Pokhara, are also part of this region. This is a densely populated region of the country with 45.5% of the total human population. It is cold in winter and warm and humid in summer. Temperatures range between 20 and 30°C in summer and between 8 and 18°C in winter. The annual rainfall is about 1800 mm.

Mountains and Himalayan regions

The high mountain/Himalayan area of Nepal lies above the mid-hills with elevations of more than 2400 m asl. It covers 35.1% (5180 thousand hectares) of the total land area of the country. It has a temperate type of climate. Rainfall ranges between 200 and 800 mm per year. Some areas are cold arid to semi-arid desert (Dolpa, Mugu, Humla and Mustang districts). This region has eight of the world' s 10 highest peaks including Mount Everest (8848 m). In this region above 4000 m, there are extensive areas suitable for grazing. Some areas in the north of Aunnapurna (8078 m) and Dhaulagiri (8172 m) in the Himalayan ranges are rain shadow areas. These areas are potentially good for sheep and goat rearing.

Natural resources production systems

Livestock are raised in all agro-ecological zones from the Tarai region to the rain shadow areas of the Himalayas. Livestock are considered to be the integral parts of agricultural systems in Nepal. These animals are maintained for meat, milk, manure and draft power. Livestock play a major role as the source of income for small and large farm owners. However, the majority of the livestock are raised by smallholders throughout the country. Farmers keep various species of animals, depending upon the size of the landholding, level of economic conditions, ethnic group, ecological regions and location. However, the animal production and management systems are governed by many factors such as cropping intensity, availability and accessibility of forest resources, grazing land, animal species and productive stage, labour availability and animal numbers per household. Almost all crop cultivation involves animal power. Composted dung as an organic manure is the main source for replenishing soil nutrients.

The estimates of 1991/92 indicate that there are 6.2 million cattle, 3.1 million buffalo, 0.9 million sheep and 5.4 million goats, 0.6 million pigs and 18.5 million poultry in Nepal. When these estimates were compared with those of 1985/86, there was a 0.6% decrease in the cattle population whereas the buffalo, sheep and goat populations increased by 1.8, 0.2 and 1.9%, respectively (Table 2). The World Bank (1989) reported that per capita, large livestock (cattle) numbers were declining. This is probably due to a response to increasing maintenance costs, limitations of grazing land and forestland, increased arable land and the high cost of animals.

Livestock play a vital role in Nepal's economy. Livestock alone make up 31.5% of the agricultural GDP and contribute about 14.3% of GDP (NPC 1993). The contribution of livestock to GDP is highest in the hills (16.8%), second in the Tarai (12.1%) and then the mountains (2.8%). However, the percentage share of livestock to GDP by species is buffalo, 52.9 (milk, meat and draft power); cattle, 24.7% (milk and draft power); goats, 10.5% (meat and draft power); poultry and ducks, 8.6% (meat and eggs); swine, 0.8% (meat): and sheep, 1.5% (meat) (Table 3; CBS 1990). Milk and milk products are the main source of animal proteins in Nepal. The estimated consumption is 47 litres of milk per person per year, and between 4.0 and 8.1 kg of per person per year, which are low.

Paddy rice, wheat, maize and millets are the main crops grown in Nepal. These crops account for nearly 85% of the cropped area. The national average holding of arable land is about 0.43 ha per family. The area under paddy and wheat crops has been increasing, resulting in increased crop production, but productivity is stagnant. However, crop production has increased by about 2.4% annually, while the human population has increased by about 2.7% (World Bank 1984). The distribution of population reflects the availability of food resources and productivity of agriculture. Due to poverty and food deficits, people have moved from the high mountains to the hill and Tarai regions. It has also been observed that human migration has followed the rainfall, e.g. from a low rainfall areas (western Tarai area) to the high rain fall areas (eastern part of the Tarai). The contribution of agronomic crops to agricultural GDP was about 46% in 1991–92 (Table 4). Average yields of the major cereal crops, paddy and wheat, have increased from 1980 kg and 1140 kg per ha, respectively, in 1974–75 to 2400 kg and 1410 kg per ha, respectively, in 1993–94. The increments in paddy and wheat field are 21% and 24%. In the case of hill crops such as maize, millet and barley, the yields are declining further compared to past levels due to continued soil erosion and environmental degradation (Nepali 1995).

Table 2. *Livestock populations and growth trend in a six-year period by agro-ecological zones in Nepal (1985/86 to 1991/92).*

Livestock	1985/86	1991/92	Per cent	% change
Yaks and chauries		56,000		
Cattle				
Mountains	800,469	808,840		
Hills	3,242,440	3,181,410	50.93	
Tarai	2,242,009	2,255,432	35.75	0.59
Total	6,284,918	6,245,682	100.00	-0.62
Buffalo				
Mountains	302,782	316,673	10.33	4.52
Hills	1,771,659	1,779,636	58.22	0.45
Tarai	928,362	962,032	31.45	3.60
Total	3,002,803	3,058,341	100.00	1.84
Sheep				
Mountains	385,286	316,673		
Middle hills	400,327	399,356		
Tarai/Siwalik	124,858	140,952	10.47	12.88
Total	910,471	912,372	100.00	0.20
Goats				
Mountains	808,594	797,271	14.74	1.40
Hills	3,098,966	3,095,196	57.27	0.12
Tarai	1,394,784	1,513,326	27.99	8.49
Total	5,302,344	5,405,793	100.00	1.95
Pigs				
Mountains		80,706	13.68	
Hills		349,629	59.26	
Tarai		159,620	27.06	
Total		589,955	100.0	
Chickens				
Mountains		1,287,251	9.53	
Hills		8,857,368	65.62	
Tarai		3,351,626	24.85	
Total		13,496,245	100.0	

Source: DFAMS (1991/92).

Table 3. *Percentage share of livestock GDP by components.*

Livestock	Milk	Meat	Eggs	Wool and hides	Transportation	Total
Buffaloes	32.7	14.4			5.5	52.9
Cattle	13.8			0.2	10.7	24.7
Goat		10.2		0.3		10.5
Poultry and ducks		3.6	5.0			8.6
Swine		1.8				1.8
Sheep		1.1		0.4		1.5
Total	46.5	31.1	5.0	1.2	16.2	100

Source: Central Bureau of Statistics (1990).

Table 4. *AGDP share by agro-ecological zones and products group (%).*

Product group	Tarai	Hills	Mountains	Total
Field crops	3.4	18.8	23.6	45.8
Horticulture	1.1	5.3	6.5	12.9
Livestock	2.8	16.7	12.0	31.5
Forest	0.7	4.1	4.0	8.8
Fisheries	0.0	0.0	1.0	1.0
Total	8.0	44.9	47.1	100.0

Source: NPC (1993).

High Mountain Region

In this area, the majority of the animals are raised under a transhumance system where they migrate from one place to another throughout the year. The region has 12.9% of the cattle population, 10.3% of the buffalo, 40.8% of the sheep and 14.7% of the goats, 13.7% of the pigs, and 9.5% of the poultry (DFAMS 1991/92; Table 2). This area is comprised of 8.6% cultivated land, 65% of the grazing land and 23.9% of forestland of the country (LRMP 1985).

The mountain region supports 10.2% of the total national meat production from buffalo, goats, sheep and poultry and 9.5% of the total milk production of the country (Tables 5 and 6). The high mountain region produces an estimated 1,416,000 t of dry matter whereas the requirement is 488,000 t (Table 7). The availability of feed is limited by climatic factors associated with the inaccessibility of remote grazing areas. In summer, all the livestock (yak, chauries, sheep and goats) are moved to high altitudes for grazing in the forest and alpine pastures. Cattle and buffaloes are grazed in the forests. In winter, these animals, with the exception of yak and chauries, are moved down to the mid-hills. Previously, these animals had free access to Tibet for grazing across the border during the winter season.

Table 5. *Meat production in three agro-ecological zones (10^3 tonnes).*

Products	Mountains	Hills	Tarai	Total
Buffalo meat	9.511	54.351	32.153	96.013
Mutton	1.419	1.150	0.475	3.044
Chevion	2.486	12.055	15.305	29.846
Chicken	0.717	6.087	2.315	9.119
Pork	1.067	5.960	3.380	10.407
Duck meat	0.004	0.037	0.230	0.271
Total	15.204	79.638	53.858	148.70
Percentage	10.2	53.6	36.2	100

Source: DFAMS (1991).

Table 6. *Milk production and distribution by agro-ecological zone (10^3 tonnes).*

Products	Tarai	Hills	Mountains	Total
Cow milk	90.027	137.307	31.896	259.230
Percent	34.74	52.96	12.30	
Buffalo milk	186.862	374.843	50.299	612.004
Percent	30.55	61.24	8.21	
Total milk	276.889	512.15	82.195	871.234
Per cent	31.78	58.78	9.44	100

Source: DFAMS (1991/92).

Animals from Tibet have free access to Nepalese pasture areas for summer grazing. With such management, it was easier to fulfil the fodder requirements of the livestock from the border areas of Nepal. However, since 1988, China imposed restrictions on the grazing of Nepalese livestock in the Tibetan areas and the traditional grazing management system has now broken down. It is a serious problem for the farmers of that area. It has become more important to conserve the extra forage available in the alpine areas during the summer. In this region, yaks and cattle/yak crossbreds are kept for milk, and draft power. Occasionally, dung from these animals is dried and used as a source of fuel for cooking. Sheep and goats are kept for meat, wool, fibre, haulage and manure. However, the Baruwal sheep breed and Sinahal goat breed of the high mountain areas of the far western region are heavily used for local transportation. In these areas, most of the passages are narrow and large animals cannot move. Sheep and goats can carry loads ranging from 10–20 kg depending upon their body weight. They carry food grains, daily use goods etc from the lower regions to the high mountains and the Chinese border where exchanges are made for rock salt and sheep wool etc. Mules and ponies are used as pack animals in the high mountain area of the western region for transporting food grains, construction materials etc. from the mid-hill markets to remote districts like Manang and Mustang. Yak and yak/cattle crossbreds (Jhopa, sterile male) are efficiently used for transporting the goods, and food boxes from Namche Bazar and Lukla to Mount Everest base camp.

Table 7. *Total feed requirements, production and balance by physiographic region (10^3 tonnes).*

	Feed requirements			Feed available			Balance		
Regions	DM	TDN	CP	DM	TDN	CP	DM	TDN	CP
Tarai	4703.6	2681.0	460.90	3452.7	1501.8	157.5	-1251	-1179	-243.4
Per cent	28.33	28.33		22.58	22.98		26.6	44.00	60.70
Siwalik	2153.7	1227.3	183.50	2586	1124.9	117.9	432.4	-102.4	-65.6
Per cent	12.98	12.98		17.22	17.21		20.10	8.30	35.90
Mid-hills	7295.0	4158.3	621.50	4337.0	1886.6	197.7	2958	-2272	-423.7
Per cent	43.95	43.95		28.87	28.87		40.50	55.10	68.20
High hills	1957.6	115.70	166.60	3232.0	1405.9	147.2	11274	290.25	-19.33
Per cent	11.80	11.80		21.51	21.52		65.10	26.00	11.60
High Himalaya	488.00	278.30	41.5	1415.6	615.8	64.6	928	337.5	23.11
Per cent	2.94	2.94		9.42	9.42		19.01	121.30	55.80
Total	16598	9460.6	1414.0	15023	6535.1	684.9	1547.2	2925.4	-729

Source: LRMP (1985).

Mid-hills

These regions possess 39.9% of the cultivated land, 31.0% of the grazing land and 50.4% of the forestland of the country (Table 8). A high percentage of the total livestock population is found in this region. This region possesses an estimated 51.0% of the cattle population of the country, 58.2% of the buffalo, 43.8% of the sheep, 57.3% of the goats, 59.3% of the pigs and 65.3% of the poultry. The milk production from this region is 512,000 t, of which cow milk is 26.8% and buffalo milk 73.2%, contributing 58.2% of the total milk production of the country. Likewise, this region produces 53.55% of the total national meat.

Table 8. *Percentage of total land use by physiographic regions.*

Regions	Cultivated land	Grazing land	Forest	Other land
Tarai	51.5	4.2	25.2	11.4
Hills	39.9	30.9	50.4	32.3
Mountains	8.6	64.8	23.9	56.4
Total	100	100	100	100

Source: Agriculture Perspective Plan, Land Resource Mapping Project (Economic Report).

In the mid-hills the total dry matter production is about 4,337,000 t whilst the requirement for livestock is about 7,295,000 t dry matter (DM). The most critical area in terms of animal feed deficit among the three ecological zones is the mid-hills. This region is poor in grazing land having only 31.0% of the country’s total. Animals have to depend on crop residues, fallow grazing land, and fodder from the forest. Because of the shortage of feed, a large number of sheep and goats along with cattle and buffalo from the upper mid-hills are moved up to high mountains to utilise the summer grazing land wherever accessible. The animals of the lower mid-hills are raised in a sedentary management system. In winter, sheep and goats are moved from the mountains to mid-hills and lower hills for winter grazing and for the utilisation of crop residues. During the winter, these animals are camped for three to four nights in the fields for manuring. The main crops grown are rice, maize, wheat, millet, barley and pulses.

Tarai

This region covers 51.5% of total the cultivated land, 25.2% of the forest land, and 4.2% of grazing land (Table 8). It possess 36.1% of the total cattle population, 35.8% of buffalo, 10.5% of sheep and 28.0% of goats, 27.1% of pigs, and 24.9% of poultry. It supports 36.2% of the total meat and 31.2% of the total milk production of the country.

Animals are kept in sedentary systems. During the day, these animals are grazed for 4–6 hours around their villages in the bunds, land terraces, fallow land, cultivated land after harvest and in nearby forest areas. Among the three agro-ecological zones, this region only has the lowest proportion of grazing land. Animals are fed crop residues and crop by-products during periods of feed shortage. In summer, green forage is harvested from croplands and the bunds. During the winter and lean periods (March–June) the main fodders are the crop residues of paddy and wheat crops. Green fodder is the limiting factor for animal production during this period especially for the livestock belonging to subsistence farmers who farm only small areas of rainfed lands.

The production system is very intensive, integrated and involves livestock, cropland, and forest. Livestock provide manure for crops and forest, while forest and croplands supply feed for the livestock. Total dry-matter production from the Tarai is about 3,453,000 t/year and the requirement is 4,704,000 t/year. There is a deficit of about 1,251,000 t/year dry matter in this region (Table 6). The sedentary system of grazing in this region should be supported by intensive fodder production programmes.

In the Tarai region, cattle are kept mainly for draft purposes (cart pulling and rice polishing). Small ruminants are kept in every household in the rural areas. These animals generate cash income for small farm holders. The shortage of agricultural land, animal feed deficits, climate and topographical limitations guide the grazing/management systems all year round.

Major problems and constraints in livestock development

Livestock population and the feed situation

Livestock populations in all regions have increased by different rates over the last five years (1985/86–91/92, Table 2). Similarly, human population has also increased from 8.3 million to 19.2 million (113%) over the last 40 years. The growing population demands more farmlands in the hills and Tarai regions to produce more food, while increasing livestock populations need more feeds from agricultural lands, grazing lands and forest areas. Most of the marginal lands were also used for crop production and the areas used for grazing and collecting forages have drastically decreased. Even steep mountain slopes have been used for crop production, which has resulted in erosion in the high hills and mountains. The exception is the high mountain areas where overgrazing is the major problem. Almost all of the livestock are underfed and productivity is decreasing.

However, a large number of animals, unplanned land use and uncontrolled grazing practices have resulted in overgrazing and serious reductions in forage and fodder productivity, leading to forest degradation and soil erosion. It has affected the ecosystems of the mid-hills, lower hills and Tarai region. Trees are disappearing. Forests are thinning. Streams and springs are drying. Overgrazed slopes show soil erosion losses greater than 40 t/ha per year. Simply by removing the cattle, erosion levels could drop to less than 5 t/ha per year in one season (LRMP 1985).

Feed deficits

According to livestock population data (DFAMS 1985) Nepal has 6.3 million cattle, 2.9 million buffaloes, 4.9 million goats and 0.8 million sheep. To obtain reasonable production from these animals, about 9.5 million tonnes of total dry-matter nitrogen (TDN) is required (Table 7). However, there are only about 6.5 million tonnes of TDN, of which forest land contributes 49.9%, shrubs, from bunds 3.6% and plantations another 0.4% (Table 9). In the mid-hills and Tarai region there is a feed deficit for 3–6 months. The animals in the mid-hills and Tarai do not get enough feed to meet their energy requirements even for maintenance. Due to feed scarcity, animals use energy to roam long distances in search of food rather than for production.

Table 9. *TDN available from various feed resources in the different ecological zones (10^3 tonnes).*

Regions	Agricultural by-products	Grazing land	Forest land	Shrub land	Bunds and plantation	Total
Tarai	1132.2	28.80	339.30	0.50	1.08	1501.88
Siwalik	263.20	11.90	839.40	10.40		1124.90
Mid-hills	538.10	169.80	1037.90	139.20	0.61	1886.64
High hills	105.00	294.10	944.70	61.50	0.65	1405.95
High Himalaya	21.30	482.30	89.50	22.60	0.10	615.80
Total	2060.80	986.80	3250.80	234.20	2.44	6534.14
Percentage	31.5	15.10	49.80	3.60	0.0	100

Thus, such animals are unable to express their genetic potential mainly due to lack of enough feed and poor management practices. Many browse species contain high concentrations of hydrocyanic acid (Panday 1981) or tannins (Shrestha and Pakhrin 1989). These chemicals decrease milk yields and can cause gastro-urinal problems in ruminants. Easily available natural vegetation is overgrazed and vegetative growth is inhibited. This results in decreasing overall biomass production. Rajbhandary and Pradhan (l991) pointed out the following reasons for livestock movement in the pastoral agriculture system in Nepal:

- shortage of manure and the need to fertilise winter crops according to the crop calendar

- shortage of feed and the efficient utilisation of the crop residues after the harvest
- the need to control free-ranging animals in the cultivated fields after planting the summer and winter crops
- efficient utilisation of the limited feed resources and scarce labour in summer and the need to herd the animals in a collective herd to use feed resources
- climatic conditions and the need to barter for basic needs (especially in the high Himal)
- management of young lambs and calves against cold and wet weather and wet feed prevailing in higher elevations.

Constraints to livestock production in the various agro-ecological zones

Mountains

- poor feed base
- overgrazing of native pasture and rangelands
- lack of information on rangelands and pasture
- inaccessibility of the area (pasture, programme implementation)
- no market outlets
- low productivity of native livestock breeds
- no knowledge of nutritive value of native pasture
- high mortality rates for lambs/kids in migratory flocks
- harsh environment
- inadequate livestock extension systems
- no administrative mechanism to restore the ecosystems.

Mid-Hills

- poor feed base
- overgrazing and deforestation
- religious restrictions on animal culling
- poor genetic make-up of native livestock breeds
- lack of market-oriented livestock keeping
- population pressure
- unprofitable livestock marketing system (depending upon social structure)
- heavy infestation of parasites
- occasional outbreaks of contagious diseases (HS, FMD, foot rot).

Tarai

- poor feed base

- occasional outbreaks of contagious diseases (RP)
- open livestock movement
- population pressure
- deforestation

Problems and constraints in animal science research

- least priority for animal science research programmes
- lack of infrastructure development
- few research stations representing agro-ecological zones
- lack of enough qualified and trained research personnel
- inadequate study of exotic germplasm.

Research and development in animal science

Livestock development was initiated at the beginning of 1950s in Nepal. Exotic livestock breeds of various species were imported with a view to produce crossbreds of high productivity.

Cattle

In 1952 20 Sindhi cows and two breeding bulls were imported. In 1957, eight Jersey cows and two bulls and two Brown Swiss bulls were imported from the USA. The Dairy Development Project for milk collection and processing was initiated in Kathmandu valley. It was established by HMG/FAO with technical assistance from the Netherlands and Switzerland. At this time, the first artificial insemination (AI) using warm semen was carried out in cattle. In 1968, the livestock development farm at Khumaltar was established. In the 1970s, crossbred bulls were produced at Khumaltar and distributed to the cattle raising farmers of various Mid-hill districts with a view to upgrade the native breed by crossing. The comparative performance of four F_1 crossbred dairy cattle produced by using frozen semen in native hill cows at Khumaltar was studied. The objective was to study the productive performance of the F_1 crossbreed.

The milk yield per lactation for 50% Jersey x native hill cows, 50% Holstein Friday x native, 50% Ayrshire x native, and 50% Brown Swiss x native and native cows for seven to eight lactations were reported to be 1417.1 litres of milk in 311 days, 1836.4 litres in 332 days, 1437.60 litres in 305 days, 1611.50 days in 336 days and 357.9 litres in 251 days, respectively (Shrestha et al 1992). The highest milk yield was found in 50% Holstein crosses, followed by Ayrshire, Jersey cross, and the Brown Swiss cross. In terms of adaptability to different ecological belts 50% crosses exhibited better performance under Hill and Tarai conditions. Holstein and Ayrshire crosses were found to perform better with improved feeding and management. The research needs for cattle and buffaloes have been discussed (Shrestha 1989).

Yak and chaury

At the beginning of 1970, two yak farms were established in the high mountains at Solukhambu and Dolpa to produce yak and nak for distributing to the farmers of that area. Studies have found that the chaury can produce 980 litres of milk in 281 days and the nak 172 litres of milk in 133 days. The chauries produced more milk at the cost of feeding twice as much as the nak.

Buffalo

In 1967, 40 Murrah buffalo cows and one breeding bull were imported from India and raised at Khumaltar along with local buffaloes. It was found that the Murrah breed produced 1347 litres of milk in 305 days. The local buffalo Lime breed produced 467 litres of milk in 305 days (Shrestha 1989). In 1970, a herd of 13 Murrah buffalo was transferred to the livestock development farm at Pokhara from Khumaltar. The Murrah produced 1167 litres of milk in 324 days while the 50% Murrah crossbreds produced 838.8 litres in 263 days. The milk yield was recorded from three teats only. The calving interval for Murrah and 50% crosses were 838 and 263 days, respectively (Pradhan 1994).

Goats

In 1967/68, a herd of 20 Sannen does and five bucks were imported from Israel for a crossbreeding research programme. Sannen bucks were mated with local hill does. Fifty per cent Sannen x hill goat produced 148 litres of milk in 134 days whereas pure Sannen produced 160 litres of milk in 155 days. Similarly, the local hill goat produced 59 litres of milk in 106 days while the Tarai goat produced 87 litres in 126 days. It was concluded that the Sannen goat was suitable for hill conditions (Pradhan 1994).

In 1976/77, the Bandhipur Goat Development Farm was established in the western part of the mid-hill region. A crossbreeding programme was launched between the Indian Jamunapari breed and hill goats. Local hill goats produced 23.21 kg weaned kid live weight per doe per annum compared to 20.61 kg with pure Jamunapari (Goat Development Farm, Bandhipur 1988; unpublished). According to available report for the period of 1983/84–1988/89 local does produced 9.6–27.2 kg for weaned kid live weight/doe per year compared to Jamunapari which produced 9.6–14.2 kg, and 50% Jamunapari x hill goat which produced 13.1–25.7 kg. During the last five years, the tropical Indian breed Barbari and the Kiko breed (New Zealand) have been imported for crossbreeding research programmes.

Sheep

In 1958, the Sheep Breeding Farm at Chitlang of Makwanpore district was established. Very few numbers of exotic sheep breeds like Rambouillet, Dorset Horn, Romney, Corriedale were introduced for crossbreeding with the local sheep, Kage. Among the introduced exotic sheep breeds, Rambouillet survived and was used for crossbreeding. Fifty and 75% crossbreds with Rambouillet and local Kage produced 1.2 and I .4 kg of wool per year, respectively, as compared to local Kage breed which produced 0.3–0.4 kg. The adult weight of 50% and 75% crossbreds (Rambouillet x Kage) were 28.6 and 37.1 kg, respectively, as compared with 23.7 kg for the Kage.

In 1965, the Sheep Development Farm, Pokhara, was established for crossbreeding programmes. A study of crossbreeding between Border Leicester and Kage was conducted at Khumaltar with a view to producing long wool for both clothing and carpet making. The 50% Border Leicester cross produced 1.5 kg. wool as compared to 0.44 kg wool from the local breed.

The Polwarth sheep breed (125 adult ewes and 20 breeding rams) was imported from Australia with the co-operation of an organisation called "FOR THOSE WHO DON'T HAVE". These exotic sheep were introduced at two sheep development farms located in the high mountains area (Karnali sheep Farm, Jumla, established in 1970 and Pansaya Kohl sheep Farm established in 1968). The objectives were to produce suitable crossbreds for wool as well as for meat production. During the study period, between 1974 and 1979, 50% crossbred between Polwarth and Baruwal (native breed) produced 1.84 kg of meat as compared to 0.9 kg from Baruwal. Later, other exotic sheep breeds like Merino D'Arle and Australian Merino were also introduced from various sources.

Pigs

In 1960, the development approach for raising the pigs was started with the introduction of exotic pigs such as Landrace, Yorkshire and Hampshire. These animals were raised under improved management systems as a viable commercial enterprise. Farmers were encouraged to raise the exotic pigs by distributing the produced piglets at a subsidised rate.

Recently Duroc pigs have been introduced at Pokhara livestock farm in the western region of Nepal to produce three-way crossbreds between Landrace, Yorkshire and Duroc for commercial production. Some other pig breeds like the Tamworth and Fa Yuen were also introduced in the eastern region of Nepal by the Pakhribas Agriculture Centre (ODA) as the people in these areas preferred dark pigs. The PAC has developed a three-way cross of Fa Yuen, Tamworth and Saddleback.

Poultry

Poultry has high commercial value as it is consumed by most of the ethnic groups of Nepal. In the beginning of 1960 dual-purpose, heavy breeds such as New Hampshire and followed by Australop and White Leg Horns were introduced. The livestock farm at Pokhara reported that the egg production per bird for White Leg Horn, New Hampshire and Australop were 198,158 and 185, respectively . Feed consumption per dozen egg production was 1.4, 2.0 and 2.1 kg, respectively.

Pasture and fodder research/development

Initial forage development work in the high altitude region dates back to the late 1950s with the establishment of cheese factories for processing cheese from milk of yaks and chauries. In 1953, pasture development programmes were launched along with livestock development. Improved pasture species—white clover, rye grass and cocksfoot—were introduced in the higher mid-hills and mountains of Nepal.

In 1968, an FAO pasture, fodder and livestock development project was implemented in Rasuwa and Nuwakot districts. The Rasuwa Pasture and Fodder Development Farm was established in 1971/72 at Langtang valley (at 2500 m) for producing seed of temperate species like white clover, rye grass and cocksfoot.

Similarly, in the lower mid-hills and Tarai, fodder species like Napier, Guinea grass, *Setaria* and annual fodder species like teosinte and Sudan grass are promoted. Now, Napier is very widely grown in the mid-hills and Tarai for fodder as well as soil conservation. Winter in Nepal is dry and cold in most parts of the country. Green fodder shortage is a serious problem in livestock keeping. To overcome this problem, oat and vetch in the mid-hills and oat and berseem in Tarai are promoted. These species are very widely grown especially in the areas where improved dairy livestock are raised.

Role of fodder trees in livestock production

Fodder trees are important sources of green fodder in Nepal. They provide green fodder only during the critical times of dry and cold winters. It is estimated that there are over 100 species of fodder trees in different agro-ecological zones of Nepal, especially the mid-hills. Major species of fodder trees are *Artocarpus lakoocha, Litsea monopetala, Ficus semicordata, Ficus ruxburghii, Ficus lacor, Garuga pinnata, Bauhinia purpurea, Bauhinia varigata, Saurauria nepaulensis* etc. In the higher altitudes, above 2000 m, *Quercus semecarpifolia* is the major fodder tree.

The contribution of fodder trees to the total fodder supply differs from one agro-ecological zone to the others. Only 5% of the total annual fodder supply in the Tarai comes from fodder trees. Their contributions in the hills are higher. It is estimated that the contributions of fodder trees in the mid-hills ranges from 7.5 to 60% of the total fodder supply depending on management.

Dry-matter production of fodder trees differs from one species to another. Species like *Bauhinia* produce 40–60 kg of dry matter per tree where as *Artocarpus lakoocha* are found to produce as much as 180–200 kg. of dry matter per tree.

Animal health

The animal disease diagnosis research activities started in 1970 after the establishment of disease investigation and parasite control. To date, the causative agents of rinderpest, Ranikhet disease, Gumboro, foot-and-mouth disease (FMD), haemorrhagic septicaemia, Black quarter, salmonellosis (Pullorum and Gallinerum), coccidiosis, theileriosis, babesiosis, fascioliasis, Khari disease and foot rot have been identified and characterised.

Major foreign-funded projects

1. First livestock development project (Asian Development Bank (ADB), 1980–87). To promote the livestock development in five districts, mainly for milk production.
2. Second livestock development project (ADB 1988–92).
3. Promotion of livestock breeding project (GTZ 1988–98). To improve planning, monitoring and evaluation to improve management in the government livestock development farms.
4. High altitude northern area pasture development project (HMG 1980–90). To improve pasture and fodder and access to grazing land in the northern districts of Nepal. Programme activities included pasture improvement through introduction of exotic grass and legumes, promotion of feed conservation methods, silvipasture establishment combining fodder tree and improved forage species and construction of new treks to accessible pasture areas.
5. Rapti integrated rural development project (USAID 1982–95).

6. High altitude pasture and fodder development project (UNDP 1987–90). To support HMG financed high altitude northern area pasture development project.
7. Rasuwa, Nuwakot rural development project (World Bank 1986–90). Intensive livestock development project through animal health, nutrition, feed and fodder development, livestock improvement and training.
8. Karnali–Bheri Development Project (CIDA 1988–92). To support technical assistance, veterinary and extension facilities and breed improvement.
9. USAID: The involvement of USAID is in establishment of the Institute of Agriculture and Animal Science. The agency facilitated the training of various levels of technical assistants for agriculture and livestock development.
10. Overseas Development Administration (ODA) of the United Kingdom: Established two agricultural training centres (Pakhribas Agriculture Centre and Lumle Agriculture Centre) for ex-Gurkha military in eastern and mid-west Nepal. A number of scientists working in these centres have been provided the opportunity to study for higher degrees in the UK. These centres have been successful in generating suitable agricultural technologies for the respective hilly regions.
11. DANIDA 1994: It has contributed to the establishment of a powder milk production plant in eastern Nepal. The plant has a capacity to produce 9000 t of milk powder per annum.

Creation of Nepal Agricultural Research Council (NARC)

In 1985, a national agricultural research and services centre (NARSC, now NARC) was established to co-ordinate the research activities of the department of agriculture. In 1987, NARC was given the status of an agency within the Ministry of Agriculture and became responsible for research activities of the departments of agriculture and livestock and animal health. The NARC system came into operation with the promulgation of the NARC Act in 1991. The goals of agriculture research are to:

1. Generate high quality technologies.
2. Provide appropriate research inputs to clients related to location-specific needs, problems and potentials.
3. Assist the government in formulation of agricultural research policies.
4. In pursuance of the goals (1) and (2) NARC has directed its efforts to generate technologies which support attainment of the following core objectives:
    - increase productivity/total production
    - generate employment/income
    - improve nutrition
    - sustain the environment and improve the natural resource base for the above stated objectives.

NARC is mandated to frame national agricultural research policies and conduct quality research work through its research networks. The research stations and farms conduct national, regional and location-specific research related to the needs and problems of the farmers and other clients (Nepali 1995).

Impact of international support for livestock development

Successful improved animal husbandry technologies such as dairy processing, animal health services and farmer's training have been extended to the more progressive dairy farmers through livestock extension programmes. However, these sorts of technologies are mainly available for the farmers in the mid-hills and eastern Tarai regions and less in the high hills except in the central regions. (Examples include the establishment of a cheese factory in the high hills, a milk-collection network and dairy processing facilities in the hills and Tarai).

Establishment of regional diagnostic laboratories to support regional and district activities.

Breed improvement programmes based on distribution of improved animals and artificial insemination programmes in 41 districts have had very limited impact. This is because these programmes have not been linked to supporting programmes, e.g. nutrition, pasture and fodder development and animal health.

Many small urban areas have related, growing livestock industries such as the development of commercial egg and poultry meat production for urban consumption as well as for supplying to the big cities of the country.

More private pig/poultry-farming ventures near urban centres are being established.

Research priorities for animal agriculture by agro-ecological zone

Farmers raising a few or more species of livestock are facing various problems and constraints due to poor feed availability, harsh environment, low productivity of native livestock breed and occasional outbreaks of contagious diseases. Programmes are to be identified for agro-ecological zones. Based on the existing constraints field research programmes are prioritised by agro-ecological zones. One of the planned activities in the high hill rangelands is the evaluation of carrying capacity.

High mountains/Himalaya

Study the nutritive value of indigenous pasture plants/fodder trees

Farmers can identify the poisonous and nutritious plants while grazing in the pasture land and forestland. However, the extent to which the plants are nutritious and important for feeding to the animals has to be known. By evaluating the nutritive value of pasture/fodder plants, farmers are to be encouraged to expand the nutritious plants in their grazing lands and discard the non-nutritive plants.

Study the economic evaluation of haymaking within the traditional production systems

During summer surplus pasture is available and improved hay making technology could be implemented for preservation and use of this feed during the winter.

Inventory of rangelands

Natural pastures and rangelands are the main source of forage for livestock in the high mountains. In recent years, these high mountain pastures and rangelands have been overgrazed, threatening the very existence of traditional migratory livestock production systems. There is not much knowledge on the range management of these high mountains pastures and rangelands such as the inventories of the existing vegetation and productivity of these rangelands.

Study on the native germplasm

Within the small land area of the kingdom, less than 150 km from north to south, there is a wide variation in climatic conditions. The vegetation differs in parallel with this climatic variation and, as a result, there are a number of native grasses and legumes with potential for intensive cultivation and adaptation to other regions with similar climates. These species include *Medicago falcata, Pennisetum flaccidum* and *Agropyron* spp in the drier areas of the trans-himalayan region, *Festuca* spp and *Carex* spp in the higher hills of eastern region, *Dactylis* spp in the humid higher hills, and species of *Vicia, Digitaria, Setaria, Pueraria*, and *Cymbopogon* in the hills. These and other available native species need to be evaluated and tested to assess their productivity under improved agronomic conditions, the possibility of introducing them in other regions with climatic conditions similar to those in which they have developed, estimation of their nutritive value, the capacity of leguminous species to fix atmospheric nitrogen, and the possibility of genetic improvement for increased forage production.

Evaluation of migratory management systems of sheep and goats in the far-western region

Mortality of lambs/kids is very high in migratory flocks. These lambs/kids are born either in winter grazing land in the lower hills or on the way back to the mountains in March/April. This is the leanest period when animals are starving resulting in weak body condition and poor rearing capability. Ewes/does do not have milk for their lambs and kids causing high mortality. Management practices can be improved either by changing lambing/kidding patterns or by providing enough feed in the lean period while the flocks come back to their home.

Utilisation of high-altitude tolerant species

Improvement of native genetic resources by selection and AI in yak and yak crosses for efficient milk production, cooked butter, meat, hides and skins, wool, animal hair and draft power. Above 2080 metres asl yak and chaury are the primary means of earning and livelihood. Twenty-two districts are located in the northern part of country, bordering Tibet (China has also got population of yak and chauries). Yak and yak/cattle crosses are the main transportation means of that area. At the same time, chauries are good milk producers in the harsh environment of the Himalayas. Similarly, Baruwal sheep and Sinahal goats of the high mountainous area of the far-western region are hardy breeds. These animals are used heavily for transportation. Selection means could be undertaken to improve the load-carrying capacity of these animals.

Study on demand and supply of yak cheese

Yak cheese is produced in large quantities in 22 districts of the mountains of Nepal. In 1994, cheese production was estimated to be 122 t, with 30 t butter production. The estimated retailed revenue of these products is US$ 525,000. Research is required to examine the market to improve the economic benefits of yak raising by farmers.

Mid-hills/mountains

Study on improvement of crossbred dairy animals (buffalo/cattle)

There is a need to improve the genetic potential of local/crossbred dairy animals by selection, semen collection and implementation of AI, and proper management. Farmers keep buffalo and cattle to produce dung for manuring the crop fields and for the little amount of milk for household consumption. These animals are already acclimatised to the harsh environment. They carry the genetic potential to produce more milk, which has not been exploited. This requires selection of good animals with high potential for milk production, collection of semen from the bulls in the same environment and use of improved animals in their environment.

Integration of forage production in cropping systems

It is an accepted fact that food crop production will always be the priority on small farms. Research should continue to focus on developing forage production systems that fit such farms. This kind of research is needed to increase the on-farm forage production and thereby to reduce the pressure on fragile hills and mountains.

Information on productivity and long-term management of different species of fodder trees

Very little information on farmers' ranking of species for growth, yield and effect of lopping frequency is available. Similarly, the effects of fodder trees on crop yield by shading and root competition are little known.

Reproductive health of cattle and buffalo

Studies need to be done to determine the causes of infertility and sterility in cattle and buffalo to assess their impact on productivity and to improve management.

Animal power in crop production systems

Animal power plays an important role in determining the productivity of agriculture in major parts of the hill regions. Animals are mainly used for ploughing while manure is secondary. Research is needed on the efficiency of draft animals, the power required for efficient cropping systems, and expense of animal power in terms of investment, feed inputs, labour and use of farm by-products.

Stall-feeding management systems

Ruminant animals convert roughage to manure. This is the only means of replenishing the nutrients taken from cropping lands. Cattle stall-fed during the night only produce 200 kg of manure per month. If the same animal is put into a stall-feeding system, it produced 600 kg. manure per month. At the same time parasite infestation and environmental degradation are reduced. Goats kept under stall-feeding management systems had fewer internal parasite infestations, no mortality by predators and less money was required for drugs (Sainju and Shrestha 1990).

Non-conventional feeding systems in poultry will also be considered.

Tarai

1. Studies on draft power.
2. Studies on buffalo, cattle and goats for milk production.
3. Studies on crop–livestock production systems.
4. Utilisation of agro-by-products (sugar-cane, oil cakes and rice bran and crop residues).
5. Studies on duck production and how it might be exploited economically in village-level production systems.
6. Studies on the productive performance of local breeds of poultry in small farm production systems.

Conclusions

Livestock in Nepal are kept for different purposes. Crop production is very much dependent on livestock for draft power and manure. Besides this, livestock are also the main source of cash in the rural areas of Nepal. For those farmers who are close to the major highways, milk is the regular source of cash income. Other small animals like goats, sheep, pigs and poultry serve as the savings accounts which are cashed as and when needed.

Ruminant production largely depends upon fodder from the forests and crop residues from the cultivated land. Due to the rapid depletion of forest areas and its reduction in productivity, the forest is no longer a fodder source for many farmers. Crop residues are poor-quality fodder and in short supply. Feed and fodder shortages, in terms of both quality and quantity, are increasingly becoming a serious constraint to increasing livestock production.

Cycles of fodder deficits contribute to decreased productivity. Cropping intensity is increasing and it is becoming important to produce more fodder from the cultivated land. A critical area where more information is required concerns opportunities to produce food and forage together in different agro-ecological zones and in different cropping systems.

Livestock in Nepal are mainly native breeds with low levels of production. To increase the productivity of different classes of livestock, genetic improvement of native breeds is given priority by crossbreeding with exotic breeds. However, it is not clear how there crossbreeds fit into the farming systems of the different agro-ecological zones, Native breeds of livestock have the capability to survive in a very harsh environment, making use of the poor feed resources and management systems. More information is needed on how such positive traits can be exploited for increased production while maintaining the ecological balance.

Developed technologies need to be environmentally sustainable, socially acceptable and economically viable. Development of sustainable animal agricultural technologies is always aimed at improving the welfare of livestock raisers and the rural communities of Nepal.

Acknowledgements

The authors are grateful to Mr S.L. Pradhan (Chief, Livestock Development Division, DOAD, Harihar Bhawan, Lalitpur) and Dr B.R. Pradhan (Chief, Fisheries Research Division, NARC) for their valuable guidance in preparing this report. They are also thankful to Dr N.P. Shrestha, Dr R. Bhurtel and Mr N.P. Osti for their fruitful contributions to the completion of this text.

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Research priorities for the improvement of livestock production by agro-ecological zone in Pakistan

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Abstract

This paper presents research priorities for the improvement of livestock production in the context of available natural resources and agro-ecological zones. Livestock contribute to about 7.6% of the gross domestic product (GDP) and are important to the national economy. The country has 10 agro-ecological zones and these are broadly grouped into four regions: dry, irrigated, barani and sandy desert. Researchable areas in animal production include livestock feeding, genetic improvement, buffalo reproduction, marketing and transfer of technology, and the development of producer organisations and dairy co-operatives. In animal health, the researchable areas include improved disease diagnosis, biotechnology and vaccination.

Introduction

The total geographical area of Pakistan is 79.6 million hectares of which 25% is under cultivation. The livestock sector is of considerable importance to the economy of the country. According to 1993–94 statistics, the agriculture sector contributes 26% of GDP and the contribution by livestock is about 7.6%. The share of total agricultural production contributed by livestock is 28%; 11% of the foreign exchange earnings of the country come from livestock products.

From the administrative point of view, the country is divided into four provinces (Punjab. Sindh, North West Frontier Province and Baluchistan), and the northern areas, Azad Jammu and Kashmir. Punjab consists mostly of plains north and south of the ancient Salt Range, which runs from east to west. The Punjab can be divided into five regions, i.e. Northern mountains, South-western mountains, Potwar plateau, upper Indus plains and deserts.

The province of Sindh consists of irrigated (lower Indus basin) and arid areas. The province of Baluchistan is made up of widespread high mountain ranges, vast plain lands and the longest coastal belt of the country. The northern zone of NWFP (North West Frontier Province) is cold and snowy in winter with heavy rainfall except for the Peshawar valley. Its summer is hot and winter is cold. Its southern zone is arid with hot summers and scanty rainfall. The topography of Azad Jammu and Kashmir is mainly high and mountainous with valleys and stretches of plains. The northern areas are located in the mountainous landscape. High peaks, deep gorges interspersed with narrow valleys, steep slopes and river terraces are the main landscape of northern areas.

Livestock resources

Pakistan is rich in livestock wealth. Products like milk, beef, mutton, poultry and eggs constitute an important part of the human diet in the country. According to the latest estimates (Economic Survey 1989–90), there are 32.3 million large ruminants, 64.6 million small ruminants, 184.7 million poultry and 4.87 million other animals that include camels, donkeys, horses and mules (Table 1).

Table 1. *Livestock resources of Pakistan (1993–94).*

Species	Population (x 10^6)
Buffaloes	14.70
Cattle	17.60
Sheep	29.20
Goats	35.40
Poultry	184.70
Others*	4.89

*Camels, donkeys, horses and mules.

Sources: Pakistan Economic Survey (1993–94), Finance Division, Government of Pakistan, Economic Advisory Wing, Islamabad.

Over the period 1976 to 1986, the population of buffaloes and cattle increased at the rate of about 2.6 and 1.3% per annum, respectively. The rate of increase in population of sheep and goats was slightly higher than that of buffaloes and cattle (Table 2). The national production of buffalo milk increased at the rate of 4.1% per year during the decade; this was higher than that of cow milk (2.6% per year).

The amount of meat produced by buffaloes and cattle has shown an increase of 4.9% per year. The corresponding rate of increase in meat production by sheep and goats averages about 7.3% per year. The amount of total milk and meat produced in the country and the rate of their increase from 1984 to 1994 is satisfactory.

The productivity of both meat and milk increased between 1984 and 1986. Annual milk yield per head of buffalo was 975 litres in 1984 and increased to 1091 litres in 1994, showing an improvement of 1.2% per year during the decade. This increase is similar to the per head milk yield of cows in the same period. The meat yield per animal (large and small ruminants) showed an increase of 2.5% per year from 1984 to 1994.

Table 3 presents the demand and supply of milk and meat in the country up to the year 2000. It is estimated that 16.72 million tonnes of milk and 1.92 million tonnes of meat will be produced in the country in year 2000. The human population of Pakistan is projected to be 149.7 million in the year 2000 and the requirements for milk and meat will be 20.05 and 2.54 million tonnes even if the consumption trend observed during 1984–96 continues for the next 12 years. This means that the gap between supply and demand will be 3.33 million tonnes for milk and 0.62 million tonnes for meat by the turn of the 20th century.

Table 2. Improvement in livestock production (1984–94).

Parameter	1984	1994	Annual increase (%)
Population (10^6)			
Total buffaloes	10.61	13.38	2.6
Buffaloes (females 3 years old and above)	6.01	7.58	2.6
Total cattle	14.85	16.74	1.3
Cattle (females 3 years old and above)	4.64	5.24	1.3
Sheep	18.93	25.85	3.6
Goats	21.69	30.78	4.2
Production (10^6)			
Buffalo milk	5.86	8.27	4.1
Cow milk	2.16	2.72	2.6
Beef (buffaloes + cattle)	0.362	0.539	4.9
Productivity (kg/head)			
Buffalo milk	975.0	1091.0	1.2
Cow milk	465.0	519.0	1.1
Beef	82.5	103.3	2.5
Mutton	12.5	15.6	2.5

Source: Livestock Division, Government of Pakistan, Islamabad.

The need for improving the productivity per head of livestock in the country is imperative to cope with the demand in future. Presently, whatever increases in national production of milk and meat have been achieved are mainly due to an increased population of livestock. If the livestock population is allowed to increase at the existing rate, there will be more than 20 million buffaloes, 21 million cattle, 39 million sheep and 29 million goats in the country by the year 2000. It will be impossible to feed such a large population of livestock. Research and development efforts should, therefore, be directed to improve per head productivity of livestock rather than multiplying their numbers. At the same time, the development of feed resources, which are non-conventional in nature but economic, is essential.

Large ruminants (cattle and buffaloes) are mainly found in the provinces of Punjab and Sindh. Small ruminants (sheep and goats) are distributed in all four provinces but their population is concentrated in Baluchistan, Punjab, Sindh and NWFP in that order.

Dairy cattle and buffaloes are generally raised on the riverbanks and canal irrigated areas of Punjab and Sindh. Grazing land constitutes the biggest land use in the country, and rangeland includes all categories of land that are not under forests or cultivation. Rangelands constitute more than 70% of the total geographical area and provide 60% of the feed requirements for sheep and goats. In terms of livestock raising, the fold carrying capacity of rangeland has been estimated to be 4.3 million animal units. This indicates that the rangelands are presently stocked with twice the number of animals that they can support.

Table 3. Production and requirements of livestock products in Pakistan by year 2000.

Parameter	1984	2000
Population (m)		
Buffaloes (females 3 years old and above)	7.58	10.34
Cows (3 years old and above)	5.24	6.19
Sheep	25.82	38.83
Goats	30.78	48.87
Production (t)		
Buffalo milk	8.27	13.01
Cow milk	2.72	3.71
Total milk	10.99	16.72
Beef	0.539	0.908
Mutton	0.500	1.011
Total meat	1.039	1.919
Requirements		
Human population (m)	97.67	149.70
Milk (t) @ 134 kg/head per year*		0.05
Meat (t) @ 17 kg/head per year**		2.54
Deficit		
Milk (mt)	3.33	(20.05–16.72)
Meat (mt)	0.62	(2.54–1.91)

* Calculated on the basis of per capita milk consumption in 1994 (102 kg) with an average annual increase rate of 2.3% recorded from 1984 to 1994 (Economic survey of Pakistan 1993–94).

**Calculated on the basis of per capita meat consumption in 1994 (12.6 kg) with an average annual increase rate of 3.5% recorded from 1984 to 1994 (Economic survey of Pakistan 1993–94).

Inadequate fodder supply is the major constraint to improving milk and meat production. Because of inadequate nutrition, the livestock have low productivity (low milk production, low fertility, prolonged inter-calving interval, high neonatal mortality, increased susceptibility to diseases). The major sources of fodder vary between agro-ecological zones (AEZs). Overgrazing and deforestation are endemic problems as there is little management of grazing lands.

Grazing is most important in the desert and rainfed areas where native pasture and trees are the sole fodder source throughout the year. Drinking water is the limiting factor in some zones (e.g. the Greater Cholistan desert) whereas overgrazing and undernutrition are the major problem in the Lesser Cholistan.

Trees are used as sources of fuel, fodder, shelter, medicines and fencing materials. The most common fodder trees are *Acacia modesta* (*Phulai*), *Acacia nilotica* (*Kikar*), *Zizyphus jujuba* (*Ber*), *Melia azadirachta* (*Dherek*), *Zizyphus numularia* (*Mulah*), *Zizyphus mauritiana*, *Albizzia procera*, and *Calligonium polygonoides*.

Poultry meat and egg production (both in the village and intensive poultry production systems) offer good prospects for continued rapid growth (12%

annually) compared with the production of foods of animal origin (milk, mutton, beef etc). Rural poultry provides 43% of the total eggs and 18% of the total poultry meat. The following factors will interfere with the above targets being achieved: inadequate nutrition, high mortality rates due to diseases and poorly designed housing, low genetic potential of village populations, inadequate capacity in hatcheries, and inadequate availability of raw material for the feed mills and housing for layer, broiler and breeding stock.

Village chickens in the Punjab have high mortality rates and adult poultry lay only 50 to 60 eggs per bird per year. Improved housing can increase egg production by 20 eggs per head per year and reduce the disease incidence. A dual-purpose bird with higher egg and meat production potential is required and research is needed to breed such chickens that are adapted to village conditions.

Agro-ecological zones

Pakistan is divided into 10 agro-ecological zones on the basis of climate, rainfall, temperature and potential land use (Figures 1 and 2):

i) Indus delta

ii) Southern irrigated plain

iii) Sandy desert (a and b)

iv) Northern irrigated plain (a and b)

v) Barani (rainfed) areas

vi) Wet mountains

vii) Northern dry mountains

viii) Western dry mountains

ix) Dry western plateau

x) Sulaiman piedmont

Figure 1. Agro-ecological zones of Pakistan.

Figure 2. Types of climate in Pakistan.

These agro-ecological zones can be grouped into four regions for the purpose of animal agriculture:

1. Dry region: This includes northern dry mountains, western dry mountains, dry western plateau and Sulaiman piedmont.
2. Irrigated region: This includes Indus delta, southern irrigated plain, and northern irrigated plain.
3. Barani region: This includes barani rainfed areas and wet mountains.
4. Sandy desert region: This includes the Thar and Cholistan deserts in north-eastern Sindh and Southern Punjab.

Research priorities for improving animal agriculture in the AEZs

Dry region

(i) Planning for increasing the quantity and improving the quality of natural grazing through re-seeding mountain grasses in rangeland, conservation of grazing areas to allow establishment of vegetation cover and introduction of grazing systems to avoid over grazing.

(ii) Conservation of crop residues and their utilisation as animal feed.

(iii) Crossbreeding of sheep and goats with highly productive exotic breeds.

Irrigated region

Due to the sufficient quantity of green fodders, most of the dairy cattle and buffaloes are located in this region. Priority areas of research for livestock improvement in this region are:

(i) Strengthening the fodder research programme to develop new and improved varieties of fodder that fit in the prevailing farming system.

(ii) Establishment of feedlot fattening systems to increase meat production from small and large ruminants.

(iii) Development of high producing dairy cattle and buffaloes through selective feeding, progeny testing and crossbreeding with genetically superior exotic dairy breeds.

(iv) Improvement in marketing infrastructure for livestock products.

(v) Research on packaging and processing for production of high quality milk and meat products.

Barani region

In this region, the livestock population consists of 11% buffaloes, 30% cows, 11% sheep and 48% goats. Due to inconsistent fodder production, this area can provide only 20% of the feed requirements of large ruminants and 60% of the feed requirements of small ruminants. Researchable areas for the Barani region should include:

(i) Improving productivity of local cattle through extensive utilisation of non-conventional feed resources.

(ii) Improving meat production of small ruminants through crossbreeding.

(iii) Introduction of feedlot fattening for utilisation of old bullocks and male calves.

(iv) Improving working ability of local cattle through research on their draft power efficiency.

(v) Crossbreeding of local goats with exotic breeds.

(vi) Strengthening of artificial insemination facilities for genetic upgrading of local cattle.

Researchable areas in animal production

There are a number of researchable areas in animal production. In view of the limited resources available and the many problems to be solved, prioritisation in research is required. Some of the top priority areas are identified below.

Livestock feeding

Scarcity of feed for livestock is a major production constraint in Pakistan. Animals are generally underfed, thus their production capabilities cannot be fully exploited. Increasing the availability and use of livestock feeds such as new agro-industrial wastes and crop residues and by enhancing the utilisation of already available feed through maximisation of their digestibility by the animal is essential. Maximising digestibility is possible through rumen manipulation studies and use of protein by-pass technology.

Genetic improvement

Better management, improved nutrition and effective disease control programmes can result in immediate, but temporary, improvement in the production performance of livestock. For genetic improvement, which is permanent but slow, we will have to strengthen the programmes of artificial insemination (AI), progeny testing and embryo-transfer technology to speed up the rate of genetic improvement in our livestock. Embryo-transfer technology is a relatively new field and extensive experimentation is required to adapt it for cattle and buffaloes. Optimisation of superovulation response, embryo collection, cryopreservation, particularly for buffaloes, are some of the areas where research efforts are necessary.

Buffalo reproduction

The Nili-Ravi and Kundi buffalo breeds are the primary dairy animals in Pakistan, contributing more than 70% of the national milk production. Due to delayed maturity and longer calving intervals, buffaloes are classified as sluggish breeders and this makes the lifetime productivity of buffaloes well below their real genetic potential. Difficulties in heat detection (because of the higher incidence of silent ovulations) and consequently lower fertility rates due to inadequate diagnostic and preventive measures for reproductive diseases are the major problems faced by buffalo breeders. Diagnostic tests based on hormone profiles, e.g. progesterone, can help to detect silent ovulation and early pregnancy in buffaloes. Similarly, by exploring the role of prostaglandin in utero-ovarian physiology, the diagnosis and control of certain reproductive disorders can be improved, which will in turn increase fertility rates of buffaloes.

Producers' organisations

As the majority of livestock producers are rural smallholders, they face difficulties in marketing even small quantities of produce as they are far away from the markets. Better marketing avenues working through producer organisations aimed at arranging collection, grading and marketing of their various products are necessary. Other essential elements include participation of producers in the planning, formation and operation of the organisation. The strategy would aim, therefore, at helping the producers to create the type of organisation they wish to have. This would involve providing information to motivate producers to form such organisations, technical guidance at the planning stage and training for some members in management and marketing skills.

Dairy co-operatives

Experience with successful dairy co-operatives elsewhere shows that the co-operative structure develops in parallel with changes in the production systems. Thus, with market access, the traditional low productivity system gives way to a better use of more intensive methods. As the genetic potential of nondescript animals becomes a constraint to increasing production, the demand for AI services increases. With market access, increasing production leads to demands for greater control of marketing channels and hence to more elaborate co-operative structures. However, provincial or national structures for dairy or wool producers' organisations could only be established once individual production and marketing organisations are operating successfully and there is a clear need for an umbrella organisation.

Marketing strategy

The improvement of marketing of livestock products would include education of consumers. For example, many consumers are insufficiently aware of the benefits (in terms of hygiene), of UHT milk and there is often a lack of discrimination over the quality of fresh milk which may be severally adulterated. Similarly, there are aesthetic considerations, for example, resistance to processed poultry and misconceptions that eggs adversely affect health during the summer. Appreciation of meat quality is often lacking. Part of the strategy for development of the sector would therefore be to create more discriminating consumers who would pay more for better quality products. Such programmes would be most suitably mounted for the private sector, but the government's encouragement could include tax rebates on the costs of promotional campaigns by the private sector.

To enable milk to be collected from rural areas for the provision of urban centres, it is proposed that milk chilling centres be established in rural areas, enabling milk to be chilled within less than three hours of milking and providing a market for evening milk.

Transfer of technology

Laboratory findings remain meaningless unless they are applied in the field to solve the problems faced by the farmers' community. The outreach or extension wings of all research institutes should be strengthened and research results translated for field application. In the beginning, the outreach programmes should focus on two main areas. The first one is the supply of cheap, nutritionally balanced and complete feeds to livestock owners. The second area is the systematic use of crossbreeding and embryo-transfer technology to upgrade the genetic potential of nondescript cattle for increased milk production at the small farmer's level. Embryo-transfer technology should also be used for the preservation and rapid multiplication of our recognised cattle breeds like Sahiwal and Red Sindhi, and for genetic improvement of buffaloes.

Researchable areas in animal health

There has been non-systematic disease surveillance and recording system in the country. The Ministry of Overseas Development of the United Kingdom in 1978, reported losses of 171,162 million US dollars from foot-and-mouth disease (FMD) in buffalo and cattle. Another publication by Pakistan Agricultural Research Council (PARC) reported loss of Rs. 15,703 and Rs. 5764 millions from mortalities and morbidities, respectively, in livestock in Punjab (Tables 4 and 5).

Table 4. *Estimated losses from foot-and-mouth disease in Pakistan (10^3 US$).*

	Buffaloes			Cattle			
Province	Dairy	Draft	Young	Dairy	Draft	Young	Total
Baluchistan	81	3	14	674	1012	222	2006
NWFP	4449	133	601	6649	6309	1821	18,982
Punjab	62,031	672	9541	19,774	34,189	6385	132,592
Sindh	5223	38	908	3258	6247	928	16,602
Total	71,784	846	11,604	30,355	47,757	9358	171,162

Source: UK Ministry of Overseas Development (February 1978).

PARC's on-going research project on Epidemiology of Major Livestock Diseases in Pakistan has collected information from Provincial Livestock Departments. The data relate only to reported cases. Due to limited resources, widespread field surveys could not be undertaken. According to this report, the most important diseases are haemorrhagic septicaemia, FMD, rinderpest in cattle and buffaloes, and sheep pox and enterotoxaemia in sheep and goats.

Table 5. Estimated losses from some important infectious diseases of livestock in Punjab.

	FMD	Mucosal disease	Rinderpest
Incidence (%)	53.0	28.3	48.6
Mortality (%)		78.3	85.7
Annual economic losses (m Rs)			
Due to mortality			15,703.0
Due to loss of milk			5,764.0
Total			21,467.0

Source: Final report of the research project on "Economic Losses from Livestock Diseases" in Punjab (l977), PARC, Islamabad, Pakistan.

Parasitic infestation due to ecto- and endoparasites is thought to be of considerable importance, but although large amounts of money are spent each year on their control, the financial impact has never been properly evaluated. Endoparasites are particularly important amongst sheep and goats and may cause death to more than 5% of lambs and kids. Warble fly can be troublesome and causes losses by downgrading livestock skins and hides.

Disease investigation services are restricted to the diagnostic laboratories located in districts and the cities. The disease investigation officer undertakes regular monthly tours to collect samples and plot disease incidence. There does not appear to be a regular collection of data or samples from the field and facilities for laboratory diagnosis of diseases are inadequate. The objective of the field diagnostic laboratories should be to assist clinicians and provide information for planning annual veterinary programmes.

Biotechnology DNA technology and monoclonal antibodies are showing promise for livestock improvement, particularly in disease diagnosis. DNA technology can be used to provide new types of vaccines that could be stored under field conditions or be used orally. Enzyme-linked immunoassay (ELISA) or other on-farm diagnosis tests could be made appropriate if preparation technology for these tests is provided. To institute biotechnology in all the major veterinary institutions in the country, long- and short-term training in such techniques as diagnostic virology, preparation of enzyme and fluorescent conjugates and hybridoma technology will be required.

Vaccination programmes

The annual vaccination schedule is prepared on a subregional and seasonal basis according to known disease incidence, movements of animals and the availability of vaccines. About 18 million ruminants are vaccinated each year, of which about 60% are large ruminants, which are vaccinated mainly against haemorrhagic septicaemia. The programme is undertaken by stock assistants (SA) and as most livestock owners have only a few animals, the SAs face difficulties in assembling large number of animals for rapid and efficient vaccination campaigns. Most animal health and vaccination cover is provided free, except for a registration fee of Rs. 1 per treatment. As budgetary provision is very small and constitute a part of the costs involved in veterinary cover, veterinary officers frequently prescribe drugs, which the owner has to buy from the market. In addition, some veterinarians are involved in private practice.

Vaccines are produced at the Veterinary Research Institute (VRI) in Peshawar and Lahore, at the Poultry Research Institute (PRI) in Karachi and the Vaccine Production Unit in Quetta. In 1993–94, 161 million doses for poultry vaccines and 26 million doses for farm animal vaccines were produced. The total production is inadequate for national needs but production standards are, in general, good.

Research priorities for animal production systems in Sri Lanka

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Abstract

Animal husbandry in Sri Lanka is predominantly a smallholder activity carried out to provide a subsidiary source of income. Past research has identified the major livestock farming systems in the different agroclimatic zones, and provided information on the performance of indigenous as well as improved cattle and buffaloes. Studies have also been done on feed resources, nutrition, reproduction and diseases of the major livestock species. Over the past two years, the participation of planners, policy makers, scientists, farmers, processors and traders have helped to identify the major constraints to improve livestock productivity and to define priority areas for research over the medium term. There is a need to further characterise and economically analyse the farming systems and to develop computer models that are of predictive value. Alternative intensive systems based on crop residues and using multi-purpose animals need to be developed for the new irrigated settlement areas. Marketing of animals and their products, epidemiology of zoonoses, better utilisation of animal wastes, and the potential of non-traditional species (e.g. micro-livestock) need to be studied. Systematic studies are also needed to document the characteristics of the indigenous varieties of livestock and poultry. In each species the needs are for studies on the most appropriate genotypes, feeding strategies, reproductive management and disease control, with the aim of developing a package of technologies that can improve the efficiency of production at the small farm level. The role of ILRI could include the facilitation and co-ordination of inputs, and the initiation of regional networks or co-ordinated research programmes. More specifically, ILRI's expertise in farming systems research, molecular and other biotechnologies, as well as environmental aspects could be drawn upon to assist national and regional efforts.

Introduction

Topography, rainfall and agro-ecological regions

Sri Lanka is a tropical island located in the Indian Ocean between 6 and 10 degrees north of the equator with a total land area of 64,000 km^2. The country is traditionally divided into three zones based on elevation: lowland, midland and upland, with separations taken at 330 and 1000 m above mean sea level (msl). Agricultural patterns are determined by the natural environment defined by the climate, physiography and soil types.

Being a tropical island, the solar radiation energy available is very favourable in its total amount and seasonal distribution and the ambient temperatures even in the coolest month are suitable for plant growth. The rainfall is determined by two monsoons that blow seasonally from the south-west and the north-east. The regional distribution of rainfall is determined by this seasonal pattern and the particular configuration of the highlands situated just south of the centre of the island. The mean annual rainfall is over 750 mm all over the island but the distribution is not uniform and some areas have an extended dry period. On the basis of total rainfall (wet zone >2500 mm; intermediate zone 2000–2500 mm; dry zone <2000 mm) and topography, the country is divided into nine climatic zones.

Although the island is small, there are some 13 great soil groups, of which the dominant ones are the Red-Yellow Podzolic soils, the Reddish-Brown Latosolic soils and the Reddish-Brown Earths. The nine climatic zones have been further subdivided on the basis of soil types into a total of 24 agro-ecological regions (AER) (Figure 1). Besides these major variations in environment, changes in the physiography due to terrain (hill top, slope, valley bottom, flood plain etc) lead to differences within an AER and as a result, many different farming situations are encountered in the country. Patterns of crop and livestock husbandry as well as the availability of feeds vary between these situations.

Figure 1. Agro-ecological zones of Sri Lanka.

Natural resources, land, crops and animals

Of the total land area about a third is farmland, of which 75% are smallholdings. Some 52% of the economically active population is engaged in agriculture. The major crop grown is rice, with mixed home gardens common in most regions. The three main export commodities are tea, rubber and coconut, grown mostly on large estates.

Animal husbandry in Sri Lanka is overwhelmingly a small-farmer activity and is predominantly done by crop farmers as a subsidiary source of income. More than 95% of the cattle and buffaloes, over 80% of goats and 76% of pigs are kept on smallholdings of 0.5 to 2 ha in size. Even the dairy cattle on large estates are often raised by the resident labour in a manner similar to that practised by the smallholders. The only large, capital-intensive animal husbandry operations are a few poultry and pig farms located around the urban centres close to the capital, Colombo.

The major products from livestock are eggs (poultry), milk (cattle, buffalo and goat), meat (poultry, pigs, cattle, buffalo, goats and rabbits) and power for farming activities (buffalo and cattle). The country has a population of 1.6 million cattle, 0.6 million buffaloes, 0.5 million goats, 85,000 pigs and 10 million poultry.

The per capita consumption of livestock products in Sri Lanka is low by international standards (Table 1). Due to the low productivity of the animal production systems in the country, even this modest requirement is barely met in the case of eggs and meat, while large quantities of milk are imported annually.

Population, distribution and utilisation of ruminants

The distribution of the ruminant population is shown in Table 2. The total milk production in 1994 was estimated at 343 million litres, of which only 86 million litres were collected by the organised market systems. Despite heavy investments by the State in the dairy sector over several decades, only marginal increases in milk production have been recorded. As a result, the country continues to import nearly half the requirement for even this low level of consumption, at a cost of some Rs 3 billion (US$ 60 million) annually. Several factors, both technical and socio-economic in nature, have contributed to this unsatisfactory situation.

Table 1. Estimated annual per capita consumption of animal products in Sri Lanka.

Product	Annual per capita consumption
Fresh milk (litres)	4.0
Powdered milk (litre equivalent)	14.1
Eggs	26.4
Chicken (kg)	0.4
Mutton (kg)	0.1
Beef (kg)	1.2
Pork (kg)	0.2

Source: Sri Lanka Livestock statistics (1991/1492), Ministry of Agriculture, Development and Research, Colombo (1992).

Table 2. Population and distribution of ruminants according to climatic zones.

Climatic zone	Buffaloes (%)	Cattle (%)	Goats (%)
Low elevations, dry	73	69	65
Low elevations, wet	17	16	17
Mid-elevations, wet	6	7	10
High elevations, wet	4	8	7
Total population (10^6)	0.56	1.60	0.54

Buffaloes

More than 90% of the buffaloes are of the indigenous swamp variety and are used predominantly for farm power in the cultivation of rice. They are located mainly in the lowlands (wet and dry zones) but are also found in the midlands, and are used for draft. Those in the dry areas are managed extensively in large herds, while those in the wet zone are usually kept singly. In some areas, buffaloes have traditionally been milked, particularly in the south-east (Ruhuna), famous from ancient times for buffalo "curd" (natural yoghurt). Buffaloes are managed very simply, being grazed on natural pastures or in fallow rice fields, with no supplementation. State sponsored crossbreeding programmes with Indian dairy breeds of buffaloes over several decades has resulted in a small but increasing population of crossbreds. These animals are kept more intensively for milk and are usually supplemented with concentrates. Buffalo milk is usually fermented to make the firm curd referred to above, which is very popular in Sri Lanka. This adds value to the milk and makes dairying from buffaloes relatively profitable.

Cattle

The majority of cattle in the dry zone are either indigenous or crossbreds with Indian breeds. They are used for draft, including road haulage, and to a lesser extent for milk. Dry zone cattle are the main source of beef in the country, and are transported to urban areas for slaughter. Farmers in the dry zone appear to keep cattle as a form of "insurance" since they can be quickly converted to cash by selling them in times of need. In the wet zone, particularly at mid and high elevations, European breeds of cattle and their crosses are found. Although the numbers are relatively small, they are a major source of milk in the country. This population is the result of artificial insemination programmes carried out over several decades. They are reared intensively and supplemented with concentrates and minerals. In some parts of the dry zone, particularly around urban areas, European cattle are kept intensively and fed on crop residues and concentrates to meet the urban demand for milk.

Goats

Most of the goats are found in the dry zone (see Table 1), and are reared mostly by specific communities in the northern parts of the island as a source of meat and milk. Indigenous goats have been crossed with imported breeds, both Indian and European, thus improving their productivity for both milk and meat. In the dry zone the goats are usually allowed to forage free during the daytime and are housed at night. In the wet zone and in urban areas, more intensive systems are found where the animals are kept indoors and fed on tree leaves and concentrates.

Livestock farming systems and their potential

The majority of smallholders engaged in crop–livestock farming keep cattle and/or buffaloes. Several distinct cattle and buffalo production systems have been identified in the country. The major determinants of these systems are the agro-ecology, cropping pattern, land availability and animal management.

Dry zone traditional village system

This is the most prevalent system in the country. The predominant genotype is the indigenous zebu, in many instances kept along with indigenous buffaloes on communal grazing lands. The management inputs are minimal, being mainly labour for herding. The primary income is from selling animals for meat and draft, while some milk is also extracted. This system is now subject to increasing pressure from unavailability of communal grazing lands.

Dry zone irrigated settlement system

Within the dry zone, in areas where pressure on land is more intense, such as in the newly irrigated settlement schemes, cattle farming has become more intensified. Small herds of cows with medium production levels are maintained under a combination of tethered grazing and stall-feeding with cut grasses, tree fodders and straw. The return from this system is marginal due to the high cost of inputs for labour and concentrate feed together with the low farm-gate price for liquid milk.

Intermediate zone (coconut triangle) system

In the intermediate zone where a large extent of land is under perennial crops, livestock farming is based on a semi-intensive system. The herd sizes are small and the animals are grazed, either free or tethered, on natural pasture under coconut and other perennial crops. Milk is the primary product, with sale of surplus animals for draft and meat bringing additional income.

Wet zone (mid- and up-country) system

In the wet zone, a unique smallholder, mixed crop livestock production system is in existence. The animals are purebred or crossbred *Bos taurus*, and are maintained under zero grazing. The inputs for feed, health control and artificial breeding are high. Although the productivity per unit is greater than that in other zones, the net return is low.

Trends in agricultural development

The Ministry of Livestock Development and Rural Industries in the Government of Sri Lanka has recently issued a policy statement which clearly indicates a strong commitment to increase the output of all animal products over the next five years. In the dairy sector, for example, the target is to double milk production by the year 2000, and to increase the quantity collected by the organised sector by 300%.

The major factor presently affecting animal husbandry activities is the decreasing land availability due to increases in the human population. Cattle and buffaloes in the dry zone are chiefly affected due to the reduction of land available for grazing. The challenge then, is to produce more from animals to meet the increasing population demands but on less land. This means that animal husbandry systems must become more intensive, more productive and, above all, more efficient than they have been in the past. The present trends are to move towards such intensive and more sophisticated systems. Such enterprises, however, need more capital and expertise, both of which farmers presently lack. They will also need better marketing and distribution systems. Unless this challenge is met, it is likely that the production of animals will decrease in relation to the needs of an expanding population. Intensification of land use is, however, not so eco-friendly and is known to have negative effects on the environment. These are concerns that need to be addressed in determining a strategy for future research to improve animal production.

Highlights of research carried out in Sri Lanka

The early studies on animal diseases can be traced back to the establishment of a facility in 1911 to provide laboratory backing to disease diagnosis. A regular veterinary laboratory was set up in 1939 and, through several transformations, culminated in the establishment of the Veterinary Research Institute (VRI) at Gannoruwa in 1967. Some of the early highlights included the development of vaccines against a number of livestock diseases, the eradication of rinderpest and breeding studies on indigenous zebu cattle and their crosses with Indian Zebu and *Bos taurus*.

University education in veterinary and animal sciences commenced in 1948. At present, the country has one Faculty of Veterinary Medicine at Peradeniya, and three Departments of Animal Sciences in the Universities of Peradeniya, Ruhuna and Jaffna. Some of the highlights of early research were studies on parasitic diseases, reproduction, nutrition, pastures and fodders.

Brief highlights of recent research done in both the VRI and the Universities are given below.

Farming systems research

Although many discipline-based field studies have been carried out, only a few of the crop–livestock farming systems in the country have been studied in detail. Those that have been studied in some depth include the small-farm buffalo production systems in the dry and wet zones, cattle farming in selected dry zone locations, upland tea plantation dairy farms, midland forest-garden small dairy farms and the village scavenging chicken system. It is clear that many systems remain to be studied.

Cattle and buffaloes

Breeding

Studies on indigenous cattle and buffaloes showed them to be well adapted to the local environment and able to survive under harsh conditions, but to have poor growth rate and milk production. It was evident that rapid improvement could only be effected by upgrading with imported breeds of cattle. Several cross-breeding studies have been done using Indian breeds such as the Sindhi, Sahiwal and Tharpakar, and European breeds such as Jersey and Friesian. Similar studies were also carried out on indigenous buffaloes upgraded with the Indian breeds Murrah and Surti, and to the Pakistani breed Nili-Ravi. Information on the productivity of these crosses, albeit under institutional farm conditions, now exists.

Reproduction

A series of studies have been carried out to examine aspects of reproduction in cattle and buffaloes, using conventional as well as isotopic techniques such as radio-immunoassay (RIA) for measuring reproductive hormones. The basic reproductive parameters of cattle and buffaloes in Sri Lanka have been established and the major causes of low reproductive efficiency at village locations have been found to be delayed puberty, long post-partum anoestrus and long calving intervals. The major contributory causes identified were poor nutrition, failure to restrict suckling by the calves, lack of oestrus detection and failure to provide a fertile service at the appropriate time.

Heat tolerance

Long-term studies which investigated the relative heat tolerance of cattle and buffaloes in the different AEZ of the country established that, even in the wet zone, at lower elevations pure European cattle suffer badly. In this respect, Friesians were worst, Ayrshires were next and Jerseys the best. Buffaloes were able to overcome these stresses provided they had constant access to water for both drinking and wallowing. There was no difference between Murrah, Surti and Lanka buffaloes in their ability to tolerate conditions in the dry zone, although Lanka buffaloes needed less water than the two exotic breeds.

Meat

Studies carried out in both the dry and the mid-country zones have yielded information on the relative growth rate and carcass quality of different breeds of cattle and buffaloes.

Pasture and fodder

Many improved varieties of grasses such as *Brachiaria*, hybrid Napier and Kikuyu introduced into the country over the years have been tested for their growth characteristics, fertiliser requirements and nutritive value. This provides the basic information needed to use these grasses in a scientific manner. However, most farmers feed their animals on natural pastures and information on these have wider application. Several studies including animal experiments have been made on the ubiquitous grass Guinea A, which is used widely by farmers in the Mid Country and elsewhere. Some studies have also been done both on the traditional and introduced varieties of tree fodders.

Crop by-products

A major research programme on ensiling rice straw with urea and its subsequent utilisation has provided information on aspects of the technology and factors governing its adoption by farmers. More recent studies have shown that urea–molasses blocks can be used to good economic advantage for feeding dairy cattle and buffaloes maintained on rice straw and other crop residues. These technologies are presently being introduced into some farming systems in the dry zone.

Minerals

Several studies, mainly in the nature of surveys, have been carried out to determine the mineral status of cattle and buffaloes in all agro-ecological regions. These studies, together with analysis of forages and feeds, have made it possible to identify the minerals that are likely to be deficient under local conditions and to formulate mineral supplements on a scientific basis unlike in the past.

Diseases

In early studies, many of the bacteria causing common diseases such as anthrax, haemorrhagic septicaemia (HS) and black quarter (BQ) together with parasites such as the common nematodes, paramphistomes and tapeworms were identified and studied. With the introduction of European cattle and their crosses for increasing milk production, several diseases such as tick fever (babesiosis) became important. These diseases were studied, leading to the development of a vaccine against tick fever which is now used to control the condition. Studies on mastitis have lead to the formulation of a cost-effective control programme using a locally available teat-dip.

In buffalo calves, the parasitic helminth *Toxocara vitulorum* causes high mortality during early life. Studies on the epidemiology and life cycle of this parasite using radioisotopes, and subsequent field studies proved that a single dose of a cheap and readily available drug, given at the critical stage of 10–16 days after birth, can effectively control the problem.

HS caused by the organism *Pasteurella multocida* has been the main cause of mortality among cattle and buffaloes in the Dry Zone. A comprehensive series of studies has led to a better understanding of the origin and spread of the disease, and to the development of a more potent vaccine for its effective control. Studies on outbreaks of the other epidemic disease in the Dry Zone, foot and mouth disease, have identified its area of origin and patterns of spread. Studies have also been made on the prevalence of brucellosis, which is transmissible to man, and at present control strategies are based on these studies and the use of a vaccine made at the VRI.

Goats

Breeding

A long-term programme was carried out using the Indian breed Jamnapari to improve the local "Kottukachchiya" breed. Later, the Boer breed was introduced with a view to producing a meat goat. The progeny from these programmes need to be further evaluated for their suitability for the specific farming systems.

Diseases

A detailed study had been done on the problem of cerebro-spinal nematodiasis in goats, which causes heavy economic losses. An effective control strategy needs to be developed.

Poultry

Breeding

The performance of different imported breeds of poultry was studied. Based on the results, a hybrid chick named "Rhowhite" was developed, which performed economically under a low plane of nutrition and management in the field. Currently, under a new programme, several genetically superior parent pure-lines imported from Canada are being used to develop lines of white and brown egg layers suitable for the more sophisticated systems of today.

Nutrition

Several research projects have investigated the feeding value of local ingredients. Over 25 locally available potential feeds have been subjected to an initial evaluation for their suitability as substitutes for imported ingredients. These materials include mainly by-products of agro-industry as well as local resources such as the rock phosphates. This work needs to be taken forward to the point where these are regularly used as substitutes for expensive imported materials.

Diseases

Chief among the important diseases is Newcastle Disease and, before the introduction of a vaccine in 1953, outbreaks were widespread. A vaccine against Fowl Pox was also developed and, together with the use of coccidiostats, allowed the growth of the industry. Other diseases such as salmonellosis, coccidiosis, gumboro and Marek's disease have also been studied. Much of the research work has been directed towards the epidemiology of the diseases in the field and improvement of the vaccines. With the rapid development of the poultry industry and its increased sophistication in recent years, a number of new poultry diseases have emerged and control of these pose a great challenge to the industry and to researchers.

Constraints to animal production

The constraints to livestock production are known in general terms and have been discussed informally over the years. In 1991, a formal process was begun to identify constraints in a systematic manner. A series of separate workshops were organised in 1994 by the Council of Agricultural Research Policy with groups such as livestock producers, processors, traders, policy makers, livestock scientists and national planners. The perceived constraints were listed, discussed and documented. Many of the constraints identified related to areas such as pricing, marketing, extension, administration and policy, which are not researchable. In the case of producers in particular, the problems were chiefly concerned with national or regional policy or with matters such as the difficulties of obtaining credit. Some of the problems that may lend themselves to solution by research are listed below, classified according to animal industry.

Cattle and buffalo farming

- shortage of animals for dairy farming, of sufficient quality and quantity
- low productivity of individual animals
- no organised marketing of animals
- high cost of concentrate feed
- lack of methods of preserving roughage
- low milk price to farmers
- poor quality of milk from smallholders
- lack of standards and simple village-level testing procedures for fresh milk
- poor utilisation of the by-products of meat processing.

Goat farming

- poor productivity of goats due to low genetic potential and parasites
- high mortality rates of kids
- goat paralysis (cerebro-spinal nematodiasis, CSN)
- inadequacy of feeds
- lack of a sustainable self-reliant, fodder-based system for goat production
- environmental hazards of goat farming.

Pig farming

- lack of good parent breeds to provide quality piglings
- high price and poor quality of feed
- inability of small-farmers to ensure a regular meat supply to processors
- non-utilisation of the by-products of meat processing

- poor storage of wet pork
- waste disposal.

Poultry farming

- climatic and management stresses
- high cost of feeds, drugs and equipment
- no standardisation in the quality of poultry products
- high incidence of disease
- waste disposal.

General

These are broader issues identified as responsible for the lack of progress in the livestock industry:

- lack of a clear and consistent national policy
- lack of reliable statistics for making correct policy decisions
- farmers not organised as pressure groups to influence policy decisions.

Proposed research areas

In formulating a research programme valid for 5–10 years, the following factors need to be considered:

- constraints faced by farmers that can be resolved by research
- appropriate work already done in Sri Lanka or elsewhere that has not been adopted
- availability of resources (research centres, equipment, trained manpower and funds)
- a prediction of the areas in which information will lead to improvements.

Many of these factors are not easy to assess and research plans are often a compromise. We therefore thought it best to identify the general areas in which research is likely to pay dividends rather than formulate a detailed research programme. A list of such areas based on the factors listed above was prepared and presented to a group of scientists for discussion. At the same time, an attempt was made to identify the centres at which the research could be carried out and the major inputs that would be needed to carry out the programme. The sections described below are the outcome of these deliberations.

Researchable areas

Farming systems, economics and miscellaneous

1. Identify and characterise (including economic analysis) existing crop–livestock systems.

2. Use the data to develop computer models that can describe the systems and their potentials, and predict their responses to further inputs. Collect data to refine these models.
3. Develop and test alternative systems that can be introduced into new settlement areas. These should be intensive, based on crop-residues and use multi-purpose animals.
4. Study the patterns of collection and marketing of animals and their produce in relation to the overall economics of the farmer and the farming system.
5. Determine the potential of non-traditional livestock species (e.g. micro-livestock) and their suitability to local farming systems.
6. Study the epidemiology of animal diseases transmissible to man (zoonoses).
7. Determine the environmental aspects of livestock farming and develop methods for better utilisation of animal wastes.

Cattle and buffaloes

1. Identify the attributes of native cattle and buffaloes that enable them to adapt to conditions in Sri Lanka.
2. Identify the characteristics of cattle, including calf survivability, that would make them suitable for dairy farming in the different agro-ecological zones and farming situations, and develop methods to identify them in the field.
3. Determine the extent and causes of infertility (infectious and non-infectious), among dairy cattle and buffaloes in different farming situations.
4. Develop new technologies in reproduction to identify and overcome problems of infertility and to increase reproduction rates.
5. Develop new varieties of fodder grasses and methods of growing and utilising them and introduce these to small dairy farms.
6. Develop methods of improving the utilisation of traditional indigenous varieties of tree fodders, and the establishment of eco-friendly forest/livestock systems.
7. Develop models of feeding systems for different farming situations using existing nutrition data, particularly for intensive systems based on crop residues, tree fodders and agro-industrial by-products.
8. Study soil–plant–animal relationships for mineral elements in different areas and assess the effect of inadequacies or excesses of minerals and vitamins on production, reproduction and health.
9. Study the pathogenesis and epidemiology of HS (haemorrhagic septicaemia), BQ (black quarter), FMD, rinderpest and mastitis. Identify the important factors that predispose to the spread of these conditions. Fit the data to computer models and use to develop strategies to control the diseases.
10. Improve the efficacy of vaccines and their use through new biotechnologies.
11. Determine the epidemiology, life cycles, pathology and severity of the diseases caused by the important parasites and develop cost-effective methods of control.

Goats

1. Develop a synthetic dual-purpose breed for the Dry Zone with more emphasis on meat production and selected for resistance against CSN.
2. Evaluate native (wild and homestead) tree fodders and incorporate into feeding systems. Develop eco-friendly forest/goat systems.
3. Develop and adopt new reproductive technologies designed to increase reproduction rates.
4. Develop control methods for helminth parasites with emphasis on CSN and gastro-intestinal parasites.
5. Study the epidemiology of and develop control methods for viral diseases.

Pigs

1. Characterise native and indigenous pigs.
2. Establish the best cross (2-way or 3-way) for use in different management systems.
3. Study the miscellaneous feeds fed to pigs and develop models of appropriate feeding systems that optimise the use of these resources.
4. Determine the epidemiology of the economically important diseases of pigs and develop control strategies.

Poultry

1. Study the environmental physiology of improved strains of poultry, determine responses to heat/humidity stress and their effects on nutrient requirements. Develop modified housing to combat such stress. Determine the ability of improved strains to cope with high fibre rations.
2. Identify desirable characteristics of native chickens and develop measures to conserve these genes.
3. Develop local parent lines by incorporating into exotic strains the beneficial genes relating to adaptation identified in indigenous birds.
4. Improve meat quality in relation to Sri Lankan consumer preferences. Control keeping quality, hygiene and residues from feed additives.
5. Determine the effects of heat and humidity on deterioration of stored feeds with particular reference to oxidation and rancidity, mycotoxins and the efficacy of additives used to combat these.
6. Determine the aetiology, pathogenesis and epidemiology of emerging disease conditions and develop vaccines and other control measures.
7. Determine the role of breed, nutrition and management on the epidemiology of long-existing disease conditions such as coccidiosis and colibacillosis and develop control measures.

Product technology

1. Dairy chemistry and technology

   a) Document the presently used technologies.

b) Adapt foreign technologies to suit Sri Lankan tastes.

c) Establish norms and standards for local use.

d) Develop expertise in dairy chemistry, microbiology and dairy technology.

2. Meat science and technology

a) Establish grading systems and standards for quality, shelf life and residue levels.

b) Develop meat-based products for Sri Lankan consumer preferences, methods of storage and cooking.

Implementation of the research programme

The centres in which a research programme can be carried out are the Veterinary Research Institute (VRI), Faculty of Veterinary Medicine and Animal Science of the University of Peradeniya and the Departments of Animal Science in the universities of Peradeniya and Ruhuna. The VRI, which is within the Government Department of Animal Production and Health, is the main institution given the task of conducting research and providing research-related services to farmers and industry. It has divisions of nutrition, breeding, farming systems, fodder crops, bacteriology, parasitology, pathology and virology, and also a vaccine production centre. The universities, apart from their primary role of teaching, do a significant amount of research in animal production and health. However, the research capabilities in the different disciplines are not uniform, being dependent on the interests of each Department.

At the workshop held to discuss the above researchable areas, it was concluded that of the 36 items identified, significant research had already been done on 11, while some work exists on a further 13. In these areas, some level of expertise and capability already exists. However, 15 of these would need more equipment and most would need some form of further training in order to carry out an effective future programme.

In the 12 areas in which no work has been carried out, most will need inputs for infrastructure development, equipment and training. These include the following areas: computer modelling of farming and feeding systems; effects of heat and humidity on feeds; dairy chemistry, microbiology and technology; improvement of meat quality; new technologies in reproduction; epidemiology of diseases; biotechnology in vaccine production; and studies on indigenous chickens.

Only limited amounts of operational funds (labour, fuel and consumables) are routinely provided by either the VRI or the universities for research and scientists are dependent on other funding sources within and outside the country. Most research projects will need such operational funds.

The workshop also determined that between the VRI and the universities, given the added inputs, most of the identified research areas could be adequately dealt with in the coming 5–10 years.

Role of the International Livestock Research Institute (ILRI)

The workshop concluded that ILRI could play a significant role in this programme. It could facilitate the provision of inputs to the programme, particularly for those that need a total build-up of infrastructure, equipment and training. Where common regional problems are identified, ILRI could co-ordinate regional research efforts. The Institute could also arrange for exchanges of information and scientists between countries as well as short visits from international specialists.

More specifically, it was felt that ILRI could assist in the following areas:

1. Characterisation of native or indigenous species.
2. Studying and modelling farming systems and situations.
3. Introduction of the use of new biotechnologies in disease diagnosis and vaccine production.
4. Environmental aspects of livestock farming.

Acknowledgements

This paper, although prepared and presented by us, is the product of several on-going processes. Many scientists, policy makers, farmers and other groups including those involved in livestock product processing and marketing were involved in the identification of constraints and development of research areas. Special mention should be made of the role played by the Council for Agricultural Research Policy in Sri Lanka and GTZ of Germany in this process.

Overcoming constraints to livestock production: The example of dairying in north-west India

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Abstract

Major developments in dairying and livestock production in north-west India, have occurred due to the creation of large-scale milk procurement, processing and marketing infrastructure, and use of technical inputs in the "Operation Flood" programmes, organised by the Dairy Development Board of India. The programme ensures that farmers are paid daily for their milk, apart from providing essential inputs to support breeding, feeding and health care of livestock, provided through village Milk Co-operative Societies. The International Livestock Research Institute (ILRI) should preferably undertake research for improving the package of practices being provided to the farmers. These areas of research are (a) breeding, (b) nutrition and (c) health care. Specific researchable issues and areas in each of these are indicated.

Introduction

There have been major developments in dairying and livestock production in north-west India during the last two decades. These have occurred primarily because of the creation of large-scale milk procurement, processing and marketing infrastructure and the technical inputs provided under the Operation Flood programmes. These programmes were implemented by the National Dairy Development Board of India, in association with Co-operative Milk Producers Unions/Federations.

The "Operation Flood" programme, which has helped usher in a white revolution in India, was launched in 1970 and was implemented in three phases. The first phase was started in 1970, and was aimed at linking the 18 best milk sheds with the milk markets in four metro cities in India (Delhi, Bombay, Calcutta and Madras). Phase II, implemented during 1980–85, increased the milk sheds to 136 and linked them to 290 urban markets. During Phase III, 1985–95, 170 milk sheds and 609 milk markets were linked. Regular procurement and payment for the milk produced by the farmers has been the biggest impetus to the livestock development programmes. Presently, about 8.8 million farmers in 75,000 Dairy Co-operative Societies (DCS), belonging to 170 milk sheds, are being paid about 13,000 million rupees per day for their milk.

In most of the villages where DCS exist, animal health care is provided through first aid centres located in the village. Routine visits by veterinarians are provided free twice a month and, emergency visits on a payment basis, within 2–3 hours of receiving a request. These have ensured better health care of animals.

For organising improved breeding programmes, 13 semen stations have been established and 15,854 village DCS have been provided with artificial insemination (AI) centres, where semen from quality bulls is supplied. Four embryo production centres are supplying embryos of elite breeds of cattle and buffalo to 14 embryo transfer (ET) centres servicing the farmers.

There are 50 cattle feed plants in the dairy co-operative sector supplying 298,455 t of balanced cattle feed per annum to 28,649 DCS. In addition, 3683 demonstrations of urea treatment of straw were organised in 55 milk sheds. Efforts are also being made towards improved fodder production; 28,645 t of fodder seeds were distributed to the farmers.

Research on karyotyping and DNA finger printing in cows and buffaloes is being undertaken at the biotechnology laboratory, NDDB, Anand. This laboratory is also engaged in the development of biologicals, vaccines and improved feed formulations.

These services and the marketing infrastructure have, to a great extent, help to overcome constraints to livestock production. However, there are many impediments such as the absence of well-defined breeding policies, infrastructure for the diagnosis and control of diseases, deficient feed and fodder availability, poor results of AI services etc.

Major priorities for overcoming the constraints to livestock development

Major priorities for livestock production include (l) selection and breeding of livestock; (2) animal nutrition; and (3) animal health care.

Selection and breeding

The increasing pressure on land because of increasing human population will not allow any significant increase in animal population. Breeding policies therefore, will have to be framed to prevent further growth of livestock populations and at the same time meet the demand of milk, which is expected to grow at the rate of about 6% per annum. Such growth is also required to sustain draft power from animals because 90% of agricultural operations are still managed by bullocks, a situation that is not likely to change in the near future. There is clearly a need for improving the quality of milch and draft animals.

Milch animals

To meet the increasing demand for milk and to maintain a constant population of milch animals, it is necessary to replace low producing animals with high yielding ones—the latter being more efficient in converting feed into milk.

Considering the example of India (Table 1), if about one-third of the 17 million nondescript cows are replaced by crossbred cows and about a quarter of the 7.6 million nondescript buffaloes are replaced by improved buffaloes, such as the Murrah and their crosses, the target of 80 million tonnes milk production by the year 2000 can be easily achieved. The remaining 35 million cows should be able to meet the requirement of 7.5 million bullocks required annually.

Table 1. *Projected cattle and buffalo population structure and milk production for a targeted level of 80 million tonnes by 2000 AD, India.*

Animal species	Population (10^6)	Average yield/ day (kg)	Total milk (10^6 tonnes)
Nondescript cows			
In milk	17.25	2.0	12.59
Dry	17.24		
Subtotal	34.49		12.59
Crossbred cows			
In milk	13.07	7.7	36.73
Dry	4.35		
Subtotal	17.42		36.73
Local buffalo			
In milk	14.91	3.5	19.05
Dry	8.15		
Subtotal	23.06		19.05
Improved buffalo			
In milk	5.73	5.7	11.93
Dry	1.91		
Subtotal	7.64		11.93
Total	82.63		80.30

India's total requirement for bullocks is roughly about 75 millions. Assuming 10 years as the life span of a bullock, the replacement needs will be 7.5 million bullocks per annum. To meet these requirements, there is need to produce better quality bullocks. Although there are several crossbreeding programmes in operation for improving milch population, no attention has been paid to the production of quality bullocks.

It is imperative, therefore, that well-focused programmes are implemented, on a regional basis, producing bulls specifically identified for producing milch and draft categories of cattle. There is a need for progeny testing and selection of bulls, so as to create germplasm, which could be rapidly expanded through large-scale artificial insemination programmes. At present, either there are no such schemes in operation or they are being operated on small-scale, government-aided farms, and the results are yet to reach the farmers.

The Dairy Board of India has initiated a few progeny-testing programmes in eight milk sheds where infrastructure for AI has been well developed. The main objective of this programme is to achieve higher genetic gains and the desired changes in feeding and management of the selected cattle and buffalo population, the main component of which is selection of breeding bulls by progeny testing.

There is a need to expand this programme and extend it to different regions and also to improve the breeding practices by initiating large-scale AI and ET schemes.

Constraints faced in the implementation of these programmes are, the poor infrastructure for milk recording, poor results of AI primarily due to improper diagnosis of oestrus and the long distances involved, and the prohibitive costs of

ET. The long duration required for recording the performance of the progeny is another major constraint.

Research efforts are required for developing cow-side tests for early confirmation of pregnancy, easy to perform tests for the detection of oestrus, and easy to operate computer programmes for the analysis and interpretation of the progeny testing data. The number of frozen semen doses produced out of each progeny-tested bull needs to be increased.

Embryo transfer has not become popular primarily due to the high costs of hormones required for super ovulation, and synchronisation of oestrus. There is need for research, for producing these reagents at reasonable costs. Sexing of embryos, if possible, would be useful in production of calves of desired sex, depending on the need for which the animal is being bred.

Buffaloes are recognised as the worlds' second most important milk producing species. Buffalo milk is rich in fat, protein and total solids and contains 37% more energy (K cal) and 33% more solids than Holstein milk. In addition, buffaloes are reported to have better roughage-utilisation capacity, lower incidence of mastitis and better adaptability for flooded areas than cattle. Despite this, buffalo have remained an underutilised and neglected species.

In India, buffaloes are the preferred dairy animal, in spite of increased emphasis on crossbred cattle. The major question is whether it is being underutilised. There is a widespread view that buffaloes can prove to be a better dairy animal. Data from Pakistan (Table 2) indicate that the buffalo has the potential for major improvements.

Recently, institutes for research on buffaloes have been established in India, Pakistan, The Philippines, Sri Lanka and Thailand. However, research at these institutes lacks field orientation. Efforts are being directed towards measuring the potential traits of buffalo, rather than improving them. There is need to intensify field research on buffalo, so as to facilitate their rapid evaluation, selection and better exploitation, and for developing milk and meat products for export.

Animal nutrition

There is an acute shortage of green fodder and concentrate feeds which is likely to be aggravated by the rapidly increasing human and animal populations. For this reason, crop residues are the major component of livestock feeding systems. Crop residues, which are deficient in nitrogen, mineral and fermentable energy, are not able to meet nutritional requirements of the ruminal microflora; this adversely affects rumen fermentation. Limited quantities of available concentrates and green fodder cannot meet the animal's nutritional requirement. Furthermore, lignocellulosic components present in crop residues prevent their digestion. Priority areas for research in animal nutrition are: (a) supplementation of crop residues with cheaper nutrient resources so as to improve their nutritive value, (b) treatment of crop residues to increase their digestibility, and (c) identification of non-conventional feed resources including development of new feed formulations.

Table 2. Performance of Nili-Ravi Buffaloes in Pakistan and their projected performance with improved feeding.

Traits	Pakistan average	Approximately twice the maintenance needs
Lactation		
1st	1854	4750
2nd	2074	5400
≤3rd	2396	5800
Yield/day of lactation (kg)	7.3	18.0
Lactation length (days)	289	300
Age at 1st breeding (months)	28.6	17.6
Age at 1st calving (months)	46.7	29.0
Days open (days)	186	125
Calving interval (days)	497	432

Source: Potential for commercial dairying with buffaloes. North Carolina State University (1995).

Application of urea and molasses has been practised for a long time for improving the nutritive value of crop residues. Application of 1% urea and 10% molasses to the roughages is recommended by many research workers. However, the technology has not become popular, probably due to difficulties encountered in application, storage and transportation of molasses. To solve these problems, many Asian countries have developed blocks consisting of urea, molasses, minerals, cakes etc. These mineral licks are reported to improve nutrient intake by ruminants, leading to improved growth and production. However, scarcity of good quality molasses and variations in the composition and texture of the blocks have prevented their large-scale use. There is need for further research, to standardise the formulation and the production process of urea–molasses blocks, and to evaluate their nutritive value.

By-pass nutrient technology has played a major role in the efficient utilisation of feed ingredients by the ruminants. Feed resources with higher nutritive value could be prevented from degradation by rumen microflora and could be gainfully digested by the enzymes in the lower parts of gastro-intestinal tract. The Dairy Board of India produces 0.22 million tonnes of by-pass protein feed commercially at their 13 cattle feed plants. However, there is need to increase this quantity and improve the formulation. Research is necessary for identifying and developing new feed ingredients that can by-pass rumen fermentation or to increase their ability to by-pass the rumen microflora so that these are most efficiently utilised.

Research is required to identify micronutrients, particularly trace elements, which are deficient in the feed and fodder on a regional basis and to suggest the levels at which these are to be incorporated in compounded cattle feeds.

Animal health care

Disease epidemics have been a major barrier to all programmes aimed at the improvement of animal productivity. The funds allocated by the government for veterinary services and disease control programmes have been meagre, primarily due to lack of reliable information on the economics of animal diseases. There has been no comprehensive evaluation of the effects of various animal diseases on animal productivity, domestic consumption, and participation in the international trade of livestock and livestock products.

Animal health research information network

In view of the above problems, it is imperative that an institutional framework is developed, at the regional level to collect and manage all information related to animal health research and disease occurrence. It is suggested that ILRI should collaborate with the participating nations in the management and sharing of an information network and provide technical expertise to the member nations.

Economics of animal diseases and control strategies

There is a lack of experience and expertise required for evaluating the economics of the diseases and formulating affordable disease control strategies in the region. ILRI can, based on its experience in Africa, provide necessary technical support for these studies. At present, south Asia has a major disease eradication campaign for rinderpest and, in the near future, it may take up the control programme against foot-and-mouth disease (FMD). ILRI can support the economic studies on FMD in the region to formulate an appropriate disease control programme.

Regional co-ordination and co-operation in animal health programmes

Different countries and the parts within them are at liberty to prioritise the area, scope and the methodologies of animal health care programmes. However, it is critical that widely accepted methods, technologies and information systems are put in place, in order to bring about co-ordinated efforts to control and finally eliminate the epidemic animal diseases.

ILRI can also help in the development of regional serum banks, maintain information on sources and availability of representative disease pathogens and livestock germplasm.

Specific disease-related research

Our understanding of the natural history and epidemiology of almost all the important diseases is very poor. Diseases like FMD, pestes des petits ruminants (PPR), bovine tuberculosis (BT) and emerging disease syndromes like neonatal calf diarrhoea (NCD) may be taken up for detailed studies.

There is need to identify diagnostic tests, including the test procedures, reagents used and their quality assurance, which are suitable and affordable. Development of diagnostic reagents for diseases like FMD, rinderpest (RP), PPR, BT, haemorrhagic septicaemia (HS), tuberculosis (TB) and Johne' s disease (JD) should be taken up initially. Tests may have to be identified for evaluating animal products (milk/meat/semen etc) for freedom from infectious agents.

Preventive medicine and animal health-care systems

A large number of diseases and disease syndromes are difficult to diagnose for want of specific reagents and manpower. It would be necessary to develop diagnostic reagents and field testing kits and to train manpower to diagnose important diseases. ILRI has experience in developing field-based diagnostic tests for protozoan diseases and it should provide the technology for regional production of reagents and kits.

Animal disease surveillance and reporting is a major weakness of veterinary services in the region. There is a need to develop appropriate means of collecting, managing and reporting animal health data. ILRI, with its experience in several countries of Africa, could help in developing appropriate animal health reporting systems.

Most of the livestock production systems in the region are of the smallholding type. There is a need to develop integrated and appropriate animal health care delivery systems, for such smallholdings. One of the major successes in sub-Saharan Africa has been the designing of appropriate livestock services for smallholders and pastoral livestock systems. This experience may hold good in the Indian context especially for its large bovine and small ruminant populations.

Vaccine and biological production

There is need to identify and ensure supply of standard strains of infectious agents for vaccine production in the region. A major handicap has been the production and delivery of vaccines, especially the maintenance of the cold chain. There has been a sea change in the production of effective vaccines that are more robust and easier to deliver using new biotechnological tools, which has enabled production of recombinant vaccines and diagnostics. ILRI should organise their evaluation and application.

The Bharatiya Agro Industries Foundation (BAIF) experience

B.R. Mangurkar

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The following are observations contributed to the discussion of Dr Singh' s paper.

1. The variation in milk yield in the crossbred cattle population is high (over 35%). The range of yield is indicative of possible genotype x environment interaction, which is not yet recognised fully.

2. There is a need to study the performance potential vis-à-vis the input level and then recommend suitable animal types for the specific situations. The data on this aspect is lacking at present.

3. Generalisation of the experience based on limited information and knowledge should be avoided. There is always a brighter side somewhere.

4. Lack of clear guidelines on breeding policy has been the major reason for altering the existing methods and breed structures.

5. The need for particular kinds of animals is changing very fast because of the process of urbanisation, economic pressure and alternative means for agricultural operations. A type of animal unsuitable at present in a particular location can often be profitably used elsewhere. We need to respond to changing priorities—as a region and at the level of the production unit.

6. Heterosis is not very important in good feeding and management. However, it is extremely important under suboptimal conditions.

7. The limitations of inputs available for production and the consequent constraints in exploiting the performance potential should be well recognised and explained in the extension programmes otherwise, there are likely to be failures.

8. Biotechnologies, like embryo transfer, cannot provide immediate solutions for enhancing productivity since the technologies are expensive, specialised and cumbersome for mass production.

9. Newer technologies should be socially compatible so as to avoid disturbances in decentralised small-scale dairy/animal enterprises in developing countries.

10. There is a need to define the goals for quality parameters of livestock products before setting breeding policy.

The experience of the Swiss Development Corporation in livestock development

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The Swiss Development Corporation (SDC) has nearly 30 years experience in livestock production with livestock being viewed as a critical part of natural resource management. The programmes have been implemented through SDC and NGO co-operation.

The main findings have been that:

- Livestock production is critically important for the livelihood of small farmers. Sixty per cent of all livestock in India are kept by small/marginal farmers providing up to 35% of their regular cash income,
- There is a strong connection between rural/ecological degradation and livestock density in semi-arid areas.
- There is a need to increase the productivity of India's livestock population.
- There have been synergistic effects within the SDC country programme e.g. the natural resource management group tries to integrate its activities with efforts in energy and environment etc.

From 1964, the SDC started collaborative activities in Kerala with a cattle development programme. Programmes have continued until the present to improve the quality of services and inputs, and the delivery systems for these services. The focus was on the transfer of technology and infrastructure for (i) breeding and artificial insemination (AI), (ii) fodder production and seeds and (iii) human resource development.

In 1976, similar programmes were started in Andhra Pradesh, but concentrated on breeding in buffaloes, the integration of livestock into farming systems and extension methodologies.

In 1990, a new programme was initiated linking production and marketing involving farmer organisations. At present, the SDC is concentrating on quality in partnerships (including NGO and producer organisations). The SDC has now been invited by the Government of India to assist in an analysis of livestock policy. Their role has been to move from bovines to general livestock production systems and from farm projects to the programme policy/strategy dialogue.

Over the years the organisation has evolved and made changes in its concept of approach. It has changed the focus from:

- Animals and services to an integrated approach with livestock as part of farming systems and associated natural resource management.
- Production of livestock outputs to productivity of the system with the optimum use of available resources by farmer communities as the central issue.
- Partnership with mainly government agencies to diversity in partnerships.
- Programme to policy discussions.

Similarly, there has been refinement of the sector programme objectives to:

- contribute to policy/strategy documents and to organisation and institutional development
- contribute development of sustainable livestock production and dairy technologies to development of effective extension methodologies
- the role of women and disadvantaged groups.

The SDC has focused its resources and programmes through geographic concentration on south India and rainfed areas.

Looking towards research requirements, on the basis of its experience the SDC would favour:

- livestock research set in the context of natural resource management
- fodder-cropping patterns and land use
- the use of crop resources and crop residues (with an emphasis on the social community factor)
- appropriate use of farmyard manure
- animal traction
- the role of livestock production in identified agro-ecological zones
- exploitation of indigenous knowledge and breeds are important aspects of research and will expressly include the involvement of farmers and women
- economics of livestock production and technology
- productivity in livestock (reproduction/nutrition)
- strengthening of the national research grid
- improvement of data bases and information systems.

Appendix I

ILRI Consultation on Livestock Research Priorities in South Asia 6–8 June 1995, ICRISAT Asia Center, Patancheru, India

Tuesday 6 June

Registration

Session 1: Welcome and Opening

Chairman – J.G. Ryan

Welcome and opening of the meeting by Dr J. G. Ryan, Director General, ICRISAT

Introduction to the Objectives of the Meeting – T. Dolan, Acting Deputy Director General (ILRI)

Session 11: International approaches to agriculture and livestock research in the semi-arid tropics of South Asia

Chairman – K. Singh

Paper 1: Resource management and plant improvement at ICRISAT: Prospects for integrating crops and livestock. M. Anders

Paper 2: FAO's programme for the conservation of domestic animal diversity in Asia. D. Steane

General Discussion

Lunch

Paper 3: Priorities for feed resource utilisation in the semi-arid tropics. G.V. Raghavan, N. Krishna and M.R. Reddy

Paper 4: Economic aspects of livestock production in selected crop/livestock system in the SAT. P.P. Rao

General Discussion

Introduction to priority setting

Wednesday 7 June

Session 111: National and regional priorities for the improvement of livestock agriculture in the SAT of South Asia

Chairman – B.M.A.O. Perera

Paper 5: Research priorities for improving animal agriculture by agro-ecological zone in Bangladesh. S. Kibria

Paper 6: Research priorities for improving animal agriculture by agro-ecological zone in India. K. Singh

General Discussion

Session 111 continued

Chairman – C. Nimbkar

Paper 7: Research priorities for improving animal agriculture by agro-ecological zone in Nepal. H. Shrestha and D.P. Pradhan

Paper 8: Research priorities for the improvement of livestock production by agro-ecological zone in Pakistan. A.H. Cheema, Z. Altaf and T.N. Pasha

Paper 9: Research priorities for animal production systems in Sri Lanka. S. Ranawana and B. M.A.O. Perera

General Discussion

Thursday 8 June

Session 111 continued

Chairman – B.R. Mangurkar

Paper 10: Overcoming constraints to livestock production: The example of dairying in north-west India. D.K. Singh

Paper 11*: A review of the Indo-Swiss programmes for livestock improvement in the semi-arid regions of India. H. Mulder

Paper 12*: The Bharatiya Agro Industries Foundation (BAIF) experience. B.R. Mangukar

Session IV: Plenary Discussion of Research Priorities

Chairman – C. Devendra

The goals of livestock improvement in the SAT (differences between ecozones and production systems) Research requirements for the improvement of individual production systems Prioritisation of livestock research requirements by production system Close of meeting by T. Dolan and J.G. Ryan

* Not an official paper

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